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Engineering Hospital Discharge Instructions: An Eye-Tracking Based Study

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ENGINEERING HOSPITAL DISCHARGE INSTRUCTIONS: AN EYE-TRACKING BASED STUDY

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Industrial Engineering

by
Haley Marie Vaigneur
May 2015

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ABSTRACT

With new healthcare reform initiatives, (e.g., the Patient Protection and Affordable Care Act) hospitals have additional requirements to reduce avoidable readmissions. This results in identifying the needs for improving the hospital discharge process, improving care transitions and discharge instructions, and increasing overall patient health literacy. In terms of discharge instructions, one of the most influential factors to patients’ understanding and compliance with their prescribed health regimen is the document’s readability. The study goal is to examine how adjusting the discharge instructions’ reading level and using human factors design guidelines can influence a novice user’s ability to read, comprehend, and recall information from discharge instructions. In this study, a novice user is serving as a caregiver who was not present during discharge. In addition to information accuracy, this study explores discharge instruction usability based on search efficiency, which is quantified with eye-tracking data and subjective measures. Insights from the results suggest that there are differences in comprehension and recall performance, and search efficiency between different formats and readability levels for the discharge instructions that can lead to design recommendations for discharge instructions. These recommendations can result in improve comprehension and support standardized discharge form initiatives. Overall, there is the potential to advance health literacy, which can contribute to efforts to reduce avoidable readmissions and improve overall health of vulnerable health care users.
DEDICATION

This thesis is dedicated to those who have selflessly cared for a loved one. Let it not be forgotten that those who devote remarkable strength to the needs of others, can still use a helping hand, themselves, every once in a while.
ACKNOWLEDGMENTS

I would like to acknowledge my thesis advisor, Dr. David Neyens. You have passed on invaluable knowledge, and your time, support, and patience during my graduate education has been sincerely appreciated. I would also like to thank Dr. Scott Mason and Dr. Ashley Kay Childers for serving as members of my thesis committee and offering encouragement throughout the completion of my thesis. Lastly, I would like to extend thanks to my family and friends who have always offered their love and support, but especially at the times I have needed it most.
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CHAPTER ONE
INTRODUCTION TO HOSPITAL DISCHARGE INSTRUCTIONS

Discharge instructions are used as a communication tool between the hospital physician and/or nurses and the patient and their caregivers (Crane, 1997; Powers, 1988; Taylor & Cameron, 2000; Vukmir, Kremen, Hart, & Menegazzi, 1993) Discharge instructions are seen as a critical piece of the discharge process for patient-centered care, especially for elderly patients (E. A. Coleman, 2003; Halasyamani et al., 2006; Kripalani, Jackson, Schnipper, & Coleman, 2007; Richardson et al., 2001) because discharge instructions are a main (and sometimes the only) educational document that the patient will receive with all of the information regarding their hospitalization and future instructions. The DI bridges the gap between hospital-based health care and home-based health care. At home, discharge instructions serve as an information resource (e.g., what to do, when to resume activities, possible symptoms and complications, and the contact information of a health care provider) (Clark et al., 2005a). The information given at discharge helps with patients’ confidence of managing their health (Henderson & Zernike, 2001). Thus, the effectiveness of such information transfer has potential to influence the patients’ at-home care and could alter compliance, patient satisfaction, and ultimately hospital readmissions (E. A. Coleman, Mahoney, & Parry, 2005; Halasyamani et al., 2006; Taylor & Cameron, 2000).

One of the goals of the Hospital Readmission Reduction Program under the Patient Safety and Affordable Care Act is to reduce the number of excessive avoidable readmissions through monetary penalties to hospitals (CDC, 2013), thus resulting in the
recent increase of care transition research (E. A. Coleman et al., 2005; Kripalani, Jackson, et al., 2007; Kripalani, LeFevre, et al., 2007). It has been suggested that patients who are not properly educated during discharge will be more likely to need additional healthcare through readmission, emergency department visits, or primary care visits (Henderson & Zernike, 2001; M. Naylor et al., 1994; M. D. Naylor et al., 1999). Aside from improving the quality of transitional care, creating more effective educational documents coincides with healthcare reform efforts to increase patient-empowerment (E. A. Coleman, 2003; Salmon & Hall, 2003; Segal, 1998; Trummer, Mueller, Nowak, Stidl, & Pelikan, 2006), as patients desire easily understandable instructions (Robinson & Miller, 1996). A national priority was set in 2003 to create informed patients that can contribute and participate in their decisions and health management and prevention (Corrigan & Adams, 2003) and the Joint Commission on Accreditation of Healthcare Organization mandates that accredited hospitals provide patients with access to understandable patient information materials.
CHAPTER TWO

CAREGIVERS INTERACTION WITH DISCHARGE INSTRUCTIONS

As mentioned earlier, discharge is just one of many possible handoffs occurring during a hospital visit. Each handoff can be explored to improve information transfer, however, discharge transition of care is the first in which the patient leaves the facility, and they (or a friend or relative) become responsible for their care. This transfer is also different in that the patient becomes the primary recipient of the information, as opposed to a health care provider.

The number of self-care responsibilities increases as patients return home (E. A. Coleman et al., 2004) and in most recent years, patients and their caregivers are also being given more responsibility to manage their disease in order to help contain health costs (Badarudeen & Sabharwal, 2010). Fifty-two million Americans serve as informal caregivers (caregivers not receiving pay) to a family member or friend who is ill or disabled (Alliance, 2001; US HHS, 1998) with 38% of informal caregivers being children aiding aging parents and 20% of informal care being given to grandparents and other older relatives (US HHS, 1998). Thirteen percent of Americans in their early twenties provide informal care, and these younger caregivers more frequently care for older relatives, as middle aged caregivers for older relatives declines as their own family obligations increase (US HHS, 1998). As older relatives in the 21st century are living longer (Fries, 2002), they are able to have more and lengthier relationships with additional generations (Giarrusso, Silverstein, & Bengtson, 1996; Hagestad, 1988).
Because of this, grandchildren have been recognized as a caregiver population for elderly relatives, fitting into the filial responsibility of providing care to older relatives without benefit or economic force (Dellmann-Jenkins & Brittain, 2003; Wolfson, Handfield-Jones, Glass, McClaran, & Keyserlingk, 1993). With this in mind, the role and needs of the caregiver, in addition to the patient, should not be neglected. A family member’s ability to serve as a caregiver depends on the resources available to them (Donelan et al., 2002; Driscoll, 2000; Edstrom & Miller, 1981). In a study investigating the needs of caregivers at home, it was found that families felt inadequately prepared and had additional information needs (Hinds, 1985). Newer studies suggest that family and caregiver needs are often overlooked during care transitions, and have thus identified four domains for measuring care transitions (CTM-Care Transition Measure): information transfer, patient and caregiver preparation, support for self-management, and empowerment to assert preferences (E. A. Coleman et al., 2002). Coleman et al., (2004) suggests that providing patient centered interventions to meet these needs and help patients manage transitions can contribute to their being half as likely to return to the hospital. Limited knowledge of the patient’s situation and treatment as well as uncertainty with role change have both been identified as stressors for the caregiver and patient (Bevans & Sternberg, 2012; Blank, Clark, Longman, & Atwood, 1989; Bragstad, Kirkevold, Hofoss, & Foss, 2014), and given that stress can impede the family’s ability to be caregivers (Hinds, 1985), the information transfer techniques should be catered to their needs as well.
This concept of focusing on the patient and their family caregiver needs can be derived from User-Centered Design. User-Centered Design (UCD), coined by Norman, emphasizes the need to consider the end user during every phase of the design process (Norman 1986). One way this can be done, is by involving them in the design process (Norman & Draper, 1986), specifically, obtaining their opinion on the usability of the product or interface. There is minimal research on patient assessment of the quality of discharge instructions found in the literature (Clark et al., 2005b). This information is critical because not only can it influence design structures, but discharge instructions satisfaction also correlates with overall hospital satisfaction (Clark et al. 2004). Given that patient satisfaction is a product of quality of care (Cleary & McNeil, 1988; Donabedian, 1988) it is very important that measures be taken to avoid discharge instructions use problems. It has been suggested that the more education and planning is invested with the patient, the more satisfied they are with their instructions (Bull, Hansen, & Gross, 2000; Clark et al., 2005a).
CHAPTER THREE

IMPROVING HEALTH LITERACY

Patient’s ability to use health education materials is impacted by their health literacy (Hill-Briggs & Smith, 2008). Health literacy pertains to the patient’s ability to obtain, process, and understand their health information in order to make appropriate decisions (Health & Human Services, 2000; Kindig, Panzer, & Nielsen-Bohlman, 2004; Ratzan, Filerman, & LeSar, 2000), and those with low health literacy have more frequent and longer hospital admissions (Friedland, 1998; Kindig et al., 2004). Poor health literacy has been found to be a result of patients’ inability to understand or comprehend their discharge instructions (Weiss, 2003). Lack of comprehension can be attributed to the readability of the document, which are the skills needed in order to understand the document (Albright et al., 1996; Cooley et al., 1995; Doak, Doak, & Root, 1996; Kindig et al., 2004; Merritt, Gates, & Skiba, 1992). However this is often overlooked when designing health documents (Badarudeen & Sabharwal, 2010; Boulos, 2005) and a disparity has been found between the average patient reading level and the reading level of patient education documents, including discharge instructions. Over the past two decades, discharge instructions have been found to be written at a level too difficult (Powers, 1988; Williams, Counselman, & Caggiano, 1996) and it has been found that up to 78% of patients do not have a complete understanding of their discharge instructions (Engel et al., 2009; Zavala & Shaffer, 2011). Poor recall and understanding of discharge instructions has found to reduce compliance (Bradshaw, Ley, Kincey, & Bradshaw, 1975; Griffin, McKenna, & Tooth, 2003). The average patient reading level is at an 8th grade
reading level (Doak et al., 1996), and it has been recommended by several health agencies that patient education materials should not exceed a sixth to eighth grade reading level (CDC, 2010; Kindig et al., 2004; Weiss et al., 1994). Patients have a greater understanding of simply written documents (Estey, Musseau, & Keehn, 1991; Weiss et al., 1998).

Another contributor to lack of discharge instructions comprehension has been found to be discharge instructions design (Griffin et al., 2003; Kripalani, Jackson, et al., 2007). The Joint Commission has documented mandatory items to be included in discharge instructions and the Society of Hospital Medicine has endorsed a discharge checklist (Halasyamani et al., 2006). However, specific guidelines for operationalizing these requirements is limited (Henriksen et al., 2008). The literature has documented the need to revolutionize discharge communication by improving the format of discharge information to make PEMs visually appealing (Arthur, 1995; Engel et al., 2009; Griffin et al., 2003) and easily understandable.

Deciding how to present the Joint Commission’s mandated items should focus on maximizing information transfer. In addition to the amount of information transferred, the quality of the information needs to be considered from a user’s point of view. These goals align with the Situation Awareness Theory in which the degree of information is perceived, comprehended, and projected, directly influences performance (Endsley, 1988). Situation Awareness Theory relates to discharge instructions, in that the patient needs to be able to perceive the document and find the needed information, easily
comprehend the information, and then project the information to plan for and complete self-care.

The study of cognitive ability has also emerged as a need for a user-centered design. Many of the cognitive theories are analogous to those of perception (Woods, 1995) and have evolved to support more complex systems. Cognitive load theory examines how information is learned and put into memory using different techniques (Sweller, 1994). One such technique is creating a schema, how a person cognitively organizes information, which is known to be able to reduce working memory load by increasing the amount of information absorbed through “chunking” multiple elements into a single unit (Egan & Schwartz, 1979; Sweller, 1994). It has been shown that the presentation of information can affect such cognitive learning (Sweller, 1994). Thus, layout design should be considered to help develop effective schemas which could result in improved information transfer quality.
CHAPTER FOUR
INCORPORATING CAREGIVER EYE TRACKING

As described previously, the quality of information transfer can impact the how an operator or user perceives and processes the information. Furthermore, analyzing human performance is a way to understand how accurately information is perceived and processed. This is traditionally measured through speed, accuracy, and attentional demand (Wickens, 1992). Eye tracking is a widely used method of evaluating speed and accuracy of visual-based tasks (Albert; Byrne, Anderson, Douglass, & Matessa, 1999; Duchowski, 2002; J.H. Goldberg & Kotval, 1999; J.H. Goldberg, Stimson, Lewenstein, Scott, & Wichansky, 2002; Poole & Ball, 2005). Visual search is a two part task consisting of attention placement and target perception (Bojko & Stephenson, 2005) where the first task involves finding the targeted information that needs to be processed, and the second task involves understanding the information and being able to relate it as needed. Eye tracking can be used to examine what catches users’ attention (fixations) and what strategies they take to reach the targeted information (scan paths, saccades), as well as clues to easy it is to comprehend the data (fixation duration). This information can be valuable in understanding the usability of the item being observed by evaluating the visibility, meaningfulness, and placement of items based on where the participant looks, and areas recognized by the researcher as being of interest (J.H. Goldberg & Kotval, 1999). The most popular metrics to evaluate usability are the number of overall fixations, overall mean fixation duration, number of fixations on area of interest, overall fixation rate, gaze percent on area of interest, mean gaze duration on area of interest (Jacob &
Karn, 2003). A fixation is “pause over informative regions of interest” (Salvulucci et al. 2000), and the number of overall fixations has been researched to be negatively correlated with search efficiency (J. H. Goldberg & Kotval, 1998). A gaze is cumulative fixations in an area of interest (Jacob & Karn, 2003), with saccades being movements between fixations (Salvucci & Goldberg, 2000). Backtracking eye-movements, known as regressive saccades, can indicate processing difficulty (Rayner & A., 1989). The scan path, the sequence of fixations, can indicate how well a document is arranged (Jacob & Karn, 2003). These metrics have been useful in identifying the underlying factors of what draws people’s attention and how they look at it (Lohse, 1997; Poole & Ball, 2005).

Eye tracking has been applied to similar research areas such as Redline and Lankford’s study investigating the scan path of adults when filling out a four page questionnaire and Cowen’s study to evaluate total fixation duration and number of overall fixations when having users search for information on web pages (Cowen, Ball, & Delin, 2002; Redline & Lankford, 2001). Goldberg et al. (2002) also had users search and extract information from web pages and evaluated eye movement metrics such as number of fixations on area of interest, saccade length, and scan path.

The effectiveness of discharge instructions are determined by how well the patient can read them (Griffin et al., 2003). Thus, this study will analyze how well participants are able to read varying reading level and layout discharge instructions through search, comprehension and recall tasks. Their perceived workload and document usability will also be collected to determine discharge instructions satisfaction.
CHAPTER 5
EXPERIMENTAL METHODS

Objective

The objective of this thesis is to evaluate how the format and reading level of discharge instructions affect a novice user’s search time, search strategy, comprehension and recall of information, and the perceived usability of the discharge instructions.

Experimental Design

The experiment was a 2x2 randomized factorial design. The two levels for discharge instructions format are 1) original discharge instructions and 2) modified discharge instructions, where format is pertaining to the arrangement of the information across the three pages of the discharge instructions. The modified format discharge instructions contained the same content as the original format discharge instructions, but had moderate formatting changes. These changes are discussed below. The two levels for discharge instructions readability are 1) low readability and 2) high readability. These levels are based on education level that the reader would need to possess to read and understand the discharge instructions (See Table 5.1).

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<tr>
<td>Original</td>
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<tr>
<td>Unaltered Format</td>
</tr>
<tr>
<td>Low 9.0 Grade Reading Level</td>
</tr>
<tr>
<td>Fairly Difficult Reading Ease</td>
</tr>
<tr>
<td>Unaltered Format</td>
</tr>
<tr>
<td>High 6.1 Grade Reading Level</td>
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<tr>
<td>Standard Reading Ease</td>
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**Discharge Instruction Changes**

A sample set of discharge instructions was obtained from a hospital in the Southeast US for hospitalization due to a rash. The sample discharge instructions contained each of the Joint Commission’s mandatory items (e.g., reason for hospitalization, significant findings, procedures and treatment provided, patient’s discharge condition, patient and family instructions, attending physician’s signature) (JCAHO, 2011). In their original form, the discharge instructions had a 9.0 grade reading level (DI A), which was found using the Flesch Kincaid Grade Scale Formula tool in Microsoft Word. The document was then modified, specifically by replacing large syllable words with smaller syllable words, changing written out numbers to digits, ensuring word consistency throughout the document, and condensing sentences (Jackson et al., 1991; Weiss, 2003; Wilson, 2009). The lower reading level discharge instructions have a 6.1 grade reading level (DI B). The layout of these two discharge instructions were then altered in the same way, specifically by using a consistent font, borders, bulleted lists, and a table for the medications list, which have been found to be effective formatting techniques to support mental models, readability, and usability (Brown et al., 1992; Doak et al., 1996; Hoffmann & Worrall, 2004; Horner, Surratt, & Julissosn, 2000; Raynor, 1998; Wade, Buxton, & Kelly, 1999). This resulted in an 8.6 grade reading level (DI C) and a 5.6 grade reading level (DI D). In order to avoid any misleading associations, the margin size was changed to “narrow” settings for all four discharge instructions to create equal three page documents. Also, in order to focus the analysis of the discharge instructions layout, the font and font size was changed to be consistent
across all four discharge instructions (12-point Times New Roman). All four of the discharge instructions remained in compliance with the Joint Commission guidelines. These sample discharge instructions can be found in Appendix A-D.

Participants

This experiment included participants (N=74) between the ages of 18 and 25 years of age. Participants were proficient in English and were recruited from Clemson, SC and surrounding areas. All participants completed an informed consent as approved by Clemson University’s Institutional Review Board (IRB# 2014-344). They were compensated $10 for their time in the form of a gift card.

Eight observations were removed from analysis. Four of them were removed due to technical difficulties with the eye tracker calibration that resulted in no recorded data for the search tasks. Three others were removed due to eye tracker calibration or data collection errors, and the last was due to a third party interruption during the study. The data analysis was then performed based on the remaining participants (N=66), with 36 females and 30 males and a mean age of M=21.15 (SD=1.8) years. Forty-eight of the participants knew what discharge instructions were, and 32 had seen discharge instructions before.

This study asked participants to perform the role of a relative or a friend aiding a patient (e.g., a grandparent) as a caregiver in their home-based care. As might happen in an actual situation, the study participant was not involved in the discharge process and thus was a novice reader of the discharge instructions. This population is important to
observe because often caregivers do not feel prepared to take care of the patient (Leske & Pelczynski, 1999).

**Independent Variables**

The independent variables for this study are the discharge instructions’ readability and the discharge instructions’ format. Each of these factors has two levels. The discharge instructions’ readability levels are “high” and “low”, and the format levels are “original” and modified”. The participant was randomly assigned a combination of these two variables for the study.

**Dependent Variables**

This experiment consisted of four main tasks that analyzed the participant’s search strategies of the discharge instructions, their recall of the discharge instructions information, their perceived usability and workload of the discharge instructions, and their comprehension of the discharge instructions information. The discharge instructions search task (Appendix E) variables were collected from the eye-tracker and were used to analyze the document’s usability (Bojko & Stephenson, 2005; Byrne et al., 1999; J.H. Goldberg et al., 2002; Jacob & Karn, 2003; Poole & Ball, 2005; Sibert & Jacob, 2000). These variables include number of overall fixations, number of fixations per Area of Interest (AOI), adjusted fixations per AOI, fixation duration per AOI, number of post target fixations, and gaze duration per AOI. Recall was measured by participant performance scores on a recall-based survey. Discharge instructions comprehension was measured by participant performance scores on a comprehension based survey (Appendix G) as well as fixation duration and gaze duration from the eye-tracker. Perceived
usability was measured using the System Usability Scale (SUS) (Brooke, 1996) (Appendix H), which has been found to be very reliable (Tullis & Stetson, 2004). Perceived workload was quantified using the NASA-tlx survey (Hart & Staveland, 1988) (Appendix I). See Table 5.2 below for reference of how each variable will be quantified.

For the search tasks, the set of nine questions were randomly ordered in three different ways, and each participant was randomly assigned an order. This procedure was the same for the recall task questions, so that the participant was always given a different order of questions on the recall task than the search task.

**Apparatus**

This study used the Tobii X60 eye-tracker with a Tobii X60/X120 monitor mount and Tobii Studio 2.X software. The eye tracker is mounted to a 22 inch Dell desktop monitor. Currently, discharge instructions are typically a paper based- printed document given to the patient, but the participant viewed them statically on a computer screen for this study for the purpose of the eye tracker. However, some hospitals already use digital versions of discharge instructions and as the idea and methods supporting e-Health continue to grow, it can be likely predicted that the norm will become to deliver discharge instructions to the patient in an electronic or digital format.

**Study Procedure**

Upon arrival at the experiment site, each participant was given an overview of the experiment and what they will be asked to do, and then given the consent form to read and complete. The participant was then asked if they have any questions about the
informed consent document or the study. The participant was then given a demographic survey (Appendix J). The participant was then be calibrated to the eye tracker, and instructed to read the presented search task instructions and then when ready, proceed to the first question. The first search task question was presented on the screen, followed by their randomly selected discharge instructions, which remained visible until the participant correctly answered the search task question orally. This was repeated for all nine of the search tasks. For each task, the AOI was set for the line of text containing the correct answer. The participant also was instructed to not move to the next search task until they have found the correct answer. This was done to ensure that the participant did not skew the search time by providing incorrect answers. They were also asked to not answer the question from previous external knowledge, memory from searching for answers to previous questions, or guessing, but to make sure that they were looking at the answer when they said it out loud.

The discharge instructions were then removed from the screen and the participant was given the recall survey. These questions were the same nine ones as the search tasks, presented as open ended questions, but the participant was not be able to look at the discharge instructions, thus evaluating how well they could recall the information they previously found.

Next, the discharge instructions appeared back on the screen, and the eye tracker was recalibrated. The participant was given 5 minutes and instructed to read through the entire discharge instructions in order to best understand how to appropriately provide care for their grandmother. They were told that after they would be given two surveys to fill
out describing how they liked their discharge instructions, but the comprehension task was not mentioned. This amount of time was determined based on time to comprehend a printed word times the word count of the longest discharge instructions (Card, Robertson, & Mackinlay, 1991; Johnson, 2010; Larson, 2004).

The participant was then given the System Usability Scale and NASA-tlx surveys. Last, they were given the comprehension survey, consisting of nine multiple choice questions, and one open ended question. These questions were designed at varying levels of complexity, and one of the question’s answers was not on the discharge instructions. One reason for this was that error detection, can be used as indication of comprehension (Harris, Kruithof, Terwogt, & Visser, 1981).

Upon completion, the participant was debriefed, any final questions were answered, and they were thanked and presented with a gift card.

Recall Hypotheses

Hypothesis I: The modified format discharge instructions (DI C &D) will be more accurately and efficiently recalled.

1.1: (Accuracy) Mean recall score will be higher for DI C & D than for DI A & B.

1.2: (Efficiency) Mean time to complete recall survey will be less for DI C & D than for DI A & B.

Hypothesis II: The high readability discharge instructions (DI B & D) will more be accurately and efficiently recalled.
2.1: (Accuracy) Mean recall score will be higher for DI B & D than for DI A & C.

2.2: (Efficiency) Mean time to complete recall survey will be less for DI B & D than for DI A & C.

Comprehension Hypotheses

Hypothesis III: The high readability discharge instructions (DI B & D) will be more accurately and efficiently comprehended.

3.1: (Accuracy) Mean comprehension score will be higher for DI B & D than DI A & C.

3.2: (Efficiency) Mean time to complete the comprehension survey will be less for DI B & D than DI A & C.

3.3: (Efficiency) Mean gaze duration per AOI will be less for DI B & D than DI A & C.

3.4: (Efficiency) Mean number of post target fixations will be less for DI B & D than DI A & C.

Hypothesis IV: The modified format discharge instructions (DI C & D) will be more accurately and efficiently comprehended.

4.1: (Accuracy) Mean comprehension score will be higher for DI C & D than for DI A & C.

4.2: (Efficiency) Mean time to complete the comprehension survey will be less for DI C & D than DI A & B.
Usability Hypotheses

Hypothesis V: The modified format discharge instructions (DI C & D) will be perceived to be more usable.

5.1: (Accuracy) Mean SUS score will be higher for DI C & D than for DI A & B.

5.2: (Accuracy) Mean NASA-tlx score will be lower for DI C & D than for DI A & B.

Hypothesis VI: The high readability discharge instructions (DI B & D) will be perceived to be more usable.

6.1: (Accuracy) Mean SUS score will be higher for DI B & D than for DI A & C.

6.2: (Accuracy) Mean NASA-tlx scores by variable will be lower for DI B & D than for DI A & C.

Hypothesis VII: The modified format discharge instructions (DI C & D) will be more usable.

7.1: (Efficiency) Mean number of overall fixations will be less for DI C & D than DI A & B.

7.2: (Efficiency) Mean number of fixations per AOI will be less for DI C & D than DI A & B.

7.3: (Efficiency) Mean search time will be less for DI C & D than DI A & B.
Table 5.2 below provides a summary of the dependent measures that were collected. Each of the three dependent variables was divided into an accuracy and efficiency category and the method that each was quantified is shown.

Table 5.2: Dependent Measures

<table>
<thead>
<tr>
<th>Dependent Measures</th>
<th>Accuracy Variables</th>
<th>Efficiency Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recall</td>
<td>• # Wrong - Pass/Fail</td>
<td>• Time on task</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Time on task</td>
</tr>
<tr>
<td></td>
<td>• Total gaze duration in AOI</td>
<td>• Total gaze duration in AOI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• # Post target fixations</td>
</tr>
<tr>
<td>Comprehension</td>
<td>• # Correct-Pass/Fail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Total time on task</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• # Overall fixations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• # Total fixations on AOI page pre-target</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• # Total fixations in AOI (first and return)</td>
<td></td>
</tr>
<tr>
<td>Usability</td>
<td>• # Search survey questions</td>
<td>• Total time on task</td>
</tr>
<tr>
<td></td>
<td>incorrectly answered</td>
<td>• # Overall fixations</td>
</tr>
<tr>
<td></td>
<td>• Perceived: SUS and NASA-TLX</td>
<td>• # Total fixations on AOI page pre-target</td>
</tr>
<tr>
<td></td>
<td>Ratings</td>
<td>• # Total fixations in AOI (first and return)</td>
</tr>
</tbody>
</table>
CHAPTER 6
EXPERIMENTAL RESULTS

Data Analysis

Software

The data analysis for this study was performed using R version 2.12.1 (R Development Core Team, 2010). Appropriate assumptions were met for each of the models used, respectively (Hothorn & Everitt, 2014).

Data Reduction

A program was developed using Microsoft Excel 2010 Visual Basic Application to reduce the eye tracking data. It was reduced for each of the nine search questions, per each page of the discharge instructions (3 pages), per each participant. The Areas of Interest (AOIs) were located over the line of text containing each of the answers for the search task. These were placed using the Tobbi Studio Software, and the sizes of the “AOI box” were as consistent as possible between discharge instructions. However, with the modifications, a couple of the AOI sizes did change, but these were adjusted in the analysis by text length. The main metrics that reduced included (1) the number of fixations on the pages prior to the one where the answer was located, (2) the number of fixations on the page that the answer was located prior to fixations in the target, (3) the number of fixations on other pages than the one with the answer post having had fixations in the AOI target (4) the number of fixations in the AOI, which was divided into the first time it was seen, and the number when returning to the answer, (5) the number of times that the participant’s eyes left the AOI and returned, (6) and the gaze duration in
the AOI. The data was reduced for each question separately to ensure consistency and be able to recognize any patterns. They were then summed across the nine questions for totals of the search task as a whole.

Recall Analysis

The accuracy portion of the recall task was the number of question wrongly answered on the recall survey. Given that the questions were open-ended, the answers were scored as a wrong answer if the participant’s response was semantically incorrect. The answers were also scored as wrong if the participant checked “I don’t know” indicating that they did not accurately recall the information from the search task. The response was not deemed wrong for syntactic errors, unless it greatly varied from the correct phrase and altered the meaning. For example, one of the questions was “What dosage of Levothyroxine should your grandmother take?”. The participant would have found the answer on their discharge instructions during the search task as “Levothyroxine - 88 mg 1 tablet by mouth a day”. If they answered the recall question with “88 mg”, “1 tablet/day”, “1 pill a day”, etc. they were determined to have answered the question correctly in that they recalled the dosage well enough that they would correctly administer the medicine to their grandmother. However, if they answered such as “8” or “88 mg 3 times a day”, the answer was determined to be incorrect. A key was created of the exact statements that were on the discharge instructions that would answer the recall/search question and all of the participants data was scored together to ensure consistency. The key and the data was also given to five other experts to score for inter-
rater reliability, and in order for the question to ultimately be marked wrong, must have been marked wrong by at least three of those five reviewers.

The overall accuracy recall scores were analyzed using a logistic regression model (Equation 1) (Neter, Wasserman, & Kutner, 1989) with a “Failing Score” being the “Number of Wrong Answers” ≥ 1, and a “Passing Score” being that the participant correctly recalled all of the nine answers. This was coded in the model as 0=Pass, 1=Fail.

\[
\text{Equation 1} \quad \log\left(\frac{\pi}{1-\pi}\right) = Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2,
\]

where \(Y = \text{Recall Score}, X_1 = \text{Readability}, X_2 = \text{Format}\)

The recall efficiency, time on task for completing the recall survey, was analyzed using a two-way ANOVA.

*Comprehension Analysis*

The participants’ answers from the comprehension survey were compiled for the accuracy portion of the comprehension task (number of correct answers). The most missed questions were examined, in order to make sure that the task appropriately measured comprehension and knowledge after reading through the discharge instructions, as opposed to memorization. Two of the questions regarding specifics about medications were missed by over 80% of the participants. These two questions were removed from the analysis because the researchers felt that they focused too strongly on memory of information, and the participant had not been instructed to “memorize” the medications chart. Furthermore, even if they had memorized all of the medication descriptions, it would not be how discharge instructions would be typically used (i.e. as a reference at home). Another question asked “When is your grandmother’s next doctor’s
appointment?”. The discharge instructions asked the patient to set up an appointment with their primary care physician and did not have a specific date. The correct answer was intended to be “Has not been scheduled”, but because a “Not on form” option was given for each question, it was realized that this question could technically be answered either way, and over 30% answered “Not on form”.

The remaining five questions were analyzed using a Logistic Regression Model, (Equation 2) and as with the recall task a “Pass” or “Fail” method was used. If the participant missed any of the questions (number correct ≤ 5) they received a “Failing Score”, and received a “Passing Score” by getting all of the answers correct. If the participant marked “I don’t know” or “Not on form” (if inappropriate), the answer was scored as wrong, as well.

**Equation 2** \[ \log\left(\frac{\pi}{1-\pi}\right) = Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_1X_2, \]

where \( Y = \text{Comprehension Score} \), \( X_1 = \text{Readability} \), \( X_2 = \text{Format} \)

The time on task to complete the comprehension survey, for comprehension efficiency, was analyzed using a two-way ANOVA. Total gaze duration in the AOIs and total number of post target fixations during the search task were also analyzed for comprehension efficiency. A Poission Regression Model was used (Equation 3). Both of these metrics were summed across the nine search questions, and participants with zeros gaze durations for three or more of search questions were removed.

**Equation 3** \[ Y_i = \beta_0 + \beta_1X_{i1} + \beta_2X_{i2} + \epsilon_i \]
Usability Analysis

For the accuracy usability metrics, the System Usability Survey (SUS) was scored in accordance with recommended methods (Brooke, 1996). The NASA-tlx was evaluated based on ratings for mental demand, temporal demand, effort, and frustration. Both of these were analyzed using two-way ANOVAs.

For the usability efficiency variables, the time on task, or time to find each correct answer during the search task, was also analyzed using a two-way ANOVA. The number of overall fixations, the number of pre-target fixations on the AOI page, and the number of fixations in the AOI were analyzed, as a total across the nine questions, using a Poisson Regression Model. The number of fixations within the AOI were adjusted for each question based on the number of words that the AOI spanned (Poole & Ball, 2005).

Recall Measures

Accuracy

For the number of wrong answers on the recall survey, it was found that those using a low readability discharge instructions were 3.31 times more likely to fail the recall task than those using a high readability discharge instructions (95% CI [1.05, 11.78], p=0.047, SE= 0.60).

Efficiency

There were no significant differences found between the readability levels or the format levels for the recall survey time on task measure.
Comprehension Measures

Accuracy

For the number of correct answers on the comprehension survey (out of the selected five questions), participants were 5.36 times more likely to receive a failing score when using an original format discharge instructions than those using a modified format discharge instructions (95%CI [1.17, 0.93], SE= 0.85)

Efficiency

There were no significant differences found between the readability levels or the format levels for the comprehension survey time on task measure. It was found, though, that participants were less likely to have longer gaze durations in the respective AOI when using a modified format discharge instructions compared to an original format (Table 6.1), and that participants were less likely to have a high number of post-target fixations when using a modified format discharge instructions compared to an original format, as well as a high readability discharge instructions compared to the low readability discharge instructions (Table 6.2).

Table 6.1: Total gaze duration results for comprehension efficiency

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>SE</th>
<th>Z Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.61</td>
<td>0.05</td>
<td>79.19</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>High Readability</td>
<td>-0.21</td>
<td>0.07</td>
<td>-3.20</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Modified Format</td>
<td>-0.18</td>
<td>0.06</td>
<td>-2.84</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>
Table 6.2: Number of post target fixations for comprehension efficiency

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>SE</th>
<th>Z Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>5.43</td>
<td>0.02</td>
<td>294.91</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Modified Format</td>
<td>-0.10</td>
<td>0.02</td>
<td>-3.82</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>High Readability</td>
<td>-0.18</td>
<td>0.03</td>
<td>-6.96</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

Usability Measures

Accuracy

For the search task, there were no significant differences found between the readability levels or the format levels for the number of wrongly answered questions. There was also not a significant difference found for the SUS scores. An above average SUS score is a 68 (Brooke, 1996), and as can be seen in Table 6.3, the average score for each condition was well beyond this.

Table 6.3: Average SUS Scores

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean (SD) Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Readability/ Original Format</td>
<td>81.85 (13.48)</td>
</tr>
<tr>
<td>High Readability/ Original Format</td>
<td>84.08 (10.63)</td>
</tr>
<tr>
<td>Low Readability/ Modified Format</td>
<td>84.51 (10.38)</td>
</tr>
<tr>
<td>High Readability/ Modified Format</td>
<td>84.11 (17.38)</td>
</tr>
</tbody>
</table>

It was found that participants required less mental demand (F(1,66)=4.83) when using the high readability discharge instructions (M=6.18, SD= 3.46) compared to low readability discharge instructions (M=8.35, SD=4.53). This was the only variable from the NASA-tlx survey that was found to have significance. The results of the survey can be found below in Table 6.4.
- **Table 6.4: NASA-tlx Workload Perception Ratings**

<table>
<thead>
<tr>
<th></th>
<th>DI</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mental Demand</strong></td>
<td>Mean</td>
<td>8.73</td>
<td>6.68</td>
<td>8.05</td>
<td>6.22</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>4.91</td>
<td>2.80</td>
<td>4.34</td>
<td>4.70</td>
</tr>
<tr>
<td><strong>Temporal Demand</strong></td>
<td>Mean</td>
<td>7.33</td>
<td>7.19</td>
<td>8.32</td>
<td>8.17</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>4.03</td>
<td>3.43</td>
<td>5.03</td>
<td>3.63</td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td>Mean</td>
<td>5.06</td>
<td>4.94</td>
<td>4.26</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>2.40</td>
<td>2.52</td>
<td>2.92</td>
<td>3.05</td>
</tr>
<tr>
<td><strong>Effort</strong></td>
<td>Mean</td>
<td>7.20</td>
<td>7.38</td>
<td>8.47</td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>4.49</td>
<td>4.35</td>
<td>5.03</td>
<td>5.56</td>
</tr>
<tr>
<td><strong>Frustration</strong></td>
<td>Mean</td>
<td>4.33</td>
<td>4.38</td>
<td>4.26</td>
<td>4.56</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>3.68</td>
<td>3.83</td>
<td>3.93</td>
<td>0.24</td>
</tr>
</tbody>
</table>

**Efficiency**

The total time on task measure for locating the correct answers in the search task was found to be significantly shorter for participants using the *modified format discharge instructions* (M=32.92, SD=21.36) compared to those using the *original format* (M=43.47, SD=20.02) \((F(1,66)=4.26)\). There were also found to be less overall fixations for *modified format discharge instructions, high readability discharge instructions*, and the *modified format & high readability discharge instructions*. See Table 6.5 below. The *modified format discharge instructions* were also less likely to have a high amount of fixations on the page that the AOI was located before finding the AOI (pre-target fixations). See Table 6.6.

**Table 6.5: Overall fixations for usability efficiency**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>SE</th>
<th>Z Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>6.57</td>
<td>0.01</td>
<td>632.75</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Modified Format</td>
<td>-0.05</td>
<td>0.01</td>
<td>-3.27</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>High Readability</td>
<td>-0.13</td>
<td>0.01</td>
<td>-9.7</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Modified Format* High Readability</td>
<td>-0.09</td>
<td>0.02</td>
<td>-4.51</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

28
Table 6.6: Pre-target fixations on AOI page for usability efficiency

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>SE</th>
<th>Z Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>5.42</td>
<td>0.02</td>
<td>328.67</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Modified Format</td>
<td>-0.25</td>
<td>0.02</td>
<td>-13.61</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

The total number of fixations within the AOI was found to be significantly greater for the modified format & high readability discharge instructions condition (Table 6.7).

Table 6.7: Total number of fixations in AOI for usability efficiency

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>SE</th>
<th>Z Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.12</td>
<td>0.16</td>
<td>6.82</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Modified Format* High Readability</td>
<td>0.74</td>
<td>0.28</td>
<td>2.62</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

Before the usability surveys and comprehension task, the participant was given 5 minutes to read through the discharge instructions. Eye tracking was also recorded for this part and used to create visualizations of the participants’ reading techniques. Heat maps for the first page of each of the discharge instructions are shown below in Figures 6.1. These represent the values of the participants’ fixations represented as colors. The red indicates the greatest number of fixations, and areas with no color indicate minimal to zero fixations. As can be seen in Figure 6.1, the top of the modified format discharge instructions, which was sectioned with borders, received more visual attention that the same section on the original format discharge instructions.

Figure 6.2 shows the Gaze Plot for the first page of each of the discharge instructions. These show where gazes occurred and how many fixations they consisted of, as well as present the paths of the participants’ eye movement. The lower readability discharge instructions’ gazes appear to be more concentrated compared to the high
readability discharge instructions, where the gaze patterns span a greater area of the page.

The duration of the gazes, as can be understood by the size of the “bubble”, also appear to be less for the modified format and high readability discharge instructions, which is consistent with the comprehension efficiency results.

\[\text{Figure 6.1: Heat Maps of Fixation Count for Page 1}\]

\[\text{Figure 6.2: Gaze Plots for Page 1}\]
Below in Table 6.7, is a summary of the results for each of the dependent measures, for a better overall understanding and comparison across independent measures. Each item listed was found to be significant, unless otherwise noted “NS”.

Table 6.8: Summary Results Table

<table>
<thead>
<tr>
<th>Dependent Measures</th>
<th>Accuracy Variables</th>
<th>Efficiency Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recall</td>
<td>• 3.31 times more likely to not pass using a low readability DI</td>
<td>• NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Shorter gaze duration with high readability DI and modified format DI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Less fixations post target with high readability DI and modified format DI</td>
</tr>
<tr>
<td>Comprehension</td>
<td>• 5.36 times more likely to fail using an original format DI</td>
<td>• Less time to find correct answer using modified format DI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Less overall fixations with modified format DI, high readability DI, and modified format &amp; high readability DI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Less total fixations on AOI page pre-target with modified format DI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• More fixations in AOI with modified format DI and modified format &amp; high readability DI</td>
</tr>
<tr>
<td>Usability</td>
<td>• Less mental demand when using the high readability DI</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 7
DISCUSSION AND CONCLUSIONS

With the awareness of unsatisfactory statistics identifying the number of people whose health literacy is adversely affected by their inability to understand and use patient education materials, the need for innovative methods that aim to improve such odds has never been greater. This experiment has intended to do just that by introducing familiar human factors engineering techniques to a typically clinical research domain. In doing so, this thesis showed that readability and format do indeed have an influence on the accuracy and efficiency of which novices comprehend and recall the information on their discharge instructions, as well as the degree to which they are able to find the information they need.

Over the past decade, the literature on patient education materials has recognized the disparity between patients’ reading level and the readability of their documents, including discharge instructions, as a cause of low health literacy (Powers, 1988; Williams et al., 1996). While low literacy levels are concerning in an aspect, low health literacy can be a disease of its own and prevent patients from understanding their materials and in turn affecting health outcomes, as those who have self-reported the worst health, have the lowest literacy levels (NCES 2006). In effort to improve this, various health agencies have begun promoting the need for more readable documents, and combined with patient literacy research, have recommended writing discharge instruction at an 8th grade reading level, which is the most recently surveyed national average (U.S. Department of Education and National Institute of Literacy (U.S. Department of
Education, 2006). However, the research has stalled at the recognition of inappropriately written documents, and there still exists a lack of understanding for how to drastically improve health literacy. Furthermore, writing patient education materials at the average level leaves at least 50% of adults unable to read and understand their document, which parallels the astounding statistic that 46% of American adults cannot understand the labels on their prescription medication (Weiss et al., 1998). Therefore, this study examined discharge instructions written at the average literacy level, as well as discharge instructions written two “grades” below the average literacy level, and found that the high readability discharge instructions, written at a ~ 6.1 grade level, resulted in better recall of discharge instruction information, required less mental demand to use, and helped participants find information quicker. It can thus be implied that writing discharge instructions at a level below the national average, while still retaining clinical validity, can contribute to better health outcomes and reduced healthcare costs (Bennett, Chen, Sorouei, & White, 2009; Schillinger et al., 2002; Vernon, Trujillo, Rosenbaum, & DeBuono, 2007).

This study examined information transfer to a caregiver. Given that 52 million Americans serve as informal caregiver’s to a relative (Coughlin, 2010) which is likely to continue to rise because of the predicted 2030 population consisting of 71.5 million adults aged 65 and older (CDC), having readable documents for a wider span of people is even more important for the health of older adults. While it has been found that involving family members in the discharge process increases caregivers’ satisfaction and acceptance in the role (Bull et al., 2000), there is still limited informal caregiver
involvement in the discharge planning process (Bull et al., 2000; Driscoll, 2000; Gravel, Légaré, & Graham, 2006), and few studies have examined the needs of the caregiver in addition to the patient (Driscoll, 2000). That being said, addressing education materials to both the patient and the family has been reported as one feature of a high-quality discharge plan (Epstein-Lubow et al., 2013). Also, younger generation informal caregivers have been shown to be typically more educated than older generations, but 43.1% of them have been found to have only a basic mandatory education (Bragstad et al., 2014). Caregivers have also noted to experience greater amounts of stress and anxiety when being dissatisfied with the information received during discharge (Bull et al., 2000; Teasdale, 1993), but found that receiving their needed information to be emotionally beneficial, and contributes to less forgotten information (Driscoll, 2000), consistent with this study’s improved recall results when using high readability discharge instructions.

Furthermore, it is important to identify strategies to ensure caregivers receive their needed information in the form of well-designed discharge instructions because of the likelihood they are not present during the discharge process. In such case, caregivers must rely on the information that is given to the patient, either verbally or printed (Bragstad et al., 2014), yet it has been found that only between 4% and 53% of patients receive printed materials (Clare & Hofmeyer, 1997; Driscoll, 2000; Tierney, Worth, Closs, King, & Macmillan, 1993). Also, it has been found that hearing loss, which is typical for elderly patients can affect their participation in the discharge process (Foss & Hofoss, 2011), and two-thirds of older people cannot understand the information given to them regarding their prescriptions (Weiss & Association, 2007) especially due to age
related cognitive impairment, thus calling attention to the potential for problematic transfer of information through the patient to the caregiver. This study examined how readability and format changes supported the role of a caregiver not present at discharge, and the needs they would have for helping with care at home. Improved performance because of increased readability was consistent with similar studies and to be expected, but improved comprehension from using a better formatted set of discharge instructions has even more implications of how to best support patients and caregivers. While the document’s general structure and flow remained unchanged, additions such as bulleted lists instead of longer paragraphs, section borders, and hierarchical heading structures were found to help the user find a needed piece of information quickly as seen through the search task, and able to perceive and comprehend the information better, potentially from creating a better mental model of the instructions. In example, the discharge instructions had a section dedicated to symptoms that would require contacting the doctor. In the format modification, this became a bordered section of its own, and with the reading level adjustment, the header was changed from “Call your Provider for any of these issues” to “Important- Call Doctor if: “. To evaluate this modification, a question regarding one of the symptoms was used in the comprehension task, and those having used the modified discharge instructions were less likely to miss the question. Additionally, the search (and recall) tasks involved questions regarding the patient’s medications, suggested and allowed activities at home, and identifying the correct answers to these questions were highly important because in Driscoll’s (2000) study found that patients who received such information regarding activities and complications
have a lower probability of medical problems post discharge, and also relayed the need for printed documents for caregivers (Driscoll, 2000).

Comprehension was also found to be better when using the modified format discharge instructions as well as the high readability discharge instructions based on the lower likelihood of a longer gaze duration and post target fixations. A longer gaze or fixation duration can indicate that the user had trouble extracting the information (Mello-Thoms, Nodine, & Kundel, 2002) and a higher number of post target fixations can indicate lack of meaningfulness or visibility (J.H. Goldberg & Kotval, 1999). Improved patient and caregiver comprehension can have many positive implications. First, it has been found that when informal caregivers are unprepared, they can contribute to increased risk of errors and inappropriate implementation of care (Eric A Coleman, Parry, Chalmers, & Min, 2006). This was seen in the comprehension results as those using the original format discharge instructions answered more questions incorrectly by choosing answers with wrong procedures and medications. Secondly, hospitalization is more likely with poor comprehension of discharge instructions (Chugh, Williams, Grigsby, & Coleman, 2008; Henriksen et al., 2005; M. D. Naylor et al., 2007). Third, recall and understanding of discharge instructions has found to reduce compliance (Bradshaw et al., 1975; Makaryus & Friedman, 2005). If patients and their caregivers cannot understand their discharge instructions, they are much less likely to be able to successfully comply with their health provider’s orders.

Compliance, or lack thereof, has also been found to be linked to discharge satisfaction (Clark et al., 2005b; Makaryus & Friedman, 2005; Thomas, Burstin, O'Neil,
Orav, & Brennan, 1996). Patients desire easily understandable and useable instructions (CDC, 2013; Robinson & Miller, 1996). Our results found that decreasing the reading level of the discharge instructions decreased the amount of perceived mental demand when using and understanding the discharge instructions. This is also crucial because 40-70% of family caregivers report symptoms of depression (Zarit, 2010), and caregivers less than 45 showed emotional, physical, and well-being deficits compared to non-caregivers (Witters, 2011). Participants also had significantly shorter search times when using the modified format discharge instructions. This is an important feature to consider because in the presence of an emergency, reaction time is critical. Also, it has been found that the caregivers found great benefit in “saving time (77%), caregiving made easier logistically (76%), making the care recipient feel safer (75%), increasing their feelings of being effective (74%), and reducing stress (74%)” (UnitedHealthcare, 2011).

This study can support governmental organizations initiatives, such as the National Patient Safety Foundation, Joint Commission, and National Patient Safety Partnership, to apply engineering techniques to healthcare to improve patient safety (Reid, Compton, Grossman, & Fanjiang, 2005). By incorporating eye tracking and methods, the higher readability and modified format discharge instructions (DI D) were found to be more usable because of supporting more effective search (fewer overall fixations) strategies and saliency of important sections (higher fixations in AOs). These implications can provide an opportunity to hospitals as well as electronic health records (EHR) designers to create better discharge instructions that support usability, comprehension, and recall even further.
Limitations

One thing to consider is that this study did not take place in a clinical setting. This as well as the use of mainly university students as participants could possibly differ in an actual hospital setting. Future work should evaluate actual care givers, both informal and formal.

The diagnosis of the patient given on these discharge instructions was a rash. It is possible that a patient with a chronic disease would have more experience with their condition and the way that they would use their discharge instructions could differ from the way that someone with a less serious diagnosis would. Future research can focus on more complex diagnosis and patients that would require higher levels of care.

Also, while it has been found that there is no significant difference in literacy levels when using either paper-based and electronic methods because the same cognitive functions are needed (OECD, 2013), this study was conducted using an electronic version of discharge instructions. Future research should investigate the differences between paper and electronic versions of discharge instructions.

Implications and Impacts

This research has the potential to contribute to the improvement of the hospital discharge process and advance the health literacy of the general patient population. This research is unique from other studies in that it considers the needs of the caregiver, and considers supporting the various uses of discharge instructions. This is valuable because it aligns informative results with common everyday situations to potentially improve conditions for a less explored, but equally important population. Using an eye-tracker
also adds another perspective to this line of research in the literature. By maximizing patient and caregiver comprehension of discharge instructions through readability and layout and reducing their subjective workload and stress levels, discharge instructions users can improve their health management. This can in turn increase their satisfaction and compliance, which can then potentially reduce the need for hospital re-admittance due to incorrect care. The results of this study can be applied to the Transition of Care Consensus Policy Statement for standardizing discharge forms (Snow et al., 2009), and support clinicians’ efforts to effectively educate their patients by informing them of the importance of considering factors such as reading level and layout in their discharge instructions design process.
REFERENCES


APPENDICES
Appendix B

Discharge Instructions

**Appendix B**

**Discharge Instructions**

**Recovery**

**Excessive, as you can be healthy.**

American Heart Association (www.heart.org) can help you eat healthy.

Some conditions may be more serious. If you work with heavy things, or if you're not eating enough, talk to your doctor about this.

**Side effects:**

1. **Nausea, vomiting, diarrhea:** Take as needed. Call your doctor if symptoms persist.
2. **Gastrointestinal intolerance:** Take as needed. Call your doctor if symptoms persist.
3. **Renal impairment:** Take as needed. Call your doctor if symptoms persist.

**Other instructions:**

- **Daily meal:** Take as needed. Call your doctor if symptoms persist.
- **Renal impairment:** Take as needed. Call your doctor if symptoms persist.
- **Gastrointestinal intolerance:** Take as needed. Call your doctor if symptoms persist.
- **Nausea, vomiting, diarrhea:** Take as needed. Call your doctor if symptoms persist.

**Important:**

- **Call your doctor if:**
  - You develop a severe rash or hives.
  - You experience severe abdominal pain.
  - You experience severe chest pain.
  - You experience severe headache.

**Warning:**

- **Seek medical attention if you experience:**
  - Severe chest pain.
  - Severe abdominal pain.
  - Severe headache.

**You may call your doctor:**

- **Emergency room:**
  - **Call your doctor if you experience:**
    - Severe chest pain.
    - Severe abdominal pain.
    - Severe headache.

**Note:**

- **Call your doctor if:**
  - You develop a severe rash or hives.
  - You experience severe abdominal pain.
  - You experience severe chest pain.
  - You experience severe headache.

**Important:**

- **Call your doctor if:**
  - You develop a severe rash or hives.
  - You experience severe abdominal pain.
  - You experience severe chest pain.
  - You experience severe headache.
Appendix D

Discharge Instructions D
## Appendix E
### Search Task Document

**Participant Task 1**

**Directions Script**: I am going to ask you a series of questions. Each one will give a brief description, and then ask you to find the item on the Discharge Instructions. When you believe that you have found the correct answer, please say the answer out loud. If the answer is incorrect, you will be asked to continue searching until the correct answer is found. Remember, it is important that you try your hardest to answer the question correctly, and search for the answer in a reasonable amount of time.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Page</th>
<th>Time (sec)</th>
<th>Incorrect on 1st Try</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Who should you call to figure out if your grandmother is okay to drive or not?</td>
<td>a healthcare provider OR doctor.</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. What is the website for the American Lung Association?</td>
<td><a href="http://www.lungsusa.org">www.lungsusa.org</a></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. What date should your grandmother remove her sutures?</td>
<td>January 15, 2015</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Your grandmother has been taking a blood pressure medication for the past 5 years.</td>
<td>call doctor immediately.</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. What is the number 1 cause of heart disease, stroke, lung disease and</td>
<td>Smoking</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. What is the first step to quitting smoking?</td>
<td>Making the decision to quit smoking.</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. What dosage of levothyroxine should your grandmother take?</td>
<td>88mg-1 tablet per day</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. What is a suggested activity that your grandmother can do to remain healthy?</td>
<td>Exercise</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. What date was your grandmother discharged from the hospital?</td>
<td>January 1, 2015</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix F
Recall Task Survey

<table>
<thead>
<tr>
<th>Participant Task 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instructions:</strong> These are the same questions that I just asked you. This time, you will not be able to look at the discharge instructions, but please answer each of them to the best of your ability. If you don't know the answer, or are concerned if it is right, mark the &quot;I don't know&quot; answer. Let me know when you are done.</td>
</tr>
</tbody>
</table>

What date should your grandmother remove her sutures?
- Answer: ___________________________  ○ I don't know

What is the first step to quitting smoking?
- Answer: ___________________________  ○ I don't know

What date was your grandmother discharged from the hospital?
- Answer: ___________________________  ○ I don't know

What is the number 1 cause of heart disease, stroke, lung disease and
- Answer: ___________________________  ○ I don't know

What dosage of levothyroxine should your grandmother take?
- Answer: ___________________________  ○ I don't know

Who should you call to figure out if your grandmother is okay to drive or not?
- Answer: ___________________________  ○ I don't know

What is a suggested activity that your grandmother can do to remain healthy?
- Answer: ___________________________  ○ I don't know

Your grandmother has been taking a blood pressure medication for the past 5 years. What should she do about taking it now?
- Answer: ___________________________  ○ I don't know

What is the website for the American Lung Association?
- Answer: ___________________________  ○ I don't know
Appendix G
Comprehension Task Survey

Participant Task 5

Remember: Please answer all of these questions to the best of your ability, not leaving any blank. It is important to select answers that you are sure of, otherwise, select "I don't know". Please let me know when you are finished.

1 What medication should your grandmother use for itching?
   □ Aspirin    □ Bendadryl    □ Vaseline    □ Not on form    □ I don't know

2 If your grandmother begins running a fever, at what temperature should you call her doctor?
   □ 99.8°F    □ 104°F    □ 101°F    □ Not on form    □ I don't know

3 Where does your grandmother need to go to have her sutures removed?
   □ Dermatologist □ Do it herself □ Return to hospital □ Not on form □ I don't know

4 When should your grandmother take the medicine Macrobid?
   □ Before breakfast    □ 4 times a day    □ Before bed    □ Not on form    □ I don't know

5 What was your grandmother's diagnosis?
   □ Rash                   □ Chicken Pox □ Chronic □ Not on form □ I don't know
   □ Heart Failure

6 When is your grandmother's next doctor's appointment?
   □ One week from today □ Next month □ Has not been scheduled □ Not on form □ I don't know

7 How often should your grandmother ice her wounds?
   □ Before physical activity □ Morning and night □ As needed □ Not on form □ I don't know

8 Which medication is not listed as one your grandmother should take?
   □ Macrobrid □ Astorvastatin □ Medrol □ Not on form □ I don't know

9 After this scare, your grandmother has decided to quit smoking. The Diabetic of America Association was listed as a good resource for help.
   □ TRUE □ FALSE □ I don't know

10 Please list below as many of the main sections on the discharge instructions as you can remember. If you don't remember any, write "None".

   58
Appendix H
System Usability Scale (SUS) SURVEY

1. I think that I would like to use these discharge instructions frequently

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

2. I found these discharge instructions unnecessarily complex

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

3. I thought the discharge instructions were easy to use

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

4. I think that I would need the support of a medical person to be able to use these discharge instructions

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

5. I thought there was too much inconsistency in the discharge instructions

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

6. I would imagine that most people would learn to use these discharge instructions very quickly

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

7. I found these discharge instruction very cumbersome to use

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
8. I felt very confident using these discharge instructions
   | Strongly Disagree | Strongly Agree |
   | 1               | 2              | 3              | 4           | 5 |

9. I needed to learn a lot of things before I could get going with these discharge instructions
   | Strongly Disagree | Strongly Agree |
   | 1               | 2              | 3              | 4           | 5 |
## Appendix I

**NASA-TLX Survey**

Hart and Staveland’s NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Low Estimate</th>
<th>High Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Demand</td>
<td>How mentally demanding was the task?</td>
<td>Very Low</td>
<td>Very High</td>
</tr>
<tr>
<td>Physical Demand</td>
<td>How physically demanding was the task?</td>
<td>Very Low</td>
<td>Very High</td>
</tr>
<tr>
<td>Temporal Demand</td>
<td>How hurried or rushed was the pace of the task?</td>
<td>Very Low</td>
<td>Very High</td>
</tr>
<tr>
<td>Performance</td>
<td>How successful were you in accomplishing what you were asked to do?</td>
<td>Very Low</td>
<td>Very High</td>
</tr>
<tr>
<td>Effort</td>
<td>How hard did you have to work to accomplish your level of performance?</td>
<td>Very Low</td>
<td>Very High</td>
</tr>
<tr>
<td>Frustration</td>
<td>How insecure, discouraged, irritated, stressed, and annoyed were you?</td>
<td>Very Low</td>
<td>Very High</td>
</tr>
</tbody>
</table>
Appendix J
Demographic Survey

1. Age __________

2. Gender □ Female □ Male

3. Major ____________________________________________

4. What is your experience with hospitals?
   □ Never
   □ Rarely
   □ Occasionally
   □ A moderate amount
   □ A great deal

5. Have you ever taken care of an ill person before? □ Yes □ No
   If yes, for approximately how long? ________________________

6. How do you prefer to read for school?
   □ Paper □ IPad □ Kindle □ Other ________________________

7. Before today, have you ever used an eye tracker before? □ Yes □ No

8. Before today, did you know what discharge instructions are? □ Yes □ No

9. Before today, have you ever seen discharge instructions before? □ Yes □ No

10. Do you ever play memory enhancing games (i.e. Luminosity)?
    □ Never
    □ Rarely
    □ Occasionally
    □ A moderate amount
    □ A great deal