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DESIGN WITH EMOTION: IMPROVING WEB SEARCH EXPERIENCE FOR OLDER ADULTS

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Human-Centered Computing

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by
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December 2014

Accepted by:
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ABSTRACT

Research indicates that older adults search for information all together about 15% less than younger adults prior to making decisions. Prior research findings associated such behavior mainly with age-related cognitive difficulties. However, recent studies indicate that emotion is linked to influence search decision quality. This research approaches questions about why older adults search less and how this search behavior could be improved. The research is motivated by the broader issues of older users' search behavior, while focusing on the emotional usability of search engine user interfaces. Therefore, this research attempts to accomplish the following three objectives: a) to explore the usage of low level design elements as emotion manipulation tools b) to seamlessly integrate these design elements into currently existing search engine interfaces, and finally c) to evaluate the impact of emotional design elements on search performance and user satisfaction. To achieve these objectives, two usability studies were conducted. The aim of the first study was to explore emotion induction capabilities of colors, shapes, and combination of both. The study was required to determine if the proposed design elements have strong mood induction capabilities. The results demonstrated that low level design elements such as color and shape have high visceral effects that could be used as potentially viable alternatives to induce the emotional states of users without the users having knowledge of their presence. The purpose of the second study was to evaluate alternative search engine user interfaces, derived from this research, for search thoroughness and user preference. In general, search based performance variables showed that participants searched more thoroughly using interface types that integrate angular shape features. In addition, user preference variables also indicated that participants seemed to enjoy search tasks using search engine interfaces that used color/shape combinations. Overall, the results indicated that seamless integration of low level emotional design elements into currently existing search engine interfaces could potentially improve web search experience.

DEDICATION

To my lovely wife, Tsigereda Kebede, to my children, Ruhama and Ephratah Abegaz, to my brother, Belay Abegaz, and to all my sisters and other family members. Thank you for everything you have done for me.

ACKNOWLEDGMENTS

I would like to thank my Super advisor, God, who sets and controls the time and resources I need to complete this research work. Thank you, for You are the one Who made this happen. I would also thank my wife, Tsigereda Kebede, for her love, encouragement, and patience.

I was fortunate to have one of the best advisors in US, Dr. Juan E. Gilbert. He thought me how to build self-confidence, care and treat people equally. He is the one who faced all the ups and downs to bring us the funding so that we focus on our research rather than worrying about money. May God bless him abundantly.

Many people contribute to my success in my journey to PhD. I would like to give thanks to Dr. Damon L. Woodard, who gave me the chance to join Clemson and encouraged me to pursue HCC. I would also like to than Dr. Daily and Dr. Remy who helped me in providing advice and support to successfully complete my research. I would also like to acknowledge the support and encouragement given by Dr. Richard Pak in shaping my research idea.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
AOI	Area Of Interest
APIs	Application Programming Interfaces
BP	British Petroleum
CSS	Cascaded Style Sheet
DOM	Document Object Model
DVs	Dependent Variables
HCI	Human Computer Interaction
HTML	Hyper Text Markup Language
IDE	Integrated Development Environment
IVs	Independent Variables
JSON	JavaScript Object Notation
ODE	Open Data Protocol
OLLI	Osher Lifelong Learning Institute
REST	Representational State Transfer
SAM	Self-Assessment Mankin
SEO	Search Engine Optimization
UI	User Interface
UK	United Kingdom
UNPFA	United Nations Population Fund Agency

List of Abbreviations (Continued)

URL	Uniform Resource Locator
US	United States
USB	Universal Serial Bus
UX	User Experience
VSM	Vector Space Model
XML	eXtensible Markup Language

CHAPTER ONE

INTRODUCTION

For information access using technology, a typical human being needs perceptual, motoric, and cognitive capabilities. However, as people get older, these capabilities tend to deteriorate. Many research findings indicate that older adults perform superficial information search prior to making decisions. For instance, Cole and Balasubramanian [1] indicated that older adults tend to consider a small amount of nutritional information when purchasing cereals. Lambert et al. [2] also indicated that older adults looked for fewer dealers, models, and brands when buying vehicles compared to other age groups. In the task of online shopping, Helversen et al. [3] showed that older as compared to younger adults performed poorly mainly because they sought fewer options by setting a lower threshold value for reaching a decision. In addition, in the recent meta-analysis study on search performance, it was indicated that, on average, older adults searched for information about 15% less than younger adults before making decisions [4]. A number of researchers associated this superficial search behavior mainly with age-related cognitive difficulties. However, recent studies claimed that emotion is linked to influence search based decision quality [5, 6].

The affective research community has reported that when people get older, they tend to possess higher positive affect. A number of studies showed that positive emotion plays an important role in cognitively biased and shallow thinking [3, 5, 6]. For instance, Cartensen et. al. [5] explained that older adults possess a higher positive affect because as people get older and the horizons for life spans are getting smaller, people prefer to invest their time and effort in situations that make them happy. Overall, several research findings indicated that people in positive moods make faster decisions with a superficial focus on important attributes. Since both affect and cognitive abilities change with age, researchers raised a question as to whether cognitive abilities or affect actually impacted older adults search behavior. In an attempt to find an answer to this question, Helversen et. al. [3] conducted a study with two groups of younger participants by inducing positive mood on one group of participants and letting the two groups carry out a search task. Their results indicated that those participants who were exposed to positive mood induction searched less as compared to the control group. Therefore, they concluded that it is not cognitive ability, but positive emotion that led older adults to conduct superficial searches. In related studies, research indicated that when performing online search, people generally trust rankings provided by the search engine result list. Generally, most search engine users consider the first few search results prior to making decisions as to whether terminate the search task or choose one from the list. Accessing fewer search results, however, may degrade the quality of decision-making. In addition, it could also increase the potential hazard of online fraud since some search results are not trustworthy.

This research proposes ways to improve search experience for older adults by incorporating low level emotional design elements. The major goal of this research is to explore design alternatives to manipulate users' affective states by incorporating emotional design elements such as colors, shapes, and color/shape combinations into search engine interfaces. The research is motivated by the broader issues of older adults' search behavior, while focusing on the emotional usability of search engine user interfaces. As a result, this research attempted to accomplish the following three objectives: a) to explore the usage of low level design elements as emotion manipulation tools b) to seamlessly integrate them into currently existing search engine interfaces, and finally c) to evaluate the impact of emotional design elements on search performance and user satisfaction.. Therefore, to achieve these objectives, low level design elements were explored. In addition, two usability studies were conducted.

The first study attempted to answer the following research questions: 1) what are the low level visual design elements related to emotion?, and 2) do these design elements have significant emotion induction capability to be used as a viable alternative to the traditional emotion induction tools like facial expressions, and movies? In general, various researches have pointed out that colors on the blue side (short wavelength) tend to be more pleasant to people than colors on the red side (long wavelength) of the color spectrum. Studies have also indicated that rounder shapes tend to be associated with positive emotion, whereas angular shapes tend to elicit negative emotion [7, 8]. With this information in mind, the first study was conducted to explore emotion induction capabilities of colors, shapes, and combination of both. The study was required to determine whether the proposed design elements have strong mood induction capabilities. The results of this study demonstrated that selected visual design elements have high visceral effects that could be used as potentially viable alternatives to invoke affective reactions on users without the users even knowing that they are present. For detailed description about this usability study, the reader is referred to Chapter Two.

Based on the results of the first study, a follow up experiment was needed to determine the relative impact of emotional design elements on search based decision making and user satisfaction. As a result, alternative search engine user interfaces were proposed. The purpose of the second study was to evaluate alternative search engine user interfaces that were derived from this research for search thoroughness and user preference. In sum, the second study attempted to answer the following research questions: 1) how can design elements be used to improve web search user experience for older adults? , and 2) are the alternative search engine user interfaces derived from this research more usable than the current search engine user interfaces for the older adult? In general, the results indicated that seamless integration of low level emotional design elements into currently existing search engine interfaces could potentially improve web search experience. Detailed description about the methodology, analysis results, and discussion is presented in Chapter Four.

RESEARCH MOTIVATIONS AND CONTRIBUTIONS

Recent findings have indicated that older adults represent the fastest growing demographic group [9-11]. As reported by the United Nations Population Fund Agency (UNPFA), the number of people older than 60 reached 810 million in 2012 and is expected to increase to two billion by 2050 [10]. The global population of age 60 and above grows at a faster pace (3.2%) than the entire population (1.1%). Similarly, by 2050, four in five people age 60 or over are expected to live in the developing world [10]. The 2010 US Census report also shows that between 2000 and 2010, there was a 9.7%

increase in the general population but a 15.1%t increase in the older population [11]. It is also predicted that the percentage of older people age 65 or over (living in US) will reach 20% by 2030 [11]. These statistics show that older adults will account for a significant portion of the future population.

Based on the above facts, one can conclude that people are getting older and living longer. At the same time, this particular group of individuals accesses the Internet more often for performing various activities such as accessing information about a specific medication [9-12]. For instance, in a telephone survey conducted by Pew Internet and American Life Project [11], it was indicated that 83% of these particular Internet users gather health related information primarily from online resources. Research in the UK also indicated that among the older adults population, 45% were reported to have 30 hours per week of online presence [10]. A recent study also showed that older adults used search engines 51% more than their younger counterparts to complete online tasks [13]. Based on the surveyed data, search is becoming a popular activity that older adults perform in their day-to-day online presence [11]. However, recent studies indicated that compared to younger adults, older adults search roughly 15% less information prior to making a decision [14].

This research approaches the question as to why older adults perform superficial searches (i.e. do not search thoroughly) in a broad range of search tasks, and how this search behavior could be improved. The research attempts to find ways to seamlessly integrate emotional design elements into search engine user interface to improve web search experience. Therefore, the contributions of this research are as follows:

- We demonstrated that low level design elements such as color and shape have high visceral effects that could be used as potentially viable alternatives to induce the emotional states of users without the users even knowing of their existences.
- We designed and implemented alternative search engine interfaces that covertly embed low level emotional design elements. Even though, the search interfaces are very similar to currently existing search and clustering engines, the idea and ways of integrating these emotional design elements into search engine interface is novel.
- We evaluated the alternative search engine interfaces derived from this research for search thoroughness and user satisfaction and provided recommendations for improving web user experience.

Based on the research findings which pointed out that positive affect indeed influences older adults' search behavior, we examined several emotion induction tools that could be used to counterbalance the impact of positive affect by indirectly encouraging users to engage in a more thorough search behavior. The objective was that alternative emotional induction tools derived from this research should seamlessly be integrated into user interface to engage older adults in a thorough search activity for better decision making. Thus, we explored various emotional induction tools as viable alternatives to the traditional emotion induction tools that seamlessly integrated into user interface and invoke affective reactions, which in turn impact the quality of decision making. Even though prior research findings indicated that low-level design elements such as color and shape have emotional induction capability, the results were contradictory. We explored colors and shapes, and color/shape combinations as emotional design elements and confirmed that they have strong emotion induction potentials and could be covertly be used to induce the required emotion.

Our findings support the hypothesis that blue and rounder shapes have strong positive mood induction capabilities. Conversely, the study indicated that red and angular shape have also strong negative mood induction potentials. Overall, the low level design elements explored in this research possess high visceral effects that could be used as potentially viable alternatives to traditional elements in an attempt to alter the emotional states subconsciously (i.e. without the users awareness).

These contributions benefit researchers and practitioners by helping them to better understand the implications of using these primitive visual design elements in system and product design. In other words, these design elements could potentially influence the user experience (UX) of the potential users. For instance, user experience designers and researchers could use these emotional design elements to manipulate user's affective states, from neutral to positive, positive to negative, negative to neutral, or vice versa. Overall, this research showed that the emotional design elements could potentially affect users' search performance. The findings of this research will be of interest to researchers and practitioners across a wide range of applications and areas such as user experience, affective computing, information visualization, and in the gaming industry. Broadly speaking, the results of this study can assist companies in adjusting their artifact designs to meet their goals. For instance, if the goal of the product design is to encourage users to focus their attention, then angular shaped design elements could be used to induce negative emotion, which in turn compels the users to exert more effort and time to attain their goal.

The remainder of this dissertation thesis is organized as follows. Chapter Two presents the effectiveness of emotional design elements such color, shape, and color/shape combinations in mood induction capability. This chapter discusses the methodology, the analysis results, discussion, and conclusion of study one. In Chapter Three, the design and implementation details of alternative search engine user interfaces will be presented. Chapter Four explains the method and results of study two. Finally, the Conclusion and Future Works will be presented in Chapter Five.

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CHAPTER TWO

EXPLORING MOOD INDUCTION EFFECTINVESS USING COLORS AND SHAPES

ABSTRACT

This study explores mood induction effectiveness using low level visual design elements such as color, shape, and a combination of both. Previous researches have provided contradictory reports on mood induction effectiveness of these low-level design elements. These design elements were presented to the users in the form of textual properties and abstract polygonal shapes. Three one-way repeated measures ANOVA were conducted for effectiveness of color, shape, and color/shape combinations. The analysis results indicated that these low-level visual design elements have strong emotion induction potentials to invoke affective reactions without the users even noticing the presence of the emotional stimuli. Overall, this study demonstrates that low level design elements such as colors, shapes, and color/shape combinations have high visceral effects that could be used as potentially viable alternatives for traditional emotion induction tools.

INTRODUCTION

Affect matters. Interaction design involves multiple facets such as graphic design, information architecture, and most importantly the interaction of the product with human beings which could potentially invoke affect. According to Affective Event theory, affect is described as "*an unconscious reaction to stimuli before any cognitive appraisal of* *events occurs*" [1]. A number of studies indicate that the affective state, whether it is positive or negative, plays an important role in influencing how we behave and act [1-5]. Recent studies indicate that people's judgments are usually influenced by their immediate emotional states at the time of decision-making. For instance, Bower [3] indicated that emotions influence judgment through biased retrieval of related information from the memory. Core & Jeffrey [5] described that emotion influences the content and style of thought. In a similar study, Forgas [6] showed that participants in positive moods make faster decisions with a superficial focus on important attributes.

Several research findings also showed that negative emotions trigger more systematic processing [7-11]. Loewenstin & Lerner [7] provided one possible explanation for the impact of positive and negative emotion on decision making via influencing pre-decisional information search. They emphasized that positive emotion twists the body by pretending all is well whereas negative emotion alerts the body that a particular situation demands attention. Moreover, negative emotion is associated with vigilance while positive emotion is associated with trust [9]. In general, there are a number of environmental stimuli that could potentially induce emotion. Roughly speaking, they can be mapped to: vision, olfactory, gustatory, auditory, and vestibular stimuli.

Common visual emotional stimuli include facial expressions, colors, movie scenes, and shapes of objects. Similarly, olfactory (smell) emotional stimuli can generally be categorized as either pleasant (i.e., smell that gives sense of pleasure) or pungent (i.e., smell that gives a sense of dislike). Likewise, gustatory (taste) emotional stimuli can be classified as sweet, sour, or bitter tastes. In addition, the auditory emotional stimuli include harmonious or discordant sounds and the vestibular emotional stimuli include temperature and smooth or rough surfaces [11, 12]. For instance, the following environmental stimuli could potentially induce positive emotion: smiling facial expressions, symmetrical objects, sweet tastes, pleasant odors, smooth surfaces, harmonious music and sounds, warm temperatures, colors on shorter wavelength sides of the spectrum such as blue, and green, movies that trigger laughter and relaxation, and rounded shaped objects [12-17]. On the other hand, stimuli that produce negative affective states include extreme weather, very bright light or darkness, angry facial expressions, pungent smells, bitter tastes, angular shaped objects, discordant sounds, harmful animals like snakes, movies that invoke fear and depression, and colors on the longer wavelength side of the spectrum such as red and orange. Common affective stimuli widely used by researchers for mood induction could be classified as visual (facial expression, color), auditory (vocal expression) or both (movie) [12-17].

From a user experience (UX) point of view, it is possible to incorporate emotional stimuli into a design in order to invoke affective reactions. Affective reaction in turn induces either positive or negative emotions that lead to a change in attitude, and then followed by behavior change. The behavior change invoked by the UX design elements can have impact on the quality of decision making. For this research, we would like to investigate the effect of color (i.e., background and foreground), shape (i.e., round, angular, and mixed), and both color and shape applied in the form of abstract stimuli. Various research studies on color have shown that including specific color in visual design can induce emotion [18-20]. Similarly, studies on shape pointed out that shape of a visual object could induce emotion [21-22]. However, their results contradict with one another on which type of affective reactions a particular visual stimulus invokes for given situations (see Table 2-1).

AFFECT INDUCTION THROUGH DESIGN

Colors

Researchers have pointed out that colors on the blue side (short wavelength) tend to be more pleasant to people than color on the red side (long wavelength) of the color spectrum [23-25]. According to a model of color and psychological functionalities developed by Ellit et. al. [18], color could roughly be explained by the following core principles. First, the meaning of color is derived from two foundations: innate and learned behavior. This principle is mainly based on the theory of Mallon [23] that explains the existence of learned associations with innate response to color stimuli. Secondly, color stimuli that carry positive meaning produce approach behavior; however, invoke avoidance behavior for negative stimuli. Third, the influences of colors tend to be associated with unconscious behavior. Fourth, color evokes varied feelings for different situations. Finally, colors generally carry contextual meanings based on their presence during a particular situation. Among the basic colors in the color spectrum, the most studied are red, blue, and green [23-29]. Table 2-1 summarizes the study findings on the performance of red color [30-37]. As presented in Table 2-1, contradictory results were reported by researchers about red color.

Study	Color Usage	Performance
Stone N.J, 1998; Stone N.J, & English A.J, 1998	Room wall	Improved performance motor task
Kawakami & Okamato, 2002	Computer Display	no color-performance relation
Hill & Barton, 2005, Attrill et al, 2008,	Clothing	Improved performance for those who wear red
Elliot & Maier, Elliot 2007, 2009;	Background color	Undermined intellectual performance
Mehta & Barton, 2009	Background color	Improved performance on detailed-oriented task
Gnambs, et al, 2010	Progress bar, buttons	Impaired test performance
Allen, 2012	Pen Ink	Improved performance on detailed-oriented task (marked more errors when correcting essays)
Bagchi & Cheema, 2013	Background color	Decreased willingness-to-pay for negotiation (against the seller) but Increased willingness-to-pay for auctions (against other bidders)

Table 2-1. Related findings on the performance of the color red

Shapes

A visual object possesses attributes such as color, texture, and shape. The shape of an object can contain either angular, rounded, or mixed edges. Studies indicate that the shapes of visual objects are strongly associated with emotion [38]. Specifically, most studies reported that rounder shape tends to be associated with positive affect, whereas angular shape tends to elicit increased negative affect [38-40]. For instance, Zebrowitz [41] reported that rounder facial shapes are perceived more positively than angular faces. Furthermore, angular stimuli tend to trigger threats and are associated with negative affective states [41]. Some researchers associate a sharp angular edge with sharp objects, like knives, which could inherently cause danger. However, objects with rounder shapes such as the faces of babies are associated with invoking positive mood [40]. Nonetheless, recent studies showed that regardless of the semantic meaning of the object, the shape of visual stimuli is associated with emotion. For instance, recent studies indicated that emotionally neutral objects with curved features invoke positive affect, whereas shapes with sharper edge contours tend to trigger negative affect [40-43]. In their study, Bar & Meta [40] used objects such as watches, guitars, and letters of the English alphabet. In general, their findings revealed that visual objects that possess curved shape enhance the level of positive affect.

Some researchers reported that angular designs were the preferred shape for picture frames and buildings [43, 44]. In the case of abstract stimuli, however, sharp angular designs seem to be associated with negative affective states. In this research, abstract design stimuli will be used to study the emotion induction capabilities of objects with varied curvatures. This research uses abstract design stimuli for shape. Specifically, we compare rounder and angular shaped emotional cues for positive and negative affect induction, respectively. By employing a more controlled study, we hope that the results obtained from this research contribute in resolving the conflicting research reports on color, shape and performance.

RESEARCH METHOD

The overall objective of this research is to explore design alternatives to manipulate users affective states by incorporating emotional design elements such as color (foreground and background), shape (angular vs. rounder edges), or both shape and color in the form of abstract visual stimuli. Three emotional design conditions were explored: foreground color as textual property (see Figure 2-1), shape as polygonal property (see Figure 2-2), and color/shape combination as background color and polygonal property. Figure 2-1 depicts the form of textual property in which the low level emotional elements are used for color emotional design elements. Figure 2-1 presents three color conditions: blue, black, and red foreground colors to induce high, neutral, and low levels of positive affect.

Similarly, for shape emotional design elements, round, mixed, and angular shapes were used to induce high, neutral, and low levels of positive affect, respectively. Presented in Figure 2-2 are the three conditions of shape emotional design element. Similar to color option, the three conditions of shape design elements: round, mixed, and angular shapes were used to induce high, neutral, and low levels of positive affect, respectively. Finally, a combination of shape and color design elements was used to manipulate the emotional states of the user. Figure 2-3 shows shape/color interface combinations. As presented in Figure 2-3, round/blue, mixed/gray, and angular/red design elements are expected to induce high, neutral, and low levels of positive affect, respectively.

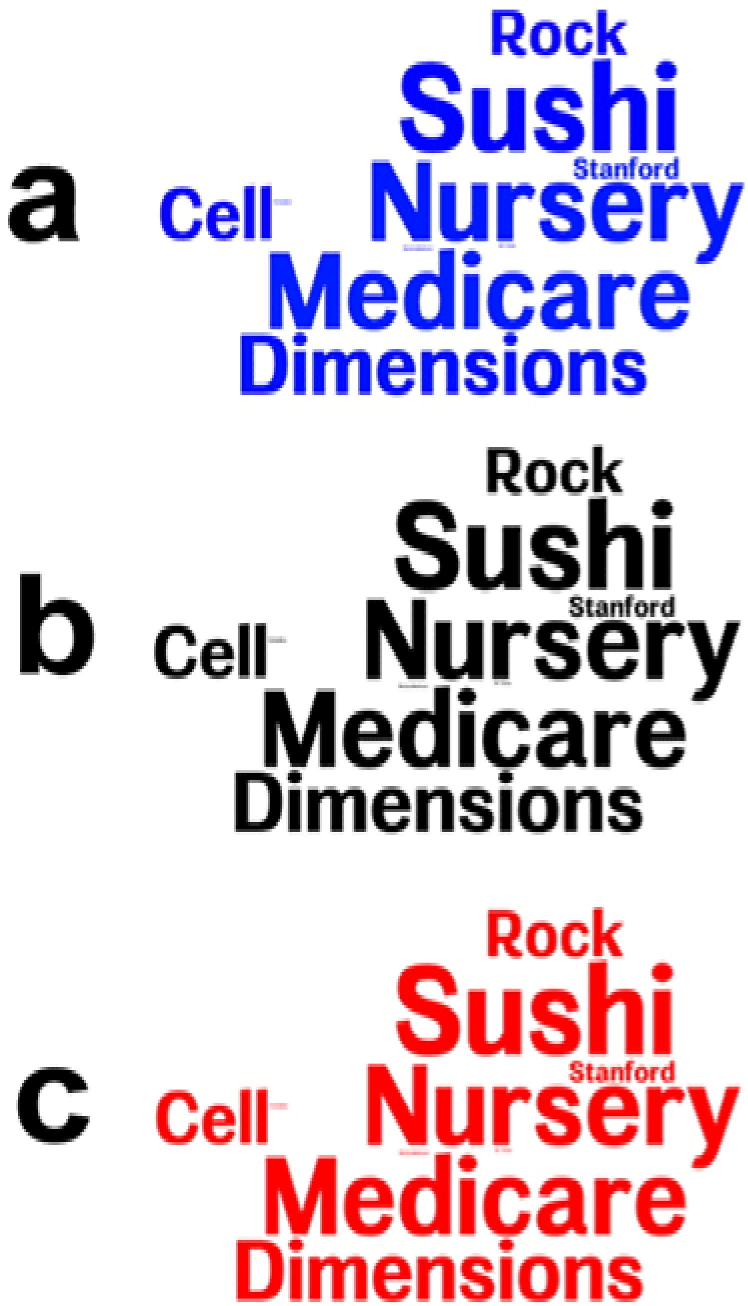

Figure 2-1. Color emotional design elements in the form of textual properties

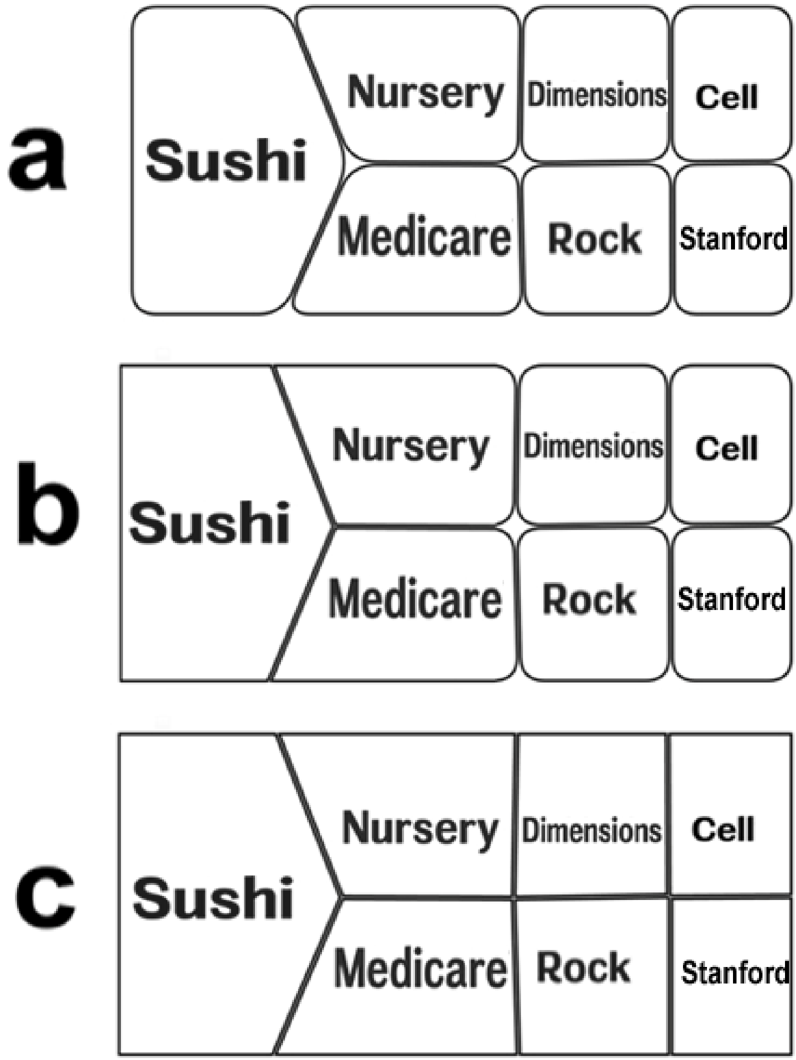

Figure 2-2. Shape emotional design elements in the form of polygonal properties: a) round, b) mixed, and c) angular shapes

Overall, as described, three emotional design elements: color, shape, and combination of shape & color are used to test if incorporating these three emotional design elements impact the emotional states of the users. It is expected that blue, round, and round-blue induce positive emotional state to the participants. Also, black, mixed-shape, and mixed shape with gray background have neutral emotional effect toward the users. Red foreground color, angular, and angular-red are expected to induce negative emotional state.

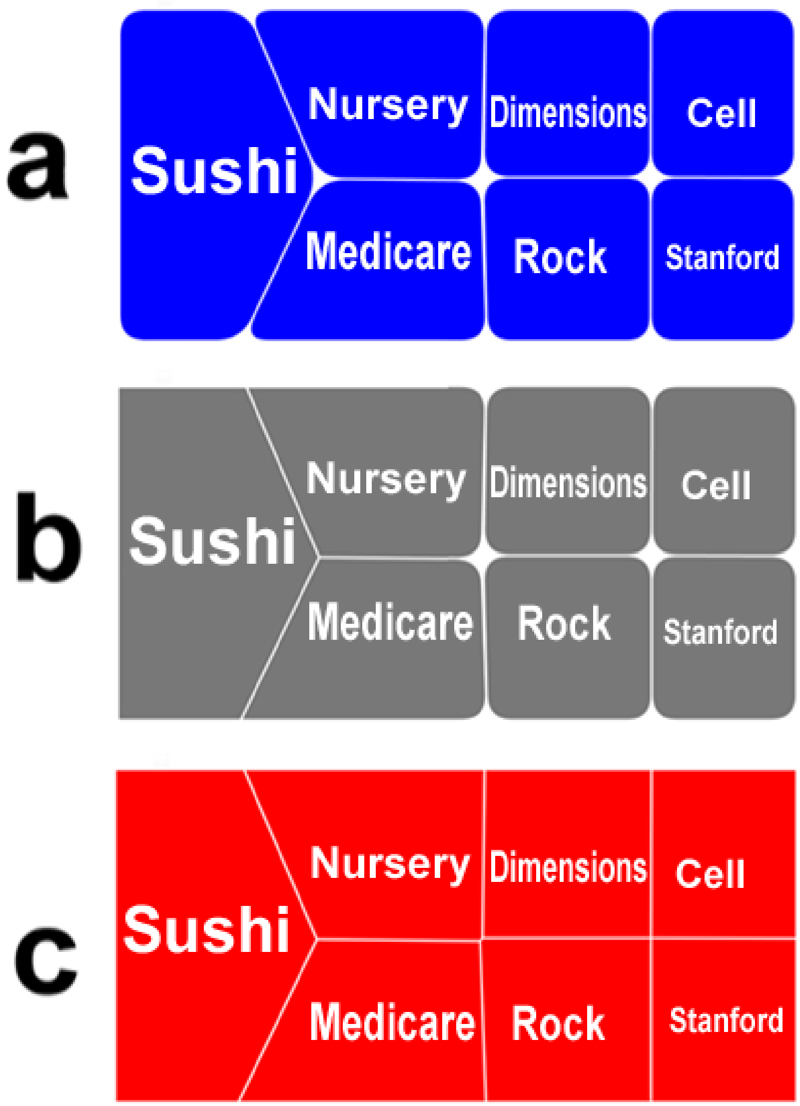

Figure 2-3. Color/shape combinations emotional design elements: a) round/blue, b) mixed/gray, and c) angular/red properties

Participants and Procedure

In total, thirteen participants were recruited for this study. As presented in Table 2-2, seven of participants were females and all of them were graduate students with ages ranging between 20 and 35. Self-Assessment-Manikin (SAM) was used to rate the emotional scale of the users (see Figure 2-4) [45]. Each participant was asked to rate their emotional state prior to being exposed to the emotional design elements. A one-second long stimulus was used to present the emotional design elements. This is followed by two-second inter-stimulus intervals with blank window to neutralize the impact of the prior emotional experience [46-48].

	Percentage	Number of Participants
Education		
Didn't Finish High School	0.0%	0
High School	0%	0
Some College	0%	0
College Degree	61.54%	8
Graduate Degree	38.46%	5
Race		
African American	53.85%	7
Caucasian	23.07%	3
Hispanic	7.69%	1
Asian	15.38%	2
American Indian	0.0%	0
Others	0.0%	0
Age		
21 and under	7.69%	1
22-35	92.31%	12
36-55	0%	0
55-65	0%	0
65 and over	0%	0
Gender		
Female	53.85%	7
Male	46.15%	6

Table 2-2. Demographic data for study one participants

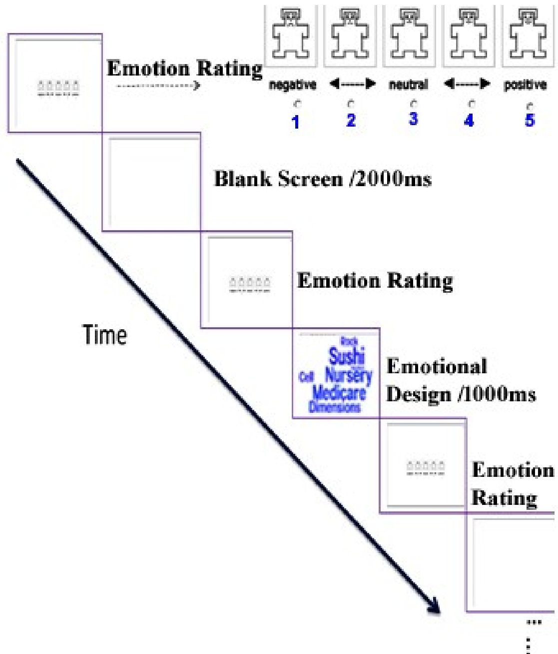

Figure 2-4. The process of mood induction rating

Study Design

This study employs a within subject study design. To measure emotional ratings more precisely, mean scores were used instead of the median. In addition, normality was assumed even though some of the trials did not pass the normality test [50, 51]. The conditions were ordered using an incomplete/partial counterbalancing using Latin square model to reduce the learning effect, biases and tiredness due to usage order. Each design element was tested nine times (i.e., three trials under each of the conditions). The dependent variable (DV) was mood induction rating (i.e., 1= strongly negative, 2= negative, 3=neutral, 4=positive, and 5=strongly positive). The mean of the three trials was used to obtain a single value that represented the mood ratings of the participants. Therefore, three one-way repeated measures ANOVA were used to analyze the statistical significance of color, shape, and color/shape combinations emotional design elements, respectively

RESULTS

Emotional Design Option one: textual properties

It can be seen from Figure 2-5 that the overall mean mood ratings for design alternative that uses color emotional design elements in the form of word cloud (WC): WC-Blue, WC-Black, and WC-Red are 3.54, 3.13, and 2.49, respectively. This concurs with our prediction that blue, black, and red foreground colors induce positive, neutral, and negative emotional states, respectively. Further analysis was needed to determine the statistical significance of the means. As indicated, a one-way repeated measures ANOVA was performed to compare the effect of textual properties as word cloud emotional type on mood induction ratings among the three conditions: WC-Blue, WC-Black, and WC-Red

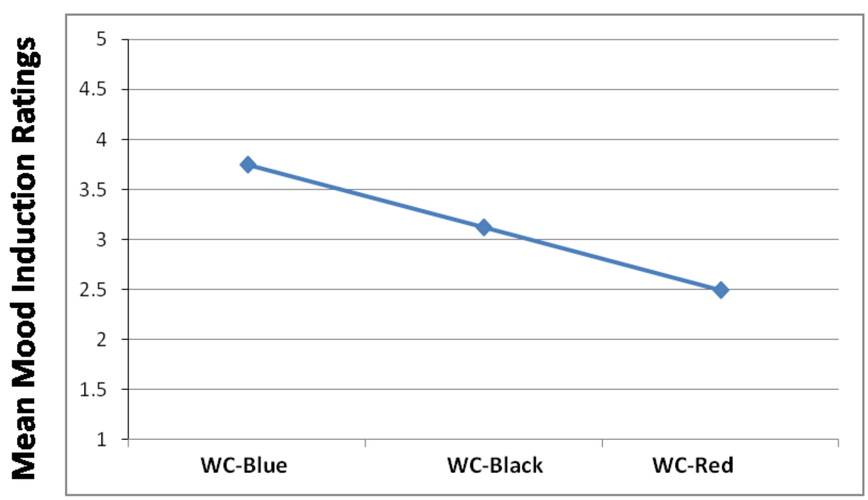

Figure 2-5. Average mood induction rating plot for color based word cloud conditions: WC-Blue, WC-Black, and WC-Red

The analysis results showed that there was statistically significant differences in mood induction ratings among the three conditions, $F(2, 24)=13.96$, $p< 0.0001$. This manipulation accounted for 0.54 of the variances in scores using eta square measure. Three paired Bonferroni tests were used to make post-hoc comparisons between the wCloud design conditions. A first paired comparison indicated that there was a significant differences in the mood induction scores for WC-Blue (M=3.54, SD=0.59) and WC-Red (M=2.49, SD=0.74) conditions; $p<0.0001$. A second paired comparison also indicated that there was statistical significant difference in mood induction ratings for WC-Black (M=3.13, SD=0.70) and WC-Red (M=2.49, SD=0.74) conditions; $p=0.047$. However, a third paired condition indicated that there was no statistical difference in the mood induction ratings between WC-Blue (M=3.54, SD=0.59) and WC-Black (M=3.13, SC=0.70) conditions; $p=0.131$. These results showed that color has a potential mood induction capability. Specifically, the results from this study indicated that the blue color induced positive emotion while the red color induced negative emotion. The black color induced neutral emotion.

Emotional Design Option two: Shape

Similar to color based emotional design alternatives, it can be seen from Figure 2-6 that the overall mean mood ratings for round, mixed, and angular shapes are 3.57, 2.95, and 2.51, respectively. This coincides with our prediction that round, mixed, and angular shapes induce positive, neutral, and negative affective reactions to the participants, respectively. Further analysis was needed to determine the statistical significance of the mean differences of shape based emotional design conditions.

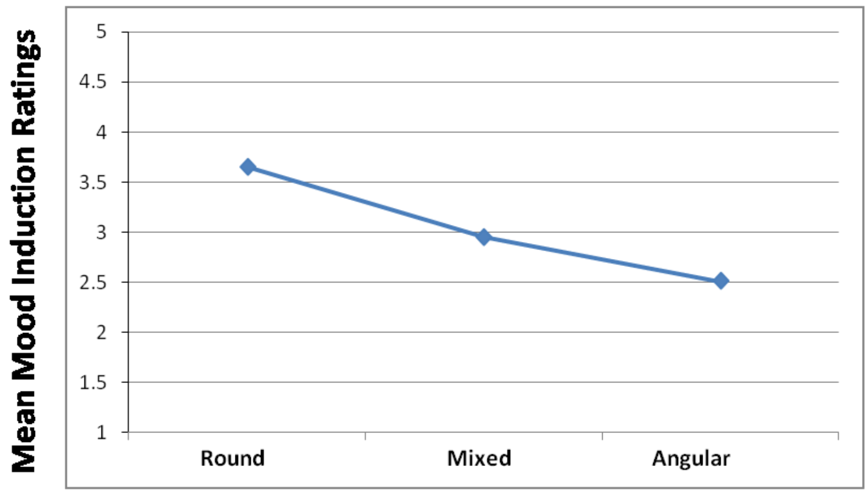

Figure 2-6. Average mood induction rating plot for shape conditions: Round-, Mixed, and Angular

Likewise, a one-way repeated measure ANOVA analysis results indicated that there was a statistically significant difference in mood induction ratings among the three conditions: Round, Mixed, and Angular shapes. , F (1.15, 13.8)=12.49, p=0.003. This manipulation accounted for 0.51 of the variances in scores using eta square measure. Three paired Bonferroni tests were performed to make post-hoc comparisons among Round, Mixed, and Angular design types. The first paired test indicated that there was statistical significant difference in the mood induction ratings for Round (M=3.57, SD=0.42) and Angular (M=2.51, SD=0.79) conditions; p=0.01.

The second paired test also indicated that there was statistical significance difference in the mood induction scores for Round (M=3.57, SD=0.42) and Mixed (M=2.95, SD=0.33) conditions; p=0.003. A third pared comparisons, however, revealed that there was no statistical significance difference in the mood induction scores between Mixed (2.95, SD=0.33) and Angular (M=2.51, SD=0.79) conditions; p=0.094. Similar to the conditions in color based emotional design, the results suggest that shape could be the potential candidate to be used for emotion induction stimuli alternatives that could be easily integrated into user interfaces. More specifically, the result suggests that round shapes induce positive emotion whereas angular shapes induce negative emotion. Similarly, the results also indicated that mixed shape contains neutral emotional stimuli.

Emotional Design Option three: Color/Shape Combination

Similarly, as presented in Figure 2-7, the overall mean mood ratings for RoundBlue, MixedGray, and AngularRed are 3.82, 3.03, and 2.49, respectively. This concurs with our prediction that RoundBlue, MixedGray, and AngularRed induce positive, neutral, and negative emotional states to the participants, respectively. Further analysis was needed to determine the statistical significance of the means.

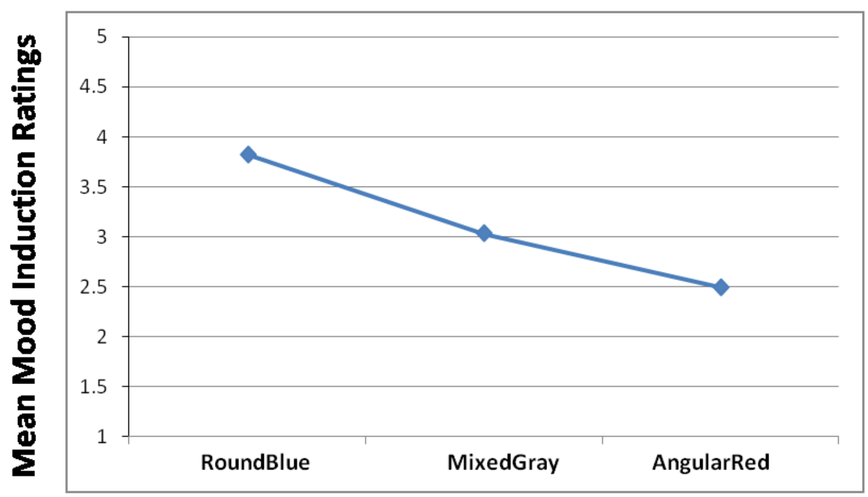

Figure 2-7. Average mood induction rating plot for color/shape conditions: RoundBlue-, MixedGray, and AngularRed

A one-way repeated measures ANOVA was performed to compare the effect of color/shape combination on mood induction ratings for the three emotional design conditions that integrate shape and color: RoundBlue, AngularRed, and MixedGray. The results indicated that there was a statistically significant difference in mood induction ratings among the three conditions, $F(2, 24)=14.96$, $p<0.0001$. This manipulation accounted for 0.55 of the variances in scores using eta square measure. Furthermore, three paired Bonferroni tests were performed to make post-hoc comparisons among RoundBlue, MixedGray and AngulaRed design types. The first paired test indicated that there was a statistical significant difference in the mood induction ratings for RoundBlue (M=3.82, SD=0.54) and Angular-Red (M=2.49, SD=0.92) conditions; p=0.002. The second paired test also indicated that there was statistical significance difference in the mood induction scores for RoundBlue (M=3.82, SD=0.54) and MixedGray (M=3.03, SD=0.50) conditions; p=0.002. However, the third pared comparisons revealed that there was no statistical significance difference in the mood induction scores between MixedGray (3.03, SD=0.50) and AngularRed (M=2.49, SD=0.92) conditions; p=0.181. The analysis results indicated that blue color and round shape combination induces positive emotion, whereas, red color and angular shape combination induces negative emotion on the participants, respectively. Furthermore, the analysis results also indicated that gray color and mixed shape combination (i.e. MixedGray) possess neutral emotion stimulus. Overall, the results indicated that the selected emotional design elements have emotion induction capabilities.

GENERAL DISCUSSIONS

As reported in the result section, three one-way repeated measures ANOVA were conducted for color, shape, and color/shape combinations to evaluate the effectiveness of low level emotional design elements in mood induction capability. The analysis results showed that the selected emotional design elements have strong emotion induction potential and could be used as alternatives for traditional methods such as facial expression, voice or multimedia to induce affective reactions to the users. Specifically, the results indicated that blue, black, and red induced positive, neutral, and negative emotions, respectively. Previous studies consistently indicated that blue has a strong positive emotion induction capability [17, 24, 25]. However, previous researches reported contradictory results for red. Some indicated that red induces positive mood (approach behavior), and others stated that it induces negative emotion (avoidance behavior) [45, 48]. Contrary to some research findings, this research indicated that exposure to red color can result in increased negative emotion.

Regarding shapes, the results obtained from this study concurs with prior research findings in that angular and rounder shapes induce negative and positive emotions, respectively. Hence, this study demonstrates that low level emotional design elements such as colors and shapes have high visceral effects that could be used to induce the emotional states of users' without the users even know their existences. This has a significant impact on affective computing research community since these design elements could covertly be integrated into user interface designs to induce the desired emotion onto users. In other words, it is simple and effective and could potentially be used as viable alternative to replace the traditional emotion induction tools.

CONCLUSIONS

The goal of this research was to manipulate users affective states by incorporating emotional design elements such as color (foreground and background), shape (angular vs. rounder edges), or both shape and color presented as abstract graphical elements. Previous researchers have presented contradictory reports on the effectiveness of these low level design elements. In conclusion, this study demonstrates that low level design elements such as color and shapes have high visceral effects that could be used as potentially viable alternatives to induce the emotional states of users without the users even knowing of their existences. More specifically, the study indicated that red and angular shapes generate negative affective reactions where as blue and round shapes induced positive emotion to the users.

LIMITATIONS AND FUTURE WORK

While the main objective of this study was to find out whether the selected design elements are good enough to induce affective reactions the users, it has several limitations. First, the study results were based on self rated emotion which could be influenced by various factors. The other obvious limitation was generalizability since only thirteen participants were used for the study. Diverse samples that represent the general population will be beneficial for accurate prediction.

In sum, in this research, we explored an approach to seamlessly integrate low level design elements to induce mood that may in turn induce behavior. The behavior invoked by these design elements can have impact on the quality of decision making. For our future work, we would like to examine the relative impact of emotional design elements on search thoroughness and user satisfaction.

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CHAPTER THREE

TAG CLOUD BASED IMPLEMENTATIONS OF ALTERNATIVE SEARCH ENGINE RESULTS PRESENTATIONS

ABSTRACT

This research proposes an implementation of tag cloud textual and polygonal properties as a form of visual design elements to build alternative search engine user interfaces. Visual design elements such as textual and polygonal properties are reported to contain significant emotion induction stimuli. Textual properties include font size, font weight, foreground color, and polygonal properties. The polygonal properties include curvatures such as sharp or round edge, size or area, and orientations of the polygon. Therefore, this research demonstrates the implementation of a tag cloud based search engine result presentations using emotional design elements into three forms: wCloud, sCloud, and wsCloud, each containing six components: input processing, data cleaning, stemming, tag cloud processing, emotion embedding, and result presentation : wCloud makes use of the popularity of a non-trivial words in the search excerpt using font size and foreground color, whereas sCloud uses the curvature and area of the polygon in the form of abstract object stimuli to build tag cloud based search interfaces. Similarly, the wsCloud search engine interface alternative combines the color and shape visual design elements as emotional manipulation tools to ultimately affect search performance. Overall, this implementation is part of an effort to enhance the web user experience of older adults.

INTRODUCTION

Tag clouds (also known as data clouds) are used to describe the content of the web, primarily in the form of summarization, visualization and interaction of concepts based on certain attributes such as textual or polygonal properties [1-3]. Tags are a form of label that represent concept in a tag cloud and generally linked with a collection of resources [1, 3]. This means that a tag generally acts as a reference pointer to link a large collection of information. In general, the association between the tag and the entity it represents can vary from application to application. For instance, a large size of text or shape could map to the frequency (the number of occurrence) of the entity in the data set, the number of clicks it receives. It could also represent the recency (currency) of the information with regards to time [3-6]. However, the most common mapping is the frequency of a tag which is represented by either using formatting properties such as font size, weight and position, foreground color intensity, or polygonal properties such as shape, area, background color, and position [7-9].

Currently, tag clouds are being used in various online applications such as social networking, blogging, photo and video sharing, message boarding, and search [2, 6]. While tag clouds are increasingly more popular, there have been a limited amount of published articles that focus on their perceived usability and effectiveness. From usability perspectives, three researches have put a greater emphasis on evaluating the effectiveness of tag cloud [10-12]. Helvey and Keane [10] performed a usability evaluation to investigate the effect of alphabetization and font size. They have recruited sixty participants and used web logging methodology to evaluate the effectiveness of tag cloud visualization. Their study results indicated that alphabetization and larger font size aided participants in accessing information quickly and easily. In addition, they reported that users tend to scan text presented as tag cloud instead of reading [10]. Interestingly, Bateman et.al. [11] studied tag font colors (blue vs. red) for their potential capability to capture users attention. And their results indicated that there was no significant difference between the two colors in capturing users' attention [11]. Similarly, Lohmann et. al. [4] compared tag cloud layouts (sequential, circular, clustered, and reference) effectiveness using eye tracking. Their results support the findings reported by Helvey and Keane that users scan tag clouds rather than read them as normal text [4, 10].

To date, a number of tag cloud layouts have been proposed by researchers and practitioners [4, 5, 10, 11, 12, 13, 14]. They can roughly be categorized into four major groups: sequential, random, circular, and clustered layouts. Sequential layout shows an alphabetically sorted arrangement based on some criteria such as the frequency of occurrence or popularity of a tag. On the other hand, as the name implies, random layout displays the tag terms in random order as opposed to sequential tag cloud presentation. In circular layout, popular tag terms are displayed at the center and less popular tag terms are displayed further away from the center of the tag cloud. The clustered layout is a more generalized form of circular layout in which tags are grouped based on some criteria (such as based on their semantic relatedness or their chronological order using factors such as time).

This research contributes to the implementation of an alternative search engine user interface that incorporates emotional design elements. Specifically, we propose the use of text formatting properties such as font color, size, and polygonal properties including curvatures such as sharp or round edges, size or area, and orientations of the polygon. This research demonstrates the integration of low level emotional design elements into search engine result lists. The research presents the implementation of tag cloud based search engine interfaces into three forms: wCloud, sCloud, and wsCloud. wCloud makes use of the popularity of a non-trivial word in the search excerpt using font size and foreground color to build the tag cloud. On the other hand, sCloud uses shape edge and area of the polygon to build tag cloud based search interface. Likewise, wsCloud uses a hybrid of color and shape emotional design elements to build the alternative user interface. In summary, this paper is organized as follows. Section II explains the related works relevant to this research. Section III demonstrates the implementation details of tag cloud based alternative search engine user interfaces that incorporate emotional design elements. In section IV, the discussion and implication of the proposed search user interface alternatives are presented. Finally, the conclusion and future work is presented in Section V.

RELATED WORK

There are a number of applications that make use of tag clouds [5, 10, 11, 12]. For simplicity, we can roughly categorize them into two groups based on their context: data visualization, and clustering. Data visualization involves formation of mental visual images for gisting or recognition of important ideas from a given data set [11, 12]. On the other hand, clustering mainly focuses on categorization and presentation of information in the context of search engine system and information inquires [12-14]. A number of tools are available online for data visualization and presentation using tag cloud methods. Some of the widely used applications include TagClowed, Worlde, ToCloud, Tagxedo, and Tagul [18-22]. Similarly, popular tag based clustering tools include Quintura, CarrotSearch, SenseBot, and DeeperWeb [23-30]. Detailed explanations will be provided for each of the category in the section below.

Visualization

As stated, visualization mainly involves matching and impression creation of important ideas. In general, three visualization applications are of interest to this research: Worlde, ToCloud, and Tagxedo. Wordle was developed by Jonathan Feinberg [19]. It is a Java based tag generating tool that uses Java2D API and jQuery to generate tags [18, 19]. It supports multiple languages. In order to use language specific stop words, Worlde selects the first fifty most frequently appearing words from user input text and counts how many of them exist in a specific language list of stop words. The language that contains the highest count will be considered the language of the user text input and the stop words will be applied to filter out trivial words [19]. In assigning weights to words, Worlde takes the frequency of non-trivial words. Worlde uses a randomized greed algorithm to place words in the canvas space. It was also specified that Worlde assigns a random color to the tag cloud. In other words, text colors are meaningless for Worlde [18]. Figure 3-1.a shows the visualization generated by Worldle.

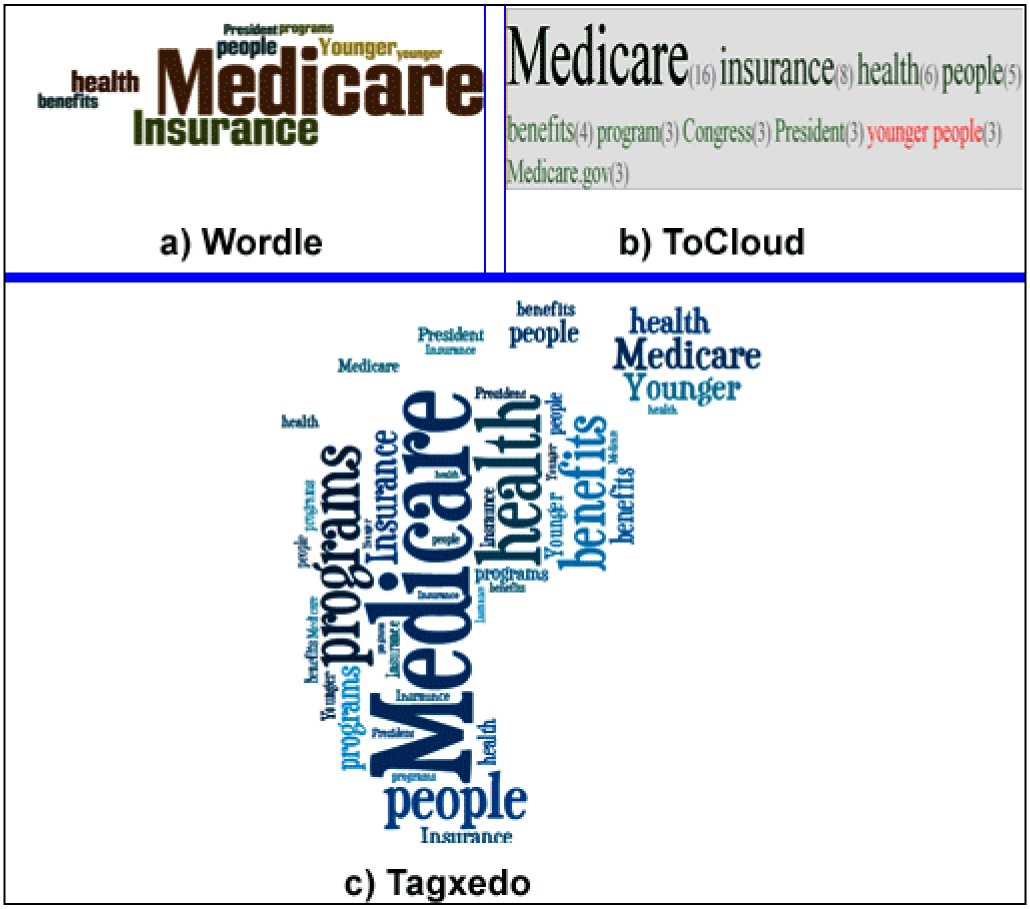


Figure 3-1. Examples of online tag cloud generating tools: (a) Wordle, (b) ToCloud, and (c)Tagxedo.

ToCloud is another tag cloud visualization tool available online. It is implemented using perl cgi as server side script [20]. The tag cloud generated by ToCloud can be displayed alphabetically, by frequency or by first occurrence [20]. It also provides an option to display the frequency count along with the tag (see Figure 3-1. b). Unlike Worlde however, ToCloud does not dynamically identify the stop words of a language. Users need to provide the stop words in order to use ToCloud in other languages (i.e, other than English) [20]. Similar to Wordle, color of text does not have any special purpose.

Similarly, Tagxedo is a tag cloud visualization application that uses text and shape as input, and presents the text as a tag cloud that fits the shape provided by the users (see Figure 3-1. c). It is implemented using Silverlight 3, which is a Microsoft application framework alternative to Adobe Flash [21]. Silverlight's run-time environment mainly works on Web browsers that run Microsoft Windows operating system. Currently, it supports only English language stop words lists to filter out trivial words from inclusion in the cloud visualization list (see Figure 3-1.c). Similar to Wordle and ToCloud, Tagxedo uses color to decorate words in a tag cloud. However, color is an important emotional design element for this research

Clustering

In the context of search, clustering can be considered a tag cloud application that categorizes search results using some form of similarity measure. Four tag based search engine applications are selected for their direct relevance to the research at hand: Quintura, CarrotSearch, SenseBot, and DeeperWeb [23-30]. Quintura is a visual context-based search application that creates clusters dynamically and displays the search results as a linear list (i.e similar to the conventional search engines) and as a tag cloud of words related to the search query (see Figure 3-2. a). It uses visual a semantic map to show close contextual relationships of the search keyword. Quintura uses the neural network approach to generate the visual semantic map [23-25]. A detailed description of the neural network based implementation is beyond the scope of this paper. However, for more information about its implementation, readers are referred to [24, 25].

CarrotSearch (Carrot^2) is another cluster based search visualization tool. It is an open source framework that fetches search results by using the APIs provided by search engines [26-28]. Carrot^2 is implemented in Java and provides a number of algorithms for clustering including: Lingo, STC (Suffix Tree Clustering), Rough K-means and Fuzzy Ants [26 ,27]. STC and Lingo clustering algorithms are widely used for search clustering [26, 27]. The Lingo algorithm makes use of the vector space model to create a term document matrix [27]. Carrot^2 offers a library of clustering functions to provide tokenizes, stemmers, and list of stop words for a number of languages [26, 27]. Carrot clustered results can be presented using a number of options (see Figure 3-2. b). Visualizations are implemented with the use of Adobe Flash player, JavaScript and HTML5 [28].

Likewise, both SenseBot and DeeperWeb are similar tag cloud based clustering tools used in the context of search [29, 30]. SenseBoat uses the semantic web search strategy to understand the various contexts in which a search query could be used [29]. In other words, SenseBoat takes Google, Yahoo, and Bing search APIs as input and uses its own semantic search engine to present the search results (see Figure 3-2 c). For instance, when users query the term “apple”, SenseBoat forms a tag cloud of words containing companies, technologies, fruits, and other similar semantic categories based on the different meanings of the query terms. Similarly, DeeperWeb uses a topic-mapping method to categorize search result provided by Google search API. It implements features such as answers search, blog search, Wikipedia search, resource search, and news search to categorize the results relevant to the user's query and presents them in the form of tag cloud [30]. Figure 3-2.d shows a sample visualization using DeepWeb cluster tool.

Overall, tag clouds have been used in various contexts such as impression formation, matching, browsing, and searching [11, 12]. Regarding the task of search, several researchers have taken a closer look at text and polygonal formatting properties [12-16]. For instance, a study performed by Sinclair and Cardwe-Hall indicated that tag based searching was preferred less compared to tradition list based search result presentation [13]. However, Sinclair and Cardwe-Hall also reported that people prefer tag cloud interfaces in searching for more open-ended information content. Overall, Sinclair and Cardwe-Hall concluded that tag cloud based searching is not a replacement but a valuable extension to traditional search tasks [13].

Additionally, Schrammel et. al. [14] conducted a usability study on the three tag layouts: sequential, random and semantic using eye tracking methodology. Their results indicated that there is no significant difference in attention among the participants using the three tag cloud layouts [15, 16]. While various research findings take a closer look at tag cloud features, we found no research report using tag cloud features from emotional design perspectives in the context of search engine user interfaces. For instance, most of the tag cloud applications reviewed in this research provided color features for beautifying the tag cloud. However, studies indicated that based on a particular context and situation colors do not just contain aesthetic values but it could carry important psychological meanings [31].

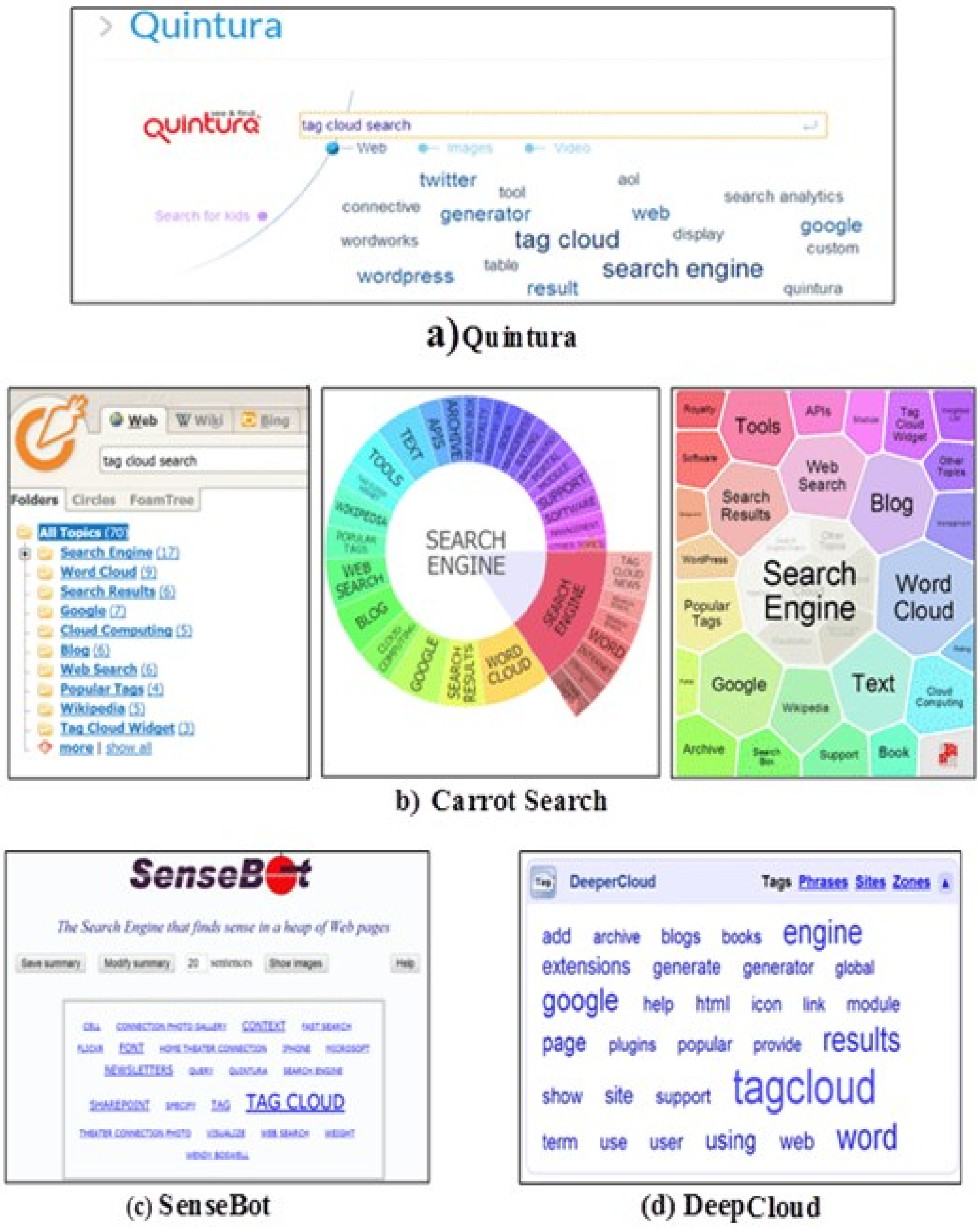


Figure 3-2. Examples of tag based search engines: a) Quintura, b) Carrotsearch, c) SenseBot, and d) DeepeCloud.

ALTERNATIVE SEARCH ENGINE INTERFACES

Search

Search is a very fundamental task that we do in everyday living. Almost everyone, who uses the Internet knows how to search for information using search engine user interfaces [30, 32, 33]. Like other technology artifacts, in order to perform search tasks using search engines, searchers need perceptual, motoric, and cognitive capabilities. Common perceptual functionalities include contrast sensitivity and visual acuity, which enable the users to detect fine details [34, 35]. Similarly, motoric functionalities include movements that encompass accuracy (how successful to hit the target goal) and response time (how quickly one initiates movement) [36]. Similar to perception and motoric capabilities, researchers categorized cognition as fluid and crystallized abilities [37, 38]. Fluid abilities are related to perceptual speed, working memory, attention, reasoning, and spatial abilities that are needed in a dynamic environment. Whereas crystallized ability represents the knowledge obtained through a lifetime of formal and informal learning which tend to increase due to aging [37, 38]. Table 3-1 shows the tasks/ subtask analysis in performing the task of searching with perceptual, motoric, and cognitive demands.

Currently existing search engines such as Google, Bing, and Yahoo provide similar search tasks for users [39-41]. Therefore, the task analysis presented in Table.3-1 is valid for all three. Moreover, all of them provide search Application Programming Interfaces (APIs) to customize the search results. However, for some search engine API providers, the search results provided by the customized result is different from the search results obtained from normal search using conventional search engine interfaces. For example, at the time of writing, Google search API returns only a maximum of eight search results for a given user query and also re-ranks the pages to penalize the Search Engine Optimization (SEO) companies and other API users. In other words, Google API does not provide the same result as searched by the normal search scenario. [39]. Moreover, the Google team usually blocks the internet protocol (IP) address if it attempts to query multiple times. This creates a bottleneck because our research will use currently existing search engine user interfaces as a control for the experimental study and compare it with the alternative search engine user interfaces. Therefore, instead of using the Google search API, this research will make use of the Bing search API [40, 41].

Task	Task Description	Perception	Motoric	Cognitive
1.0	Search an information using search engine interface			
1.1	Scan the search engine page for a search box	Visual acuity		Visual search, attention
1.2	Move the mouse pointer or your finger over the search box	Visual acuity	Motor control	Spatial translation, attention
1.3	Click/touch the search box		Motor control	Visual search, attention
1.4	Type the search keyword		Motor control	Attention, visual search
1.5	Click/ touch the "search" button or hit enter	Visual acuity	Motor control	Visual search, attention
1.6	Evaluate the search result page for search match	Visual acuity		Attention, reasoning
1.7	Make decision to view a specific search result			Attention, decision making
1.8	Move the mouse pointer or your finger over the selected search result link	Visual acuity	Motor control	Attention, spatial translation
1.9	Click/touch the search result link		Motor control	Visual search, attention

Table 3-1. Task Analysis of search with Perception, Motoric, and Cognitive demands

The Bing search API is part of Microsoft Windows Azure cloud-based data services that allows developers to query and embed search results in a variety of applications [41]. The API includes metered subscriptions of query result (For example, the default maximum result list per query is 50 and a total of 5000 transactions per month for free subscription). In addition, it provides results in various media formats such as JavaScript Object Notation (JSON), Extensible Markup Language (XML), and Open Data Protocol (ODP) which is a standard web application protocol that enables the creation of Representational State Transfer (REST)-based data services to expose data. For instance, Figure 3-3 shows a PHP code fragment that uses the API to request and obtain the search result in JSON media format. It uses the file_get_content() and json_decode() functions to send a request to the JSON interface and returns the search results into JSON object, respectively. Similarly, Figure 3-4 also shows the code fragment that parses and stores the search result presented in JSON into MySQL database

```php
<?php
// account key is obtained from subscription to the service
$accountKey     = '+mxx3cWgoo5zjhEI4OKiHGXQ7vNMsXuaQGY6dc7/N1U=';
$ServiceRootURL = 'https://api.datamarket.azure.com/Bing/Search/';
$WebSearchURL   = $ServiceRootURL . 'Web?$format=json&Query=';
$context        = stream_context_create(array(
    ". . . /Create a stream using htttp . .."
));
$request        = $WebSearchURL . urlencode('\'' . $_POST["searchText"] . '\'');
$response       = file_get_contents($request, 0, $context);
$jsonobj        = json_decode($response);
```

Figure 3-3. PHP code fragments for presenting search results in JSON format

```
<?php
foreach ($jsonobj->d->results as $value) {
    $SQL = "insert into tblbingjson(title, description, url, keyword) values
            ('" . mysql_real_escape_string($value->Title) . "',
            '" . mysql_real_escape_string($value->Description) . "',
            '" . mysql_real_escape_string($value->Url) . "',
            '" . $_POST["searchText"] . "')";
    mysql_real_escape_string($SQL);
    if (!mysql_query($SQL))
        die("Error" . mysql_error());
}
```

Figure 3-4. PHP code fragments for storing search results into MySQL database

wCloud

Research in color and psychology indicated that colors have strong emotion induction capability and are context specific [42]. This research attempts to use color as an emotional design element that can be embedded into search engine user interfaces to induce various forms of emotion. wCloud is a tag cloud based search engine user interface implemented as part of this research. It makes use of text formatting properties such as text color as part of emotional design elements applied on tag clouds. Roughly speaking, almost all of the tag cloud based implementation discussed use color as one form of visualization elements. However, they do not attach any meaning to the color of tag clouds. In other words, colors are meaningless and only used to give contrast and aesthetic values. However, the core component of this research is the usage of color as emotional design element to induce emotion.

As shown in Figure 3-5, wCloud has six parts or stages which could be mapped to functions: input processing, data cleaning, stemming, tag cloud processing, emotion embedding, and result presentation. The input processing function accepts the search result list returned from search engine APIs. It then filters out the title and Uniform Resource Locator (URL) and returns the search description to data cleaning phase. This function also includes the tokenization process, where each search description is split into a sequence of tokens, which usually represent words. The data cleaning subroutine discards stop words, punctuations (non-letter characters), spaces, and strip any html tags. Stop words are words that do not describe a concept either because they are not useful or common such as ‘a’ or ‘the’. This research used MySQL full-text stop word list from MySQL source distribution [43]. The output of data cleaning subroutine is passed to the stemming functions so as to reduce the non-trivial words into their respective stem forms. In other words, the stemmer reduces words to their base forms. For instance words such as *satisfying*, *satisfaction*, *dissatisfaction*, *dissatisfy*, *dissatisfying* belong to the root word *satisfy*. Therefore, the results of the stemming process consist of non-trivial words from the search result description content that have been stemmed using the porter stemming algorithm [44]. It was implemented using Hypertext preprocessor (PHP) and this implementation used a significant portion of the open source code of porter stemming algorithm presented in [45].

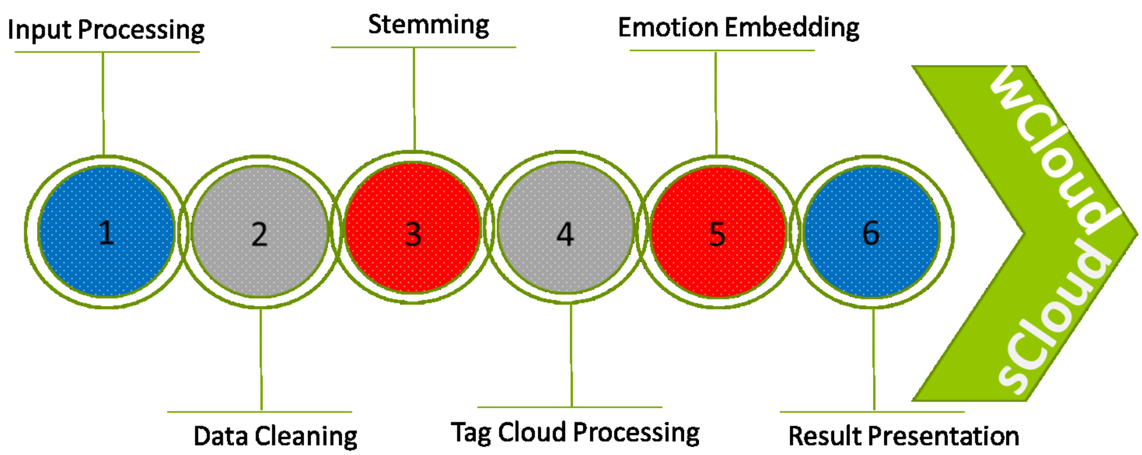


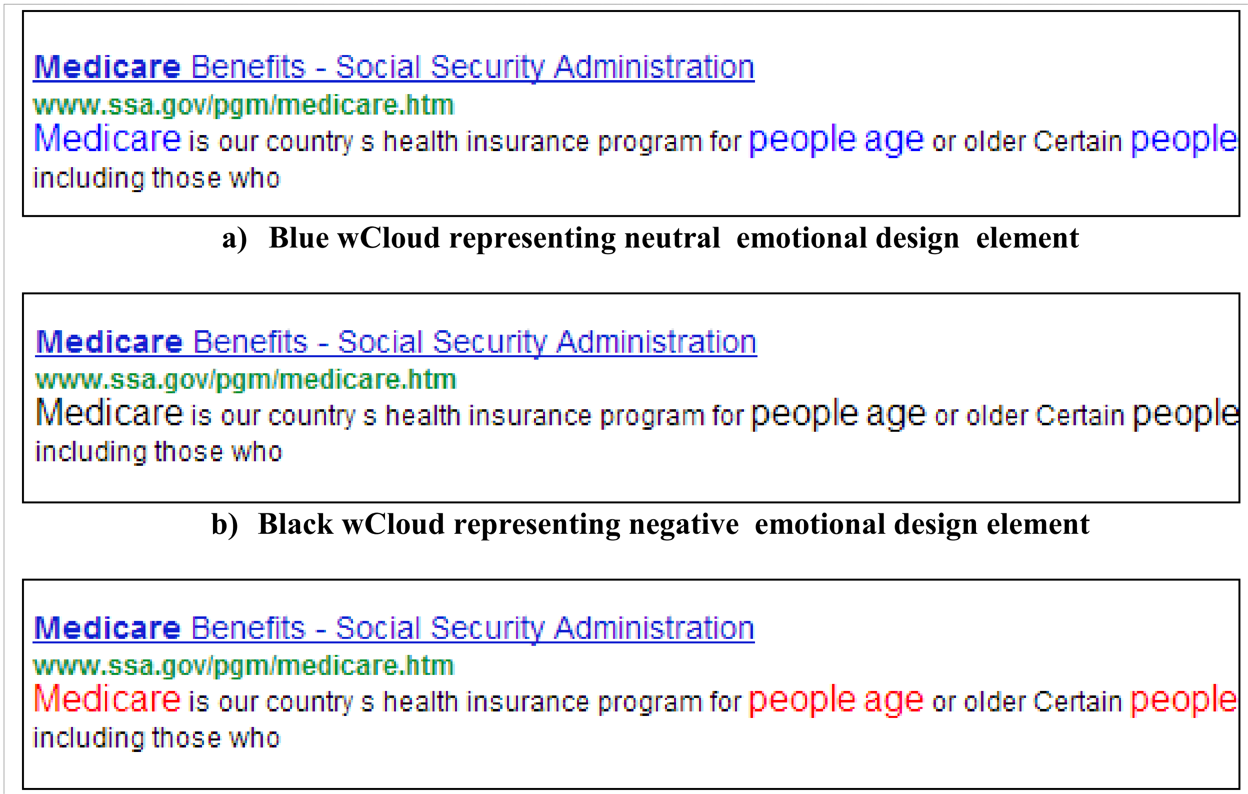
Figure 3-5. Stages of generating wCloud and sCloud alternative search engine user interfaces

Tag cloud processing and construction is a stage in which the non-trivial stemmed terms generated from stemming stage are used as input. It implements the concept of vector space model (VSM) where the text excerpt of each search results for a given search query are combined to form a document. In a VSM, this document can be represented as a vector $d= [w_{t0}, w_{t1}, w_{t2,\ldots} w_{tn}]$ where d represents the document generated by the entire text excerpt whereas, $t_0, t_1, t_{2,\ldots} t_n$ represent the terms, and w_{ti} represent the weight proportional to its count, which is the frequency of the occurrence of the term in the document. The frequency is then used to assign the term a font size. Tag cloud processing is applied for each of the search result description. During assignment, the original search description is parsed, and whenever a tag term is encountered text formatting is applied on that specific term at each specific position without sorting or rearranging any term from its original position. This is done in order to maintain the readability of the search result description. Figure 3-6 shows the PHP code fragment that is used to generate the wCloud search tag cloud. Specifically, looping through the results set, the code shown between lines 13 and 18 indicate the tag cloud generation process.

```
2  //...
3  require_once('tagcloud.php');
4  $per_page = 10;
5  $start    = ($page - 1) * $per_page;
6  if (!$result = $db->query("SELECT * FROM tblbingjson order by rank limit $start,$per_page")) {
7      throw new Exception("<b>Could not read data from the table </b>");
8  }
9  while ($data = $result->fetch_object()) {
10     $rank         = $data->rank;
11     $url          = $data->url;
12     $title        = $data->title;
13     $description  = $data->description;
14     $text_content = $description ;
15     $wCloud       = new TagCloud();
16     $wCloud->setUTF8(true);
17     $wCloud->addTagsFromText($text_content);
18     $desc = $wcloud->creatCloud();
19     //...
```

Figure 3-6. PHP Code fragments for generating wCloud search interface

The emotion embedding component accepts sets of tag cloud terms returned from the tag cloud generation function and applies the respective emotional elements on the terms. Specifically, it applies the corresponding font colors to those tag cloud terms with frequency values greater than one. So, for the three variants of wCloud search engine user interfaces, hexadecimal values of #0000FF (blue) ,#000000 (black), and #FF0000 (red) are applied to embed positive, neutral, and negative emotional elements, respectively. Finally, the result presentation stage provides output of search result presentation of wCloud search engine user interface. For instance, Figure 3-7.c shows the wCloud interface with positive emotional induction capability, whereas Figure 3-7.b and Figure 3-7.a show the interfaces that are predicted to induce negative and neutral emotions to the searchers, respectively. As can be seen from Figure 3-7, the terms ‘medicare’, people, and age undergo tag cloud processing.



a) Blue wCloud representing neutral emotional design element

b) Black wCloud representing negative emotional design element

c) Red wCloud representing positive emotional design element

Figure 3-7. wCloud presentation (a) positive, (b) neutral, and (c) negative affect levels

sCloud

sCloud alternative search engine user interface is also a tag cloud based search engine presentation that makes use of polygonal shape as emotional stimuli. The frequency occurrence of non-trivial words will be used as metrics to define the ratio of the area covered by a specific tag cloud when forming a polygon with respect to the parent canvas. Like the wCloud search interface type, sCloud implementation is illustrated in six parts (see Figure 3-5). Since the stemming and data cleaning stages are the same with wCloud, only tag cloud processing, emotion embedding, and result presentation stages are discussed. For sCloud search user interface alternative, contrary to wCloud, tag cloud processing is applied on the entire search result lists. Figure 3-8 shows the PHP code fragments that store shape based tag cloud data into an array, which will be used to assign the term a polygonal area proportional to its count. The larger the frequency, the more space a specific term will occupy on the interface relative to the parent canvas.

```
<?
//...
if (!$result = $db->query("SELECT ClustName, COUNT(ClustName)as Clustweight FROM cluster
where keyword='$keyword' group by ClustName order by Clustweight desc")) {
    throw new Exception("<b>Could not read data from the table </b>");
}
$id = 0;
while ($data = $result->fetch_object()) {
    $label[$id]      = $data->ClustName;
    $wFrequcny[$id] = $data->Clustweight;
    $id             = $id + 1;
}
$db->close();
//...
```

Figure 3-8. Code fragment to store tag cloud data into arrays

HTML5 Canvas API has many features such as drawing any shape, creating gradients and patterns, and manipulating texts and pixels. The API is so powerful that it allows users to literally draw anything with the integration of scripts. For instance, as shown in Figure 3-9, line 5 finds the <canvas> element in the document object model (DOM) [46, 47]. To draw, we need the drawing context shown in line 6, which contains a getContext() method. The context is the access point to draw and paint on the canvas. Once we get this context method, we can draw and paint anything on the canvas polygon. As can be seen from Figure 3-9, the variable jsArrayOfVornoiRegions (see Figure 3-9, line 7) contains an array of JavaScript objects. Each jsArrayOfVornoiRegions object represents the shape tag cloud polygon containing four important properties namely regionId, wFrequeny, label, and action. As its name indicates, the regionId identifies a specific tag term and will be used to sort the tag terms based on their wFrequency values. For instance, the polygon with the highest wFrequency will be placed at the top of the tag cloud layout. The property wFrequeny contains the frequency of a specific tag term appeared in the document. The label represents the term generated from the tag cloud. Line 7 to 11 presents the assignment of frequency, label and address of the search results that contains a specific tag word. This part of the implementation used considerable size of code from an open source implementation of Vornoi Diagram using Javascript by Raymond Hill [46].

```
//...
<canvas id="sCloud" width="200" height="100%"></canvas>
<script type="text/javascript">
var canvas =docuemnt.getElementById("sCloud");
var context= canvas.getContext('2d');
var jsArrayOfVornoiRegions= [{ regionId:'0',
    wFrequcny: <? echo $wFrequcny[0]; ?>,
    label: "<? echo $label[0]; ?>",
    action : function() {
    parent.document.location.href= "index2.php?clust=<? echo $label[0]; ?>";}},{ regionId:'1',
...
sCloud =  new voronoiDiagram({...
 //...
```

Figure 3-9. Code fragment to build sCloud polygonal interface

Emotion embedding function accepts tag cloud polygon returned from tag cloud generation stage and applies the respective shape edge to the polygonal border such as angular, mixed, and round edges to represent negative, neutral, and positive emotional induction elements, respectively. In order to apply polygonal border, the HTML 5 and CSS3 (Cascaded Style Sheet) property named “border-radius” is used. According to W3 specification, the value of the border-radius property describes “the radii of the ellipse that defines the shape of the corner of the outer border edge” [47]. In other words, it defines how rounded border corners are. As shown in Figure 3-10, the three versions of the sCloud interfaces are visually similar in appearance, but differ in their shape curvature features: angular, round, and mixed border shapes. The angular shape interface depicts the sharp edge polygon (see Figure 3-10.a). The value for the border-radius property for this interface is zero. The round shape interface depicts the curved edge polygon (see Figure 3-10.c). The value of the border-radius property for rounded shape interface is 25pt. None of the related research publications we have encountered reveal what border-radius value they have used for their research. Therefore, this research used the default value specified in the W3 specification example [48]. Similarly, mixed shape interface uses approximately 50% of the round (i.e border-radius: 25pt), and 50% angular (i.e border-radius: 0pt) edge characteristics, respectively (see Figure 3-10.b).

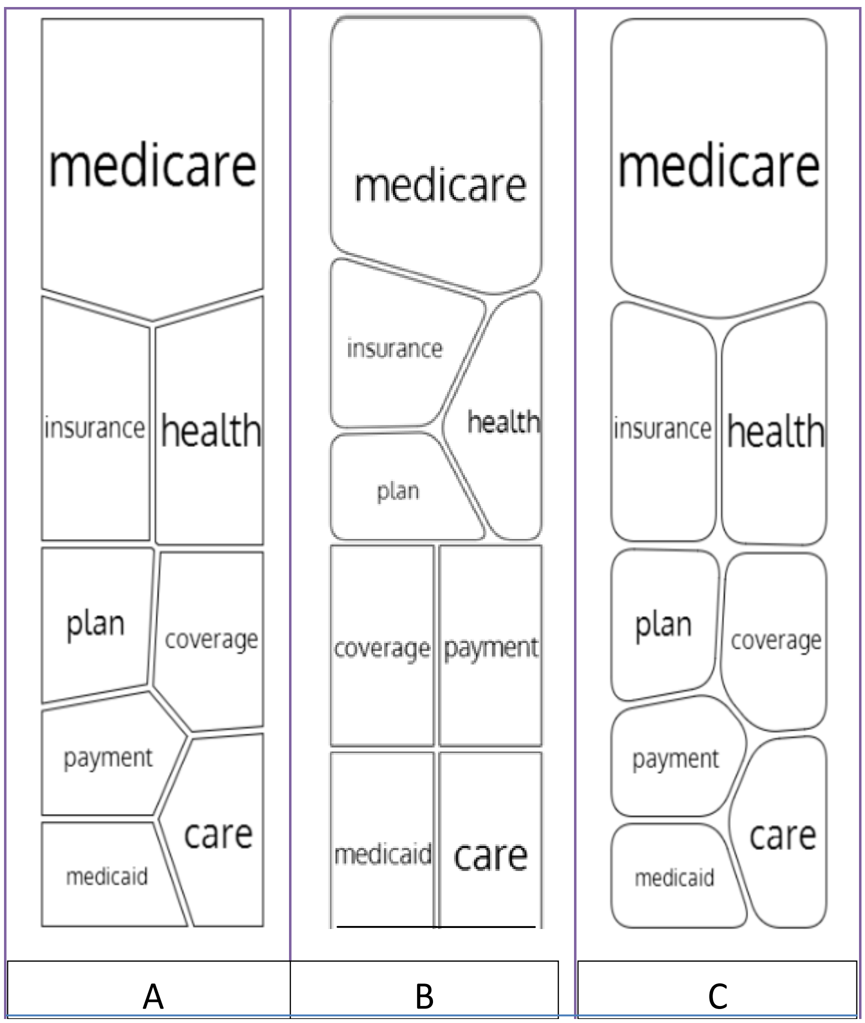


Figure 3-10. sCloud variants: a) angular, b) mixed, and c) rounder shapes

CONCLUSIONS AND FUTURE WORK

This research proposes an implementation of tag cloud textual and polygonal properties as a form of visual design elements to build alternative search engine user interfaces. Visual design elements such as textual and polygonal properties are reported to contain emotion induction stimuli. Textual properties include font size, font weight, foreground color, and polygonal properties. The polygonal properties include curvatures such as sharp or round edge, size or area, and orientations of the polygon. As a whole, three primitive visual design elements were selected: color, shape, and color/shape combinations. The colors were implemented as either foreground or background based on the interface design type used. Similarly, the shapes were implemented on the curvature of the abstract design elements

Overall, this research demonstrates the implementation of tag cloud based search engine interfaces using emotional design elements into three forms: wCloud, sCloud, and wsCloud. The wCloud based interface type used the popularity of a non-trivial words in the search excerpt using font size and foreground color, whereas sCloud used the curvature and area of the polygon in the form of abstract object stimuli to build tag cloud based search interfaces. Similarly, wsCloud search engine interface alternative combines colors and shapes as visual elements. To implement wsCloud, three colors variants were used on top of sCloud implementation. For the angular based sCloud interface option, red (#ff000) was applied as a background color. Similarly, for mixed and rounder sCloud variants, gray (#cccccc) and blue (#0000ff) were applied as background colors, respectively. The ultimate goal of integrating emotional design elements into search engine user interfaces was to induce the emotions of the searchers so as to affect search based decision making.

For our future work, alternative search engine interfaces derived from this implementation will be used to evaluate the effectiveness of low level design elements on search performance. For our follow-up usability study, we would like to evaluate the design alternatives as ways to manipulate users' affective states by incorporating emotional design elements into currently existing search engine interfaces.

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CHAPTER FOUR

AN INVESTIGATION OF THE PERCEIVED USABILITY AND CHOICE SATISFACTION OF ALTERNATIVE SEARCH ENGINE'S INFORMATION PRESENTATION FOR OLDER ADULTS

ABSTRACT

The purpose of this study was to examine the effects of low level emotional design elements such as colors, shapes, and color/shape combinations on search performance and user satisfaction. Forty-five older adults participated in search tasks using alternative search engine interfaces. The experimental data was collected using the EyeTribe eye tracker. A preliminary analysis including gender as a between subject factor revealed no significant main or interaction effects, so it was omitted from further consideration. Consequently, this study was adjusted as a 3 by 4 repeated measure factorial design ANOVA with two independent variables: positive affect levels (high, neutral, and low) and search interface types (control, wCloud, sCloud, and wsCloud). Major findings were: a) shape emotional design elements impacted search performance. Specifically, the finding indicated that rounder shapes generally led to superficial search whereas angular shapes led to a more thorough search behavior on users; b) color and color/shape combination didn't significantly affect search performance; and c) color/shape combination based search interface alternative design was the most preferred interface. In general, the results of this research suggests that seamless integration of low level emotional design elements as part of search engine interfaces could potentially improve web search experience.

INTRODUCTION

Search is a big deal: it is simple and integrated in almost every application. It is also one of the dominant features of the web user experience (UX) and users have developed a solid mental model on how it is supposed to work. From a usability perspective, the task of online searching involves two stages: query formulation and search results exploration. In the query formulation stage, searchers express their information inquiry by formulating a query in a format that a search engine can understand. The most common query formulation interface contains a textbox and a search button. Using this interface, users express their intent by typing their query into the textbox and press the search button to execute the query. Similarly, the search result exploration stage is where searchers spend most of their time viewing and evaluating the results provided by the search engines.

To date, a large number of researchers and practitioners have proposed a wide range of ideas to improve the accessibility and usability of search engine user interfaces [1-5]. However, the most successful and widely accepted ideas are incorporated in currently existing major search engine user interfaces [6-11]. A typical search result exploration interface contains a vertically ranked list, which presents the title of the web page, its URL, and a short text excerpt from the website. Meanwhile, search engine companies generally claim that the list is ordered based on the relevance of the documents to the user's query [12, 13]. However, this claim is not necessarily true [12, 13].

Various researchers have shown that the list provided by the search engines create a cognitive bias by causing users to believe that the top few list results are the most relevant search results [14, 15, 16]. Pan et al. [14] indicated that people's selection of the search results were strongly biased towards the first few list results regardless of the relevance of the abstracts. Surprisingly, a finding by Joachims et al. [15] showed that users still showed similar search behavior even though the lists were presented in the reverse order. However, the fact that a particular website appears at the top of the list does not necessarily indicate that it is the desired search result.

On one hand, search engine companies are business entities that manipulate the rankings based on their business values. A case in point is the recent oil spill in the Gulf of Mexico which occurred in 2011 [16]. British Petroleum (BP) paid millions of dollars to major search engine companies to obtain the first rank for all user queries related to the oil spill. On the other hand, there are several deceptive entities that manipulate search engine rankings; some involve criminal activities that specifically target older adults. These entities use mainly search engine optimization (SEO) tricks known as Black SEO. For instance, older adults are reported as the most affected victims in financial crimes due to their health issues, loneliness, and their possession of significant amount of retirement savings [12]. Furthermore, most of this group was not aware of the risks and security hazards of online searches and usually trusts information obtained online as accurate and useful [13]. Consequently, it is important to understand that by relying simply on search engine rankings, searchers are likely to miss important information relevant to their query.

Other important findings indicated that older adults search for information all together about 15% less than younger adults prior to making decisions [17, 20]. Prior research findings associated such behavior mainly with adverse cognitive age-related difficulties [18, 19]. However, recent studies indicate that emotion is linked to influence search decision quality [17, 19, 20, 21]. A number of studies indicate that positive emotion plays an important role in cognitively biased and superficial thinking. This research approaches the question as to why older adults search less and how this search behavior could be improved. The research is motivated by the broader issues of older users' search behavior, while focusing on the emotional usability of search engine user interfaces. This is a follow-up for the study presented in chapter two, which explored the emotion induction capabilities of colors, shapes, and combination of colors and shapes. As discussed in chapter two, the study was required to determine whether the proposed design elements have strong mood induction capabilities.

Therefore, the purpose of this study was to evaluate alternative search engine user interfaces for search thoroughness and user preference. More specifically, this study focuses on the actual search tasks using alternative search interfaces that seamlessly integrate low level design elements. Mainly, this study was conducted to answer the following research questions: 1) how can design elements be used to improve web search user experience for older adults? 2) are alternative search engine user interfaces derived from this research more usable? The remainder of this paper is organized as follows. In Section II, the related works relevant to this research are presented. Section III discusses the methodology used for this research. Section IV presents the experimental results. In section V, a discussion of the results and their implications will be presented. Finally, the conclusion is presented in section V.

RELATED WORK

Various methods have been used in the past to capture, store, and analyze users' behaviors when using technological artifacts [24-28]. For example, researchers mainly used web logs, click through, and think-out-loud methods to encode users search behavior when performing the task of searching. In general, these methods provide limited information related to users' actions such as which search results the user selected and how long does it to complete the task [27, 28]. Although these methods have been useful, they did not provide a precise measure on how users make decisions. More recently, UX researchers have been considering other methods such as eye tracking, and video recording to study and examine users search behavior in decision making process [29-32]. The application of eye-tracking methodology enables researchers and practitioners to understand users' behavior at the time of decision-making. As a result, several researchers have applied the techniques of eye tracking methodology to examine users' behavior in online search task [30, 31].

Eye tracking methodology is based on the Eye-Mind hypothesis which presumes the associations of eye gaze with dynamic track of user's attention in relation to a given visual stimulus. In general, eye tracking provides several relevant metrics to help researchers gain an understanding of the cognitive resources that the users allocate in performing tasks. Some of the metrics include number of fixations, fixation durations, patterns of fixations (scanpaths), and pupil dilations [29, 30]. In general, eye tracking metrics enable researchers to obtain a more comprehensive measure than other conventional UX metrics on how users process information [30, 32]. As a result, a number of researchers employed eye tracking methodology in various domains of applications such as information processing and visualization [29, 30, 32].

A typical eye tracker comes with two important components. The first component acts as the source of near-infrared light to create the reflection, and the second component records the reflection of the infrared light from retina and cornea to accurately capture the eye movement. The retina is the light sensitive part of human eye located at the back of the eyeball. Whereas the cornea is the light transparent part located at the front of the eye ball. The reflection from the retina will help us find the center of the pupil, which is a black opening that allows light to enter into the retina. To determine exactly where a particular human being is looking, we need to locate the center of the pupil relative to the corneal reflection since this position does not change when the head moves while the person is looking at the same point [31]. In general, when looking straight ahead, humans have a 180 degrees (90 at the left and 90 at the right) visual field. However, only 2 degrees belongs to the fovea and the rest belong to the peripheral vision [31, 32]. That is why the eye must move to have a clear picture of a particular location. As a whole, visual information is extracted whenever the eyes are relatively motionless while focusing on something which represents eye fixation point. This eye fixation lasts around 100-600ms. Following eye fixation, a rapid movement of the eyes (which is called saccade) follows to transfer the eyes to another location then to another eye fixation so and so forth. Overall, eye-tracking could be very helpful to precisely locate the search results to which searchers pay more attention and the results they generally ignore.

Pan et al [14] used eye tracking methodology to find the pattern of searchers when evaluating search results. Their results indicated that people follow linear pattern of searching from top to bottom regardless of the relevance of the data. Rele and Duchowski [35] conducted the eye tracking study on search task types (i.e. information vs. navigational) and reported that the types of search tasks provide different fixation patterns. In general, they indicated that more fixations were observed for navigation task than the information task [35]. In a more recent eye tracking study comparing adults and children's search behaviors, Gossen et al. [36] reported the following findings: a) adults scan the first three search results and then decided either to choose one or reformulate the search query, while children exhaustively scanned the search results, and b) adults give more emphasis on search description as compared to children. In another study, Cutrell and Guan found that providing more information for search description in the navigation task degraded performance whereas it improved performance in the information task [37]. Overall, with regards to online searching using search engines , consistent patterns of fixations were observed near the title of the search results while user's peripheral vision quickly processed content from the description of a given search result [33, 34]

Regarding this research, search thoroughness is one of the measures that need to be precisely captured and analyzed. This research defines search thoroughness as a numerical count that depicts the number of areas of interest (AOI) that contain at least one eye fixation. As stated, eye fixation is the moment that the eyes are relatively stationary looking at a particular AOI in order to encode information. As any other eye tracking experiment, this research assumes that the position where a particular person is looking depicts their attention allocation at that given moment in time. In other words, search thoroughness measures the number of search results the searchers read before they make a decision to either leave the search or select one from the list. This research employs eye tracking methodology to accurately capture search thoroughness. Detailed descriptions about search thoroughness and eye fixation are provided in the methodology section.

METHODOLOGY

Participants

Participant recruitment was conducted by email and word-of-mouth through local community organizations. The effect size of pilot two was used to estimate the size of the participants using G*Power [38]. Forty-five participants were recruited, of which twenty-nine were recruited from Clemson Emeritus College members and the rest were recruited from Osher Lifelong Learning Institute (OLLI). However, six participants were excluded from data analysis. Among the six participants who were excluded, four were due to calibration issues which resulted in incomplete or inconsistent data. The other two were excluded due to data screening (cleaning stage) as they were outliers from the rest of the groups. Therefore, the final results include data analysis for 39 participants. Approximately 97% (38) of the participants were Caucasian while the remaining was an Asian. Twenty-one participants were females and 18 were males. Approximately 69% of the participants (27) had graduate degree while nine participants (23.1%) reported they had college degree, two participants (5.2%) reported they had a high school diploma. More than half of the participants, 51.3%, were between the age 65 and 74, while 14 (35.9%) participants were between the age range of 75 and 84. The remaining were 85 years or older. Similarly, 97.4% (38) had normal or corrected vision while the remaining 2.6% reported that they had some partial color blindness. In addition, as shown in Table 4-1, 84.6% of the participants reported that they have search experience with Google search engine.

Search Engine Experience	**Number of Participants**	**Percent**
Google	33	84.6%
Bing	15	38.5%
Yahoo	23	59.0%
Other	12	30.8%
None	1	2.6%

Table 4-1. Participants' Search Engine Experience

Materials and apparatus

The experimental data was collected using the EyeTribe eye tracker [39]. The eye tribe is non-intrusive tracker with a sampling rate of 30 Hz and 60 Hz with an accuracy range of between 0.5^{0} and 1^{0} and spatial resolution of 10. The latency of this device is less that 20ms at 60Hz. The data output is binocular gaze data. It requires a computer with USB 3.0 super speed connection [39]. It provides a calibration at 9, 12, and 16 points and its operating range is between 45 and 75 centimeters. The application programming interface (API) was implemented using C# and SQL server 2012 on Visual studios 2014 integrated development environment (IDE). Participants performed the search tasks using a Windows 8 Dell desktop with a 25 inch flat panel display monitor. The main purpose of having a 25 inch monitor is to avoid scrolling by displaying all the search results and to provide better spacing which increases accuracy of eye gaze data. In addition, since our participants are older adults (age 65 and over), having a larger screen size will increase the readability of the fonts. The prototype was implemented using HTML5, JavaScript, PHP, MySQL, C#, and SQL server 2012. The system was configured to run on Google chrome version 36.0. All data entry was done using the standard Dell desktop keyboard and mouse. Figure 4-1 demonstrates the EyeTribe eye tracker device used for this research.

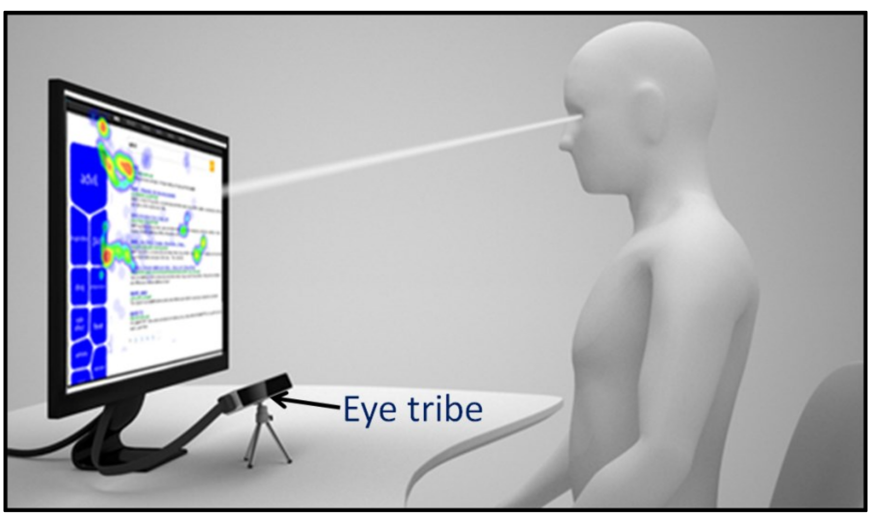

Figure 4-1. The eye tribe eye tracker device

Task Scenarios

A one-minute training task was given to each participant before they began the search task. The objective of the training task was that when conducting the first pilot study, we found out that only four out of nine participants clicked the user interfaces that contain clustered result displayed at the left of the vertical search result list (see Figure 4-1). Two of the participants reported that they considered the clustered interfaces as ads whereas three did not understand its purpose. For this reason we conducted a second pilot study with training task before starting the search task. The primary reason for conducting this study was to train the participants to realize that the cluster results are clickable and provide filtered search results when clicked. From the first pilot study, we found out that the average task completion time for a given search task was 39 seconds. However, since our target participants were older adults, we increased the training time to 60 seconds. A screen capture that demonstrated this was provided to the participants before they began the search task. Eight participants, who did not participate in the first study, were recruited for the second pilot test. The results from the second pilot indicated that six of the participants clicked the clustered search results multiple times. This result clearly indicated that training helped participants to understand that the clustered results were part of the search user interfaces. Therefore, we hoped that this training will help older adults understand that the clustered results provided are part of search result list.

In addition, from the second pilot study, we also identified that digitally presenting the search task instruction (i.e instead of using paper) improved the quality of gaze data by minimizing unnecessary head movements. All the ten search tasks were presented with a full screen (see Figure 4-2). Figure 4-2 depicts the overall task flow that each of the participants followed when performing the search tasks. The task flow started with a welcome screen followed by search task, and a splash screen that transfers the users to the next search task after selecting the desired search result until the users completed all the search tasks.

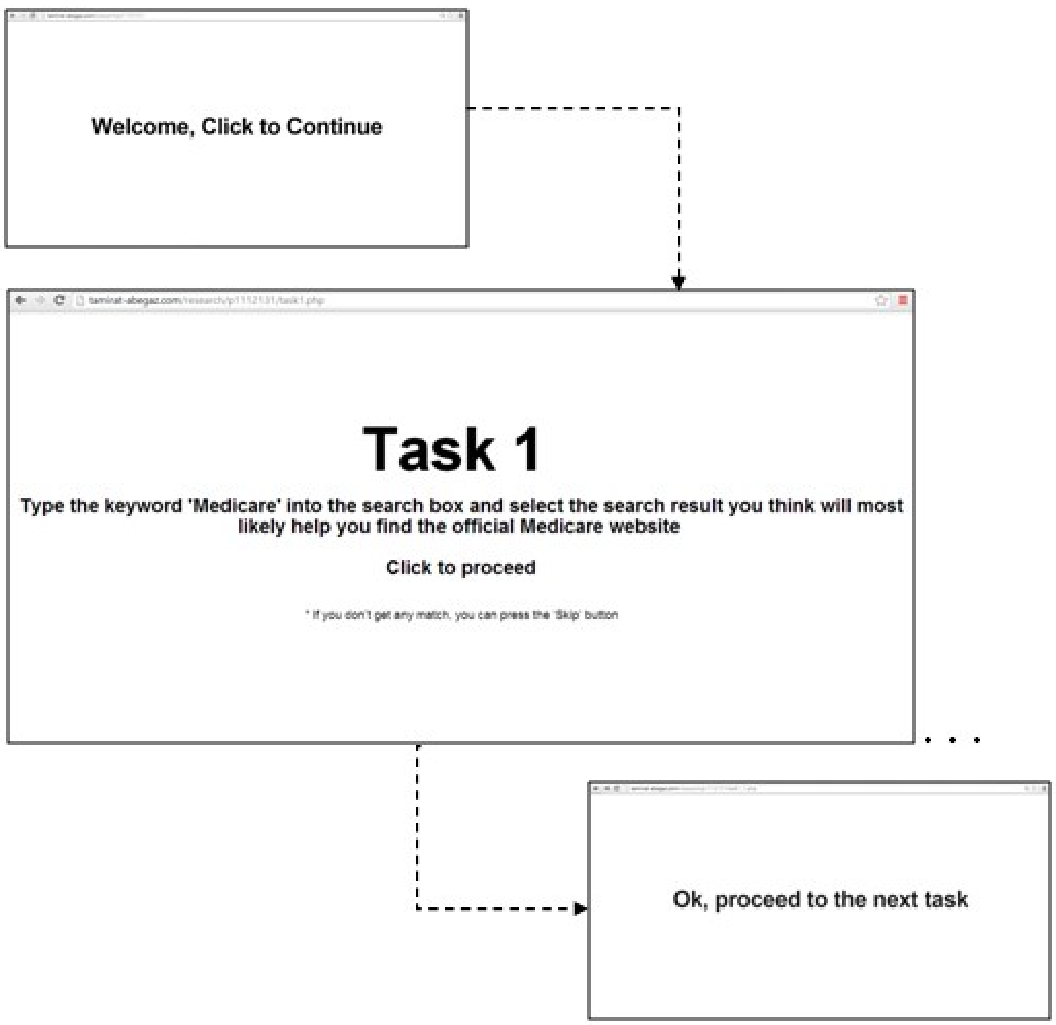

Figure 4-2. Demonstration of on-screen instructions related to search task

The intent of each of the respective search tasks was given as flows. Task 1 asks the user to find the official site of the Medicaid program, 2) to get information on how to make wine, 3) to find out the side effect of Advil 4) to reserve (book) a hotel for your next travel 5) to find the official website for Stanford University, 6) to purchase a watch, 7) to find the nearest pre-school, 8) to locate the official website of the New York Times, 9) to obtain information about the causes of snoring, and 10) to get information about the natural process of rock formation (see Appendix A). All of the keywords were purposefully selected to have neutral emotional content and to have to have at least some importance to the older participants [40-43]. Each task is assigned for distinct user interfaces. The study was designed using Latin square model to counterbalance the learning effects, and to reduce biases and tiredness due to order effects.

Experimental Procedures

This study was conducted in two sites: OLIE conference room and Clemson Central library. Both locations were very similar in their walls color. As recommended by Pernice and Nielsen [44], for both locations, a fixed chair was selected for the participants to sit in order to reduce head and body movement. Upon arrival, each participant was greeted and provided with an informed consent form. The informed consent form explained the purpose of the study, risks, benefits, and that the study was voluntary and could be ended at any time. If the participant agreed to continue, he/she was provided with a demographic questionnaire. The demographic questionnaire included questions about the participant's personal characteristics including their age, gender, race, educational background, their vision state (e.g. whether they have normal or corrected vision, or are partially or fully blind), and experience with search engines. After completing the demographic survey, the participant was then asked to sit as comfortable as possible. The eye tracker was then calibrated using 9 points, and the users were asked to follow the dot as with their eyes as it moves around the computer screen [38]. After the calibration process was completed, a one-minute demonstration was presented to the users in order to familiarize them with shape based prototype search engine interfaces. Following the practice, the actual search tasks were presented to each users.

After completing the search task, each participant was then escorted to a table that showed all the ten search interfaces labeled from A to J and was asked to provide their subjective rating (see Appendix A). All users were forced to select their five favorite interfaces and rank them based on their preference. In order to avoid content bias, all of the search interfaces display the same query results. In addition, each participant was told that the subject preference ratings are not based on the content. After their ranking was completed a short debriefing session was conducted with those participants who didn't click any of the clustered based prototypes. They were asked why they disregarded the clustered results. Afterward, the participant was thanked and provided with $15 USD for their participation in the study. The whole experimental process took between 25 to 35 minutes to complete. Figure 4-3 shows an example snippet of each positive affect level (high, neutral, and low) in experiment for 'Medicare' search query for wsCloud search interface.

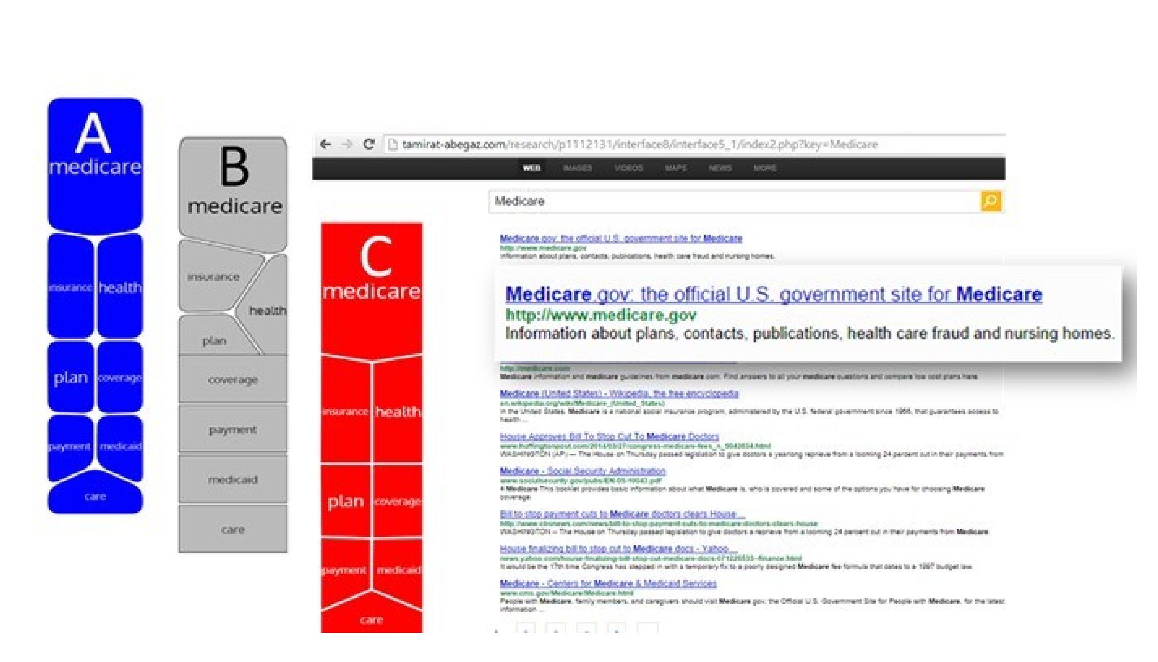

Figure 4-3. Examples of wsCloud interface types: a) high, b) neutral, and c) low positive affect levels

Experimental Design and data analysis

As stated in the methodology section, the experimental data was collected using the EyeTribe eye tracker, which is a non-intrusive tracker with binocular gaze data output. Ten neutral search queries were selected for search task. A preliminary analysis including gender as a between subject factor revealed no significant main or interaction effects, so it was omitted for further consideration. Therefore, this study is adjusted as a 3 by 4 repeated measure factorial design ANOVA with two independent variables (IVs). The first IV is positive affect which includes three levels: high, neutral, and low. The second IV (i.e., search interface type) contains four conditions: baseline (control), wCloud, sCloud, and wsCloud. The dependent variables (DVs) are search thoroughness, and user perception of the search engine user interfaces. Search thoroughness is a measure that depicts the number of AOIs that contains at least one eye fixation. In other words, search thoroughness measures the number of search results the searchers read before they make a decision to either leave the search or select one from the list. Positive affect level and search interface type were analyzed for search thoroughness and user preferences. Figure 4-4 shows the gaze plot for the search task using the keyword Medicare. Only three AOIs contain a visible fixation. Therefore, the number of search results viewed by a given participant for accessing the official website of Medicare.gov is three.

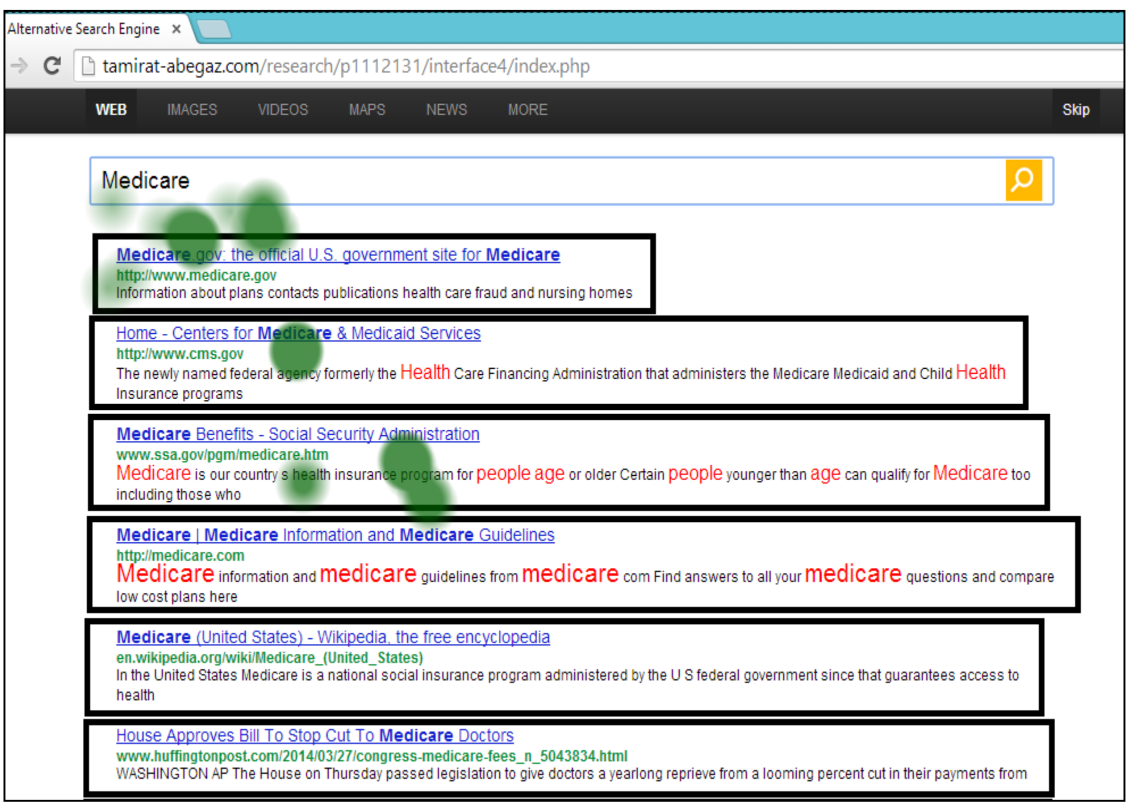

Figure 4-4. Sample Gaze plot for a search task using the keyword ‘Medicare’.

RESULTS

Search Thoroughness

The descriptive statistics of the influence of emotional design elements on search performance are provided in Table 4-2. As shown in Table 4-2, mean search thoroughness for sCloud increase as the level of positive affect decreases. The means search thoroughness of sCloud search interface type for high, neutral, and low positive affect level are 2.00, 2.82, and 3.85, respectively. However, Table 4-2 shows that the control, wCloud, and wsCloud search interfaces type did not follow this pattern. Further data analysis was required to find out the statistical significance of each of the conditions. For Search thoroughness, Table 4-3 shows that the analysis indicated a statistically significant interaction between positive affect level and search interface type, F (3.2, 121.602) =3.525, ρ=0.015, η_p^2 =0.09 .

Search Interface Type	**Positive Affect Level**	**Mean**	**Std.Dev**
Control	(High= Neutral= Low)	2.54	1.54
wCloud	High (wBlue)	2.56	1.12
	Neutral (wBlack)	2.74	1.38
	Low (wRed)	2.71	1.78
sCloud	High (sRound)	2.00	1.05
	Neutral (sMixed)	2.82	1.78
	Low (sAngular)	3.85	2.55
wsCloud	High (wsRoundBlue)	3.33	1.36
	Neutral (wsMixedGray)	2.97	1.91
	Low (wsAngular)	3.31	2.04

Table 4-2. Descriptive Statistics of Search Thoroughness

Source of Variance	SS	df	MS	F	P(Sig)	Partial Eta Squared
Search Interface Type	28.256	2.461	11.480	2.437	0.680	0.15
Error (Search Interface Type)	440.577	114	3.865			
Positive Affect Level	23.389	2	11.694	6.627	0.002	0.06
Error (Positive Affect Level)	134.111	76	1.765			
Search Interface Type * Positive Affect Level	48.321	3.200	15.100	3.525	0.015	0.09
Error (Search Interface Type * Positive Affect Level)	520.864	121.602	4.283			

Note: SS=Sum of Square, MS=Mean Square, Result of 4 (Search Interface Type: Control, wCloud, sCloud, wsCloud) * 3 (Positive Affect Level: High, Neutral, Low)

Table 4-3. Repeated Measure two-way ANOVA for Search Thoroughness

For search thoroughness, Figure 4-5 shows the plot of the comparisons of estimated mean differences in search thoroughness by positive affect level and search interface type. As shown in Figure 4-5, search thoroughness for control search interface type does not change over the level of positive affect. Similarly, the wCloud search interface type was relatively unaffected by the level of positive affect. However, the plot in Figure 4-5 shows that as the level of positive affect decreases, the values of search thoroughness increases. This is consistent with our prediction. In addition, the plot for sCloud crosses all the plot depicting a potential disordinal interaction effect. With regards to the wsCloud search interface type, the result was not consistent with our expectation. In general, the plot in Figure 4-5 shows that for sCloud, low positive affect level led to higher search thoroughness followed by neutral, and higher positive affect levels, respectively. However, this pattern did not reflect to the rest of the search interface alternatives.

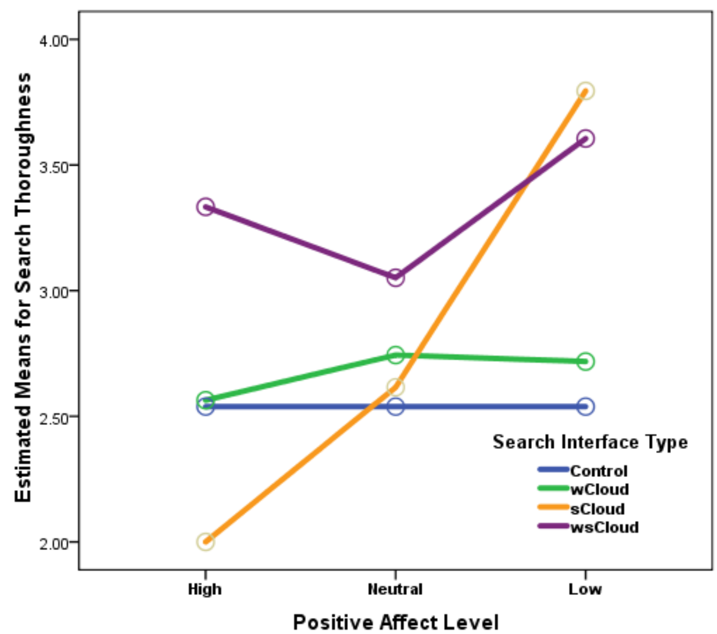

Figure 4-5. Estimated means for search thoroughness of positive affect level for each type of search interface

Follow up analysis of mean differences on search thoroughness for search interface types at each level of positive affect were performed. The result indicated that statistical significance of mean search thoroughness was observed for sCloud search engine interface type. However, for all the other alternatives of search interface types, the results indicated that the mean search thoroughness were not statistically significant. Furthermore, as shown in Table 4-4, post-hoc pair-wise comparisons of mean search thoroughness for sCloud at each level of positive affect indicated that there was statistical significance difference between high (M=2.00; SD=1.05) versus low (M=3.85; SD=2.55) positive affect levels. However, the result indicated that there were no significance differences between high vs. neutral (M=2.82; SD=1.78) or neutral vs. low.

Comparisons by Search Interface Type	Estimated Mean Difference	Standard Error of Difference Mean	Sig (p)	Bonferroni Adjustment 95% CI
Control				
High vs. Neutral	0	0.37	1.00	-0.90, 0.90
High vs. Low	0	0.37	1.00	-0.90, 0.90
Neutral vs. Low	0	0.37	1.00	-0.90, 0.90
wCloud				
High vs. Neutral	-0.18	0.37	1.00	-1.08, 0.72
High vs. Low	-0.15	0.37	1.00	-1.05, 0.74
Neutral vs. Low	0.03	0.37	1.00	-0.87, 0.92
sCloud				
High vs. Neutral	-0.62	0.37	0.301	-1.51, 0.28
High vs. Low	-1.79	0.37	0.000*	-2.69, -0.89
Neutral vs. Low	-1.18	0.37	0.050	-2.08, -0.28
wsCloud				
High vs. Neutral	0.28	0.37	1.00	-0.62, 1.18
High vs. Low	-0.28	0.37	1.00	-1.18, 0.62
Neutral vs. Low	-0.56	0.37	0.394	-1.46, 0.33

Note: *p< 0.05, where p-values are adjusted using Bonferroni method

Table 4-4. Mean Differences in Search Thoroughness by Positive Affect Level and Search Interface Type

Similarly, the mean difference in search thoroughness for positive affect level at each search interface type indicated that low level of positive affect was significant (see Table 4-5). However, for both high and neutral positive affect levels, the result indicated that there were no statistical differences for mean search thoroughness. Moreover, post-hoc pair-wise comparisons of mean search thoroughness for low positive affect level at each type of alternative search interface indicated that there were statistical significance difference between sCloud vs. wsCloud and wCloud vs. sCloud alternative search interface types.

Comparisons by Positive Affect Level		**Estimated Mean Difference**	**Standard Error of Difference Mean**	**Sig (p)**	Bonferroni Adjustment 95% CI
High					
	Control vs. wCloud	-0.03	0.37	1.00	-1.02, 0.94
	Control vs. sCloud	0.54	0.37	0.89	-0.45, 1.53
	Control vs. wsCloud	-0.79	0.37	0.20	-1.78, 0.19
	wCloud vs. sCloud	0.56	0.37	0.79	-0.43. 1.55
	wCloud vs. wsCloud	-0.77	0.37	0.24	-1.76, 0.22
	sCloud vs. wsCloud	-1.33	0.37	0.02*	-2.32, -0,34
Neutral					
	Control vs. wCloud	-0.21	0.37	1.00	-1.19, 0.78
	Control vs. sCloud	-0.08	0.37	1.00	-1.07, 0.91
	Control vs. wsCloud	-0.51	0.37	1.00	-1.50, 0.48
	wCloud vs. sCloud	0.13	0.37	1.00	-0.86, 1.12
	wCloud vs. wsCloud	-0.31	0.37	1.00	-1.29, 0.68
	sCloud vs. wsCloud	-0.44	0.37	1.00	-1.43, 0.55
Low					
	Control vs. wCloud	-0.18	0.37	1.00	-1.17, 0.81
	Control vs. sCloud	-1.26	0.37	0.05	-2.25, -0.27
	Control vs. wsCloud	-1.08	0.37	0.025*	-2.07, 0.09
	wCloud vs. sCloud	-1.08	0.37	0.025*	-2.07, -0.09
	wCloud vs. wsCloud	-0.89	0.37	1.00	-1.89, 0.09
	sCloud vs. wsCloud	0.18	0.37	1.00	-0.81, 1.17

Note: *p< 0.05, where p-values are adjusted using Bonferroni method

Table 4-5. Mean Differences in Search Thoroughness by Search Interface Type and Positive Affect Level

User Preference

The descriptive statistics of the influence of emotional design elements on search performance are provided in Table 4-6. Table 4-6 shows that the mean user preference ratings for all the wCloud, sCloud, and wsCloud search interface types follow a similar pattern in that neutral positive affect level rating was the lowest. Further data analysis is required to find out the statistical significance of each of the conditions of alternative search engine interfaces.

Search Interface Type	Positive Affect Level	Mean	Std.Dev
Control	(High= Neutral= Low)	1.10	1.88
wCloud	High (wBlue)	0.95	1.52
	Neutral (wBlack)	0.85	1.35
	Low (wRed)	0.95	1.67
sCloud	High (sRound)	1.18	1.45
	Neutral (sMixed)	1.51	1.55
	Low (sAngular)	1.41	1.48
wsCloud	High (wsRoundBlue)	3.15	2.10
	Neutral (wsMixedGray)	1.79	1.67
	Low (wsAngualr)	2.08	2.02

Table 4-6. Descriptive Statistics of User Preference

Regarding user preference, Figure 4-6 presents the plot of the comparisons of estimated mean differences in user preference by positive affect level and search interface type. As shown in Figure 4-6, user preference for control search interface type does not change over the level of positive affect. Similarly, the mean values in user preference for wCloud and sCloud are roughly constant across all levels of positive affect. In addition,

Figure4-6 shows that the mean user preference values for each of the positive affect levels of wsCloud are higher than the rest of the search interface types. Further analysis is required to identify the interaction effect of positive affect and search interface types for user preference.

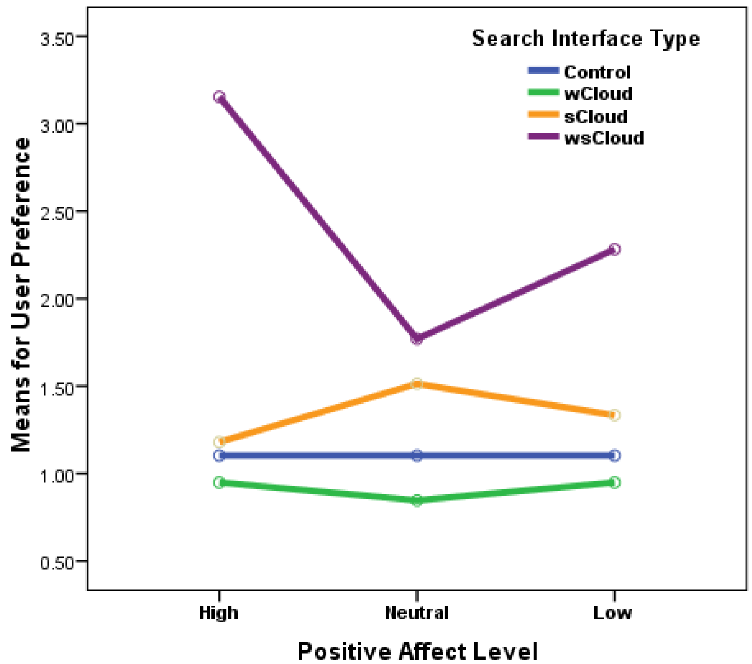

Figure 4-6. Estimated means for user preference of positive affect level for each type of search interface

Further analysis provides interesting findings for user preference ratings for alternative search engine interfaces. For instance, Table 4-7 presents the analysis results for the effects of user preference for positive affect level and search interface type. It indicated that there was a statistically significant interaction between positive affect level and search interface type, F (4.421, 167.991) =4.358, $\rho<0.0001$, $\eta_p^2= 0.086$. Similar to search thoroughness, follow-up analysis for comparisons of mean differences in user preference of search interface types at each level of positive affect were performed. As shown in Table 4-8, the results indicated that color/shape combination based alternative search engine interface type (i.e. wsCloud) was significant. However, for all the other alternatives of search engine search interface types including the control, wCloud, and sCloud, the results indicated that the mean user preference were not statistically significant. Furthermore, post-hoc pair-wise comparisons of mean user preference for wsCloud at each level of positive affect indicated that there was statistical significance difference between high (M=3.15; SD=2.10) vs. neutral (M=1.79; SD=1.67) positive affect levels. However, the result indicated that there were no significance differences between high vs. low (M=2.08; SD=2.02) and neutral vs. low.

Source of Variance	**SS**	**df**	**MS**	**F**	**P(Sig)**	**Partial Eta Squared**
Search Interface Type	151.197	1.882	79.792	6.598	0.000	0.11
Error (Search Interface Type)	864.970	114	7.587			
Positive Affect Level	6.722	2	3.361	2.106	0.129	0.041
Error (Positive Affect Level)	121.278	76	1.596			
Search Interface Type * Positive Affect Level	35.944	4.421	8.131	4.358	0.000	0.086
Error (Search Interface Type * Positive Affect Level)	313.389	167.991	1.866			

Result of 4 (Search Interface Type: Control, wCloud, sCloud, wsCloud) * 3 (Positive Affect Level: High, Neutral, Low)

Table 4-7. Repeated Measure two-way ANOVA for User Preference

Comparisons by Search Interface Type	**Estimated Mean Difference**	**Standard Error of Difference Mean**	**Sig (p)**	Bonferroni Adjustment 95% CI
Control				
High vs. Neutral	0	0.39	1.00	-0.94, 0.94
High vs. Low	0	0.37	1.00	-0.94, 0.94
Neutral vs. Low	0	0.39	1.00	-0.94, 0.94
wCloud				
High vs. Neutral	-0.10	0.39	1.00	-0.84, 1.05
High vs. Low	0	0.39	1.00	-0.94, 0.94
Neutral vs. Low	-0.1	0.39	1.00	-1.05, 0.84
sCloud				
High vs. Neutral	-0.33	0.39	1.00	-1.28, 0.61
High vs. Low	-1.15	0.39	1.00	-1.09, -0.79
Neutral vs. Low	0.18	0.39	1.00	-0.76, 1.12
wsCloud				
High vs. Neutral	1.38	0.39	0.001*	0.44, 2.33
High vs. Low	0.87	0.39	0.081	-0.07, 1.82
Neutral vs. Low	-0.51	0.39	0.577	-1.46, 0.43

Note: *p< 0.05, where p-values are adjusted using Bonferroni method

Table 4-8. Mean Differences in User Preference by Positive Affect Level and Search Interface Type

Moreover, comparisons of mean difference in user preference of positive affect level at each search interface type were performed. As shown in Table 4-9, the result indicated that high and low levels of positive affect were significant. However, for neutral positive affect levels, the result indicated that there was no statistical difference. Therefore additional follow-up analysis was required to find out which of the alternative search interface types are significant for high and low positive affect levels. Overall, the post-hoc pair-wise comparisons of mean user preference for high positive affect level at each type of alternative search interface indicated that there were statistical significance differences between control vs. wsCloud and sCloud vs. wsCloud search alternatives. In addition, the post-hoc pair-wise comparisons of mean user preference for low positive affect level at each type of search interface indicated that there was statistical significance difference between control vs. wsCloud pair only.

Comparisons by Positive Affect Level	Estimated Mean Difference	Standard Error of Difference Mean	Sig (p)	Bonferroni Adjustment 95% CI
High				
Control vs. wCloud	0.15	0.39	1.00	-0.89, 1.19
Control vs. sCloud	-0.78	0.39	1.00	-1.12, 0.96
Control vs. wsCloud	-2.05	0.39	0.000*	-3.09, -1,01
wCloud vs. sCloud	-0.23	0.39	1.00	-1,27, 0,81
wCloud vs. wsCloud	-2.21	0.39	1.00	-0,81, 1.27
sCloud vs. wsCloud	-1.97	0.39	0.000*	-3.01, -0.93
Neutral				
Control vs. wCloud	-0.21	0.39	1.00	-0.78. 1.29
Control vs. sCloud	-0.08	0.39	1.00	-1.45, 0.63
Control vs. wsCloud	-0.51	0.39	0.54	-1.71, 0.37
wCloud vs. sCloud	0.13	0.39	0.12	-1.71, 0.37
wCloud vs. wsCloud	-0.31	0.39	0.54	-1.96, 0.12
sCloud vs. wsCloud	-0.44	0.39	1.00	-1.29, 0.78
Low				
Control vs. wCloud	-0.18	0.39	1.00	-0.89, 1.19
Control vs. sCloud	-1.26	0.39	1.00	-1.27, 0.81
Control vs. wsCloud	-1.08	0.39	0.017*	-2.22, -1.39
wCloud vs. sCloud	-1.08	0.39	1.00	-1.43, 0,66
wCloud vs. wsCloud	-0.89	0.39	0.04	-2.37. -0.29
sCloud vs. wsCloud	0.18	0.39	0.097	-1.99, 0.09

Note: *p< 0.05, where p-values are adjusted using Bonferroni method

Table 4-9. Mean Differences in User Preference by Search Interface Type and Positive Affect Level

GENERAL DISCUSSIONS & IMPLICATIONS

Search thoroughness

For search thoroughness, the analysis results indicated that there were significant interaction effects of positive affect level by search interface type. Further analysis indicated that shape based alternative search interface type (i.e., sCloud) was statistically significant. In terms of color, prior research reported conflicting results. For instance, in terms of red color, Elliot et. al. [45, 46] and Aslam M [47] reported that red color is associated degradation of performance whereas Metha and Zhu [48] indicated that red enhances performance. However, our results on color based search interface types did not provide significant differences. In terms of shape, however, consistent with prior researches, our results indicated that those participants who were exposed to positive mood induction (rounded shape) searched less as compared to the neutral (mixed shape) or low (angular shape). Specifically, the mean search thoroughness of sCloud with high level positive affect was 2.0, which is lower than the neutral (2.82). Similarly, the mean search thoroughness of low level positive affect was 3.85, which is higher than the neutral or high positive affect level. This indicates that the shape based design elements with rounded curvatures resulted in superficial search. In other words, the research findings indicated that people in positive mood make faster decisions with a superficial focus on important attributes.

Furthermore, post-hoc pair-wise comparisons of mean search thoroughness for sCloud at each level of positive affect indicated that there was statistical significant difference between high vs. low positive affect levels pair only. In comparing the effect of positive affect for search thoroughness, the results indicated that only low level positive affect produced a statistical significant result. Additional post-hoc pair-wise comparisons of mean search thoroughness for low positive affect level at each type of alternative search interface reveled significance difference between the baseline and wsCloud, and wCloud vs. sCloud alternative search interface types. In both cases, it seems that shape plays an important role to affect search performance since both wsCloud and sCloud contain shape emotional design elements. Overall, search performance related variables indicated that participants when encounter angular shaped search interface type searched more thoroughly than all other search interface types. However, the results also indicated that in terms of performance variables, there is no conclusive indication about the impact of color on search thoroughness.

In comparing the scan behavior of participants, the aggregate heat map indicated that all search engine interface alternatives including the control were roughly mapped with the popular golden triangle scan shape [33]. However, looking more closely at sCloud and wsCloud interface alternatives, an interesting scan behavior was observed. Prior research indicated that the side sponsored ads attracted users' at the later stage of their search activities. Perhaps this might be the case of participants' behavior for this research [33]. As shown in Figure 4-7, participants did not give attention to the top results of the clustered interface provided as part of sCloud and wsCLoud search interface alternatives. However, closely looking at the heat map presented in Figure 4-7, it seemed that users gave more attention at the top organic search results and ignore the boxed results and when they looked further down the search results, the boxed results seemed to attract their attention. Apparently, from our preliminary study we learned that many participants thought the boxed results shown in as sponsored ads and have ignored them. This may be the case that when searchers spend more time, they might give a considerable attention to what is available. This perhaps means that participants looked the shape based interface parts after they looked the top part of the search results.

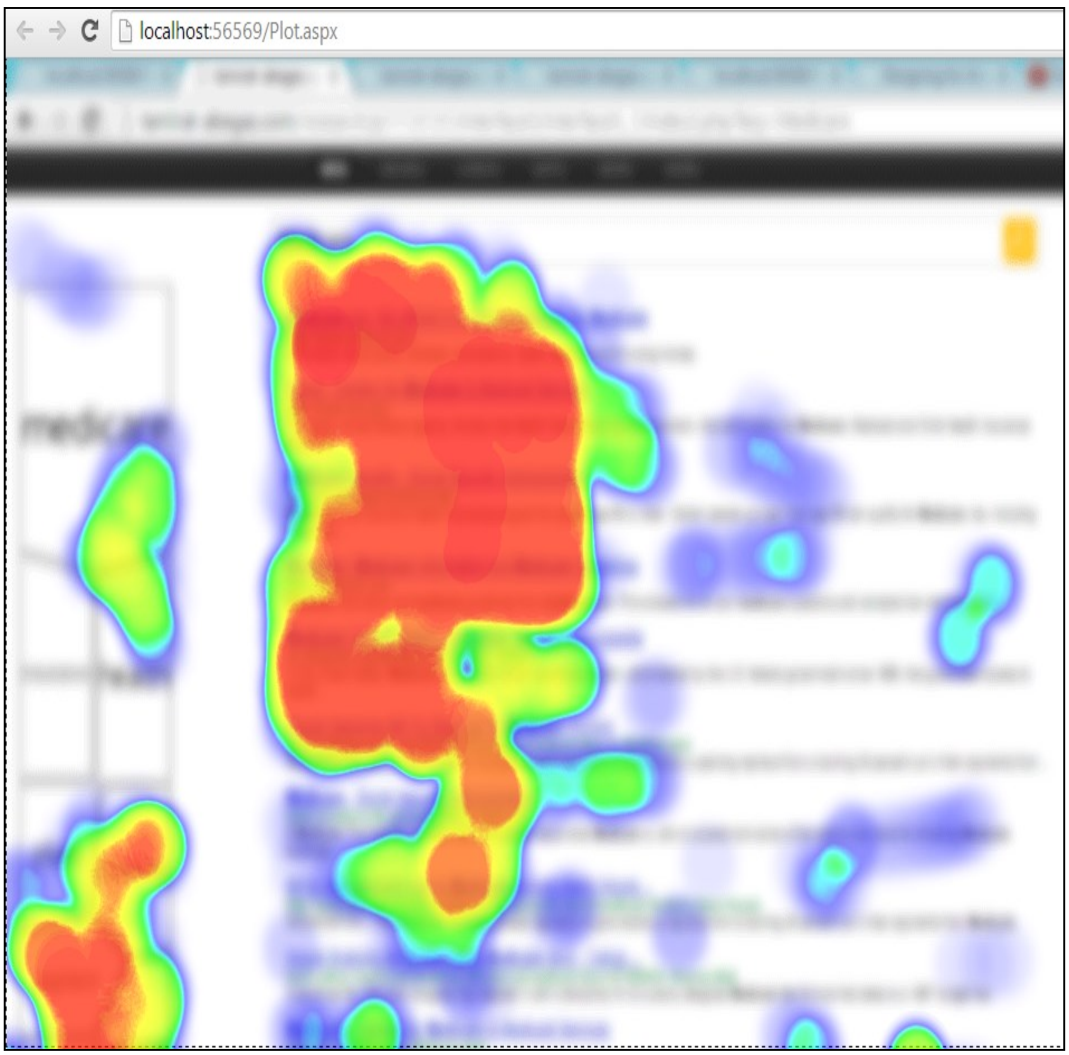

Figure 4-7. Sample heat map plot for aggregate search thoroughness for sCloud based interface

User Preferences

Regarding user preference, the analysis result indicated that there were significant interaction effects of positive affect level by search interface type. Further analysis of comparing the positive affect level for each types of alternative search interface showed that combination of color and shape based alternative search interface type (i.e., wsCloud) was statistically significant. This shows that among all categories of alternative search interface, the wsCloud (see Figure 4-3) interface type is the most preferred. Further investigation using pair-wise comparisons of mean difference user preference values for wsCloud at each level of positive affect indicated that there was statistical significance difference between high vs. neutral positive affect levels pair only. This implies that there was no significant difference between blue/round and red/angular combination interface types. Indirectly, this indicated that blue/round and red/angular are more or less perceived equally positively. This does not concur with our expectation. In terms of red color, prior searches reported conflicting findings [30-37]. Overall, user preference related variables showed that participants seemed to enjoy searching using color/shape combination interface types.

CONCLUSION

In conclusion, this study explores mood induction effectiveness using low-level visual design elements such as color and shape. These primitive design elements are embedded into search engine user interfaces. The colors are included as either foreground or background based on the interface design type used. The shapes included in the study are rounded, mixed, and angular edges. In addition, combination of shape and color was also explored in the study. The major goal of this research is to examine the effectiveness low level design elements such as color (foreground and background), shape (angular vs. rounder edges), or both shape and color into search engine interfaces on search thoroughness and user satisfaction. Search based performance variables showed that participants searched more thoroughly using interface types that integrate angular shape features. In addition, preference variables also indicated that participants seemed to enjoy searching using color/shape combination of search interface type. Overall, major findings were: a) shape emotional design elements impact search performance. Specifically, the findings indicated that rounder shape generally led to superficial search whereas angular shape led to a more thorough search behavior on users; b) color and color/shape combination did not significantly affect search performance; and c) color/shape combination based search interface alternative design was the most preferred interface. In general, the results of the investigation suggest that seamless integration of low level emotional design elements into currently existing search engine interfaces could potentially improve web search experience.

LIMITATIONS

Our results may have implications for real world search based decision making. Overall, the results indicated that negative emotion could lead to limited search, and this limited search could in turn results in decreased decision quality. Furthermore, our results indicated that color was not effective in influencing users search performance. One possible reason for this could be that color emotional design elements used on search interface may not be sufficiently influencing participants' search behavior. Alternatively, this search explored limited colors. Therefore, exploring additional combination of colors and varying the intensity could potentially lead to significant results. In terms of the participants' educational and search engine experience, the descriptive statistics showed that the sample of older adults was highly educated and had a working experience in search engine utilization (see Table 4-1). Consequently, the results might not be representative to the general populations of older generation. However, despite these limitations, the findings of this research will be of interest to a wide range of applications and areas such as user experience researches and practices, affective computing, information visualization, and gaming industry.

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CHAPTER FIVE

CONCLUSIONS & FUTURE WORK

Search is a mode and a method of interaction with rest of the world. Search engines become intimate friends literally to all categories of users spanning children, the young and older adults. Many search engine users, including older adults, rely on search engine rankings. Arguably, it may be acceptable to say that search engine results have a near spiritual quality in the mindset of many users. However, the fact that a particular website appears at the top of the list does not necessarily indicate that it is a desired search result. There are a number of attractive, but deceptive entities that manipulate search engine rankings; some involve criminal activities that specifically target older adults (e.g. financial crime). A number of studies indicated that older adults generally search less information before making decisions. This research approaches the question as to why older adults search less and how this search behavior could be improved. The research is motivated by the broader issues of older users' search behavior, while focusing on the emotional usability of search engine user interfaces. As a result, this research attempted to accomplish the following three objectives: a) to explore the usage of low level design elements as emotion manipulation tools b) to seamlessly integrate them into currently existing search engine interfaces, and finally c) to investigate the impact of emotional design elements on search performance and user satisfaction. Therefore, to achieve these objectives, two usability studies were conducted.

As reported in Chapter Two, study one was conducted to evaluate the effectiveness of low level emotional design elements in mood induction capability compared to the traditional emotion induction methods such as facial or vocal expression. The analysis results from first study showed that the selected emotional design elements have strong emotion induction capability. Specifically, the results indicated that blue and red induced positive and negative emotions, respectively. Previous studies indicate that blue has positive emotion induction capability. However, particularly on red color, researchers reported contradictory reports, some indicated it induces positive mood (approach behavior), and others stated that it induces negative emotion (avoidance behavior). Contrary to some research findings, this research indicated that at least for abstract graphical objects, exposing to red color can result in increased negative emotion. Regarding shapes, the result obtained from study one concurs with the prior research findings in that angular and rounder shapes induce negative and positive emotions, respectively.

Hence, this study demonstrates that the selected emotional design elements such as colors and shapes have high visceral effects that could be used to induce the emotional states of users without the users even knowing their existences. This has a significant impact on affective computing research community since these design elements could covertly be integrated into user interface designs to induce the desired emotion onto users. In other words, it is simple and effective and could potentially be used as viable alternative to replace traditional emotion induction tools. Based on the results of study one, a follow up experiment was conducted to find out the relative impact of emotional design elements on search thoroughness and user satisfaction

The results from the second study indicated that search based performance variables showed that participants searched more thoroughly using interface types that integrate angular shape features. In addition, preference variables also indicated that participants seemed to enjoy searching using color/shape combination of search interface type. Overall, major findings were: a) shape emotional design elements impact search performance. Specifically, the finding indicated that rounder shape generally led to superficial search whereas angular shape led to a more thorough search behavior on users; b) color and color/shape combination didn't significantly affect search performance; and c) color/shape combination based search interface alternative design was the most preferred interface. In general, the results indicated that seamless integration of low level emotional design elements into currently existing search engine interfaces could potentially improve web search experience. In general, this research recommends integration these primitive emotional design elements in the design and evaluation of search user interface to improve search experience. This may be achieved by maximizing the effort to empower older people to obtain potentially relevant information.

The findings of this research will be of interest to a wide range of applications and areas such as user experience research and practice, affective computing, information visualization, and gaming industry. Broadly speaking, the results of this study can assist companies to adjust their artifact designs to meet their goals. For instance, if the goal of the product design is to engage users to focus their attention, then angular shaped design elements could be used to induce negative emotion, which in turn enforces the users to exert more effort and time to attain their goal. For example, a website like medicare.gov, acts as a, portal for members to compare insurance companies, physicians, certified nursing homes, and pharmacies. So it is important that they should exhaustively compare the lists before they make decisions to choose one. To covertly encourage members to search thoroughly, the portal could incorporate angular design elements such as buttons, forms, and other interface elements at least for the part of the website that provides search functionality. On the other hand, if the goal an application requires short term decision making, then the application should use rounder shaped design elements.

Future work will be needed to better understand how to integrate low level emotional design elements to effectively influence users' search behavior. More colors from the color spectrum should be investigated to enhance the color usage options to seamlessly integrate colored based emotional design elements in various consumer products. Furthermore, additional research that includes the representative participants from the general population is also beneficial since search is a universal task and we believe, more thorough search will enhance the quality of decision making.

APPENDICES

<u>Appendix A</u>

<u>PROTOCOL & MATERIALS</u>

Email Recruitment Script

Hello, my name is Tamirat Abegaz**.** We are conducting a usability evaluation of search engine user interfaces. We would like to understand things that you find easy to do and things that may be difficult to do during online searching using search engines. In this study, we will be observing what you look at as you perform searching using search user interfaces. So we will use technology to track your eye movements. Your part in the study will be perform online search and provide feedback about the search engine user interfaces. The study will require 30-40 minutes of your time and you will be provided with $15 for your participation.

To be eligible to participate you must be 65 years of age or older. If you are interested in participating, please contact **Tamirat Abegaz** at **tabegaz@clemson.edu or 336-587-3538** to check your eligibility to participate.

Verbal/Telephone Recruitment Script

Hello, my name is Tamirat Abegaz**.** We are conducting a usability evaluation of search engine user interfaces. We would like to understand things that you find easy to do and things that may be difficult to do during online searching using search engines. In this study, we will be observing what you look at as you perform searching using search user interfaces. So we will use technology to track your eye movements. . This will only take a few minutes of your time and no one will attempt to sell you anything. This is strictly for research purposes. To be eligible to participate you must be 65 years of age or older. If you are interested and qualify for the study, you will be paid $15 to participate.

1.1 Pre-Questionnaire

1. What is your education?

   ☐ Did not finish High School

   ☐ High School

   ☐ Some College

   ☐ College Degree

   ☐ Graduate Degree

2. What is your Race or Ethnicity?

   ☐ African American

   ☐ Caucasian

   ☐ Hispanic

   ☐ Asian

   ☐ American Indian

3. What is your gender?

   ☐ Male

   ☐ Female

4. How old are you?

   ☐ 65-74

☐ 75-84

☐ 85 years or older

5. Which of the following best describes your vision?

   ☐ I have normal or corrected to normal vision. “Corrected to normal” means that if you wear glasses or contacts, they allow you to read newspapers, magazines, or books without trouble

   ☐ I can only see some colors; I don’t see red, blue colors

   ☐ I can only read large-print, high contrast text (I cannot read normal-sized text, even when wearing glasses or contacts, unless it is held very close to my face)

6. 22. Which of the following search engines have you used?

☐ Google

☐ Bing

☐ Yahoo

☐ Other

☐ None

Search Task Instructions:

	Task
1	Type the keyword '**Medicare'** into the search box and select the search result you think will most likely help you find the official Medicare website.
2	Type the keyword '**Wine production'** into the search box and select the search result you think will most likely help you get information on how to make a wine.
3	Type the keyword '**Advil'** into the search box and select the search result you think will most likely help you find out the side effects of Advil.
4	Type the keyword '**Reserve hotel**' into the search box and select the search result you think will most likely help you book a hotel for your next travel.
5	Type the keyword 'Stanford University' into the search box and select the search result you think will most likely help find the official website of Stanford University.
6	Type the keyword '**Watch'** into the search box and select the search result you think will most likely help you buy a watch.
7	Type the keyword '**Nursery**' into the search box and select the search result you think will most likely help you find the nearest pre-school.
8	Type the keyword '**NY times'** into the search box and select the search result you think will most likely help you find the official website of the New York Times.
9	Type the keyword '**Snoring'** and select the search result you think will most likely help you to get information about the causes of snoring.
10	Type the keyword '**Rock formation''** and select the search result you think will most likely help get information of the natural process of rock formation you achieve the intended task.

Pre-Survey for User Preference Study (A-J for 'Medicare' Query)


A
WEB
IMAGES
VIDEOS
MAPS
NEWS
MORE
Skip
medicare
Medicare.gov: the official U.S. government site for Medicare
http://www.medicare.gov
Home - Centers for Medicare & Medicaid Services
http://www.cms.gov
Medicare Benefits - Social Security Administration
www.ssa.gov/pgm/medicare.htm
Medicare | Medicare Information and Medicare Guidelines
http://medicare.com
Medicare (United States) - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Medicare_(United_States)
House Approves Bill To Stop Cut To Medicare Doctors
www.huffingtonpost.com/2014/03/27/congress-medicare-fees_n_5043834.html
Medicare - Social Security Administration
www.socialsecurity.gov/pubs/EN-05-10043.pdf
Bill to stop payment cuts to Medicare doctors clears House ...
http://www.cbsnews.com/news/bill-to-stop-payment-cuts-to-medicare-doctors-clears-house
House finalizing bill to stop cut to Medicare docs - Yahoo ...
news.yahoo.com/house-finalizing-bill-stop-cut-medicare-docs-071226533--finance.html
Medicare - Centers for Medicare & Medicaid Services
www.cms.gov/Medicare/Medicare.html
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B
WEB
IMAGES
VIDEOS
MAPS
NEWS
MORE
Skip
medicare
medicare
insurance
health
plan
coverage
payment
medicaid
care
Medicare.gov: the official U.S. government site for Medicare
http://www.medicare.gov
Information about plans, contacts, publications, health care fraud and nursing homes.
Home - Centers for Medicare & Medicaid Services
http://www.cms.gov
The newly named federal agency, formerly the Health Care Financing Administration, that administers the Medicare, Medicaid and Child Health Insurance programs.
Medicare Benefits - Social Security Administration
www.ssa.gov/pgm/medicare.htm
Medicare is our country's health insurance program for people age 65 or older. Certain people younger than age 65 can qualify for Medicare, too, including those who ...
Medicare | Medicare Information and Medicare Guidelines
http://medicare.com
Medicare information and medicare guidelines from medicare.com. Find answers to all your medicare questions and compare low cost plans here.
Medicare (United States) - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Medicare_(United_States)
In the United States, Medicare is a national social insurance program, administered by the U.S. federal government since 1966, that guarantees access to health ...
House Approves Bill To Stop Cut To Medicare Doctors
www.huffingtonpost.com/2014/03/27/congress-medicare-fees_n_5043834.html
WASHINGTON (AP) — The House on Thursday passed legislation to give doctors a yearlong reprieve from a looming 24 percent cut in their payments from ...
Medicare - Social Security Administration
www.socialsecurity.gov/pubs/EN-05-10043.pdf
4 Medicare This booklet provides basic information about what Medicare is, who is covered and some of the options you have for choosing Medicare coverage.
Bill to stop payment cuts to Medicare doctors clears House ...
http://www.cbsnews.com/news/bill-to-stop-payment-cuts-to-medicare-doctors-clears-house
WASHINGTON -- The House on Thursday passed legislation to give doctors a reprieve from a looming 24 percent cut in their payments from Medicare.
House finalizing bill to stop cut to Medicare docs - Yahoo ...
news.yahoo.com/house-finalizing-bill-stop-cut-medicare-docs-071226533--finance.html
It would be the 17th time Congress has stepped in with a temporary fix to a poorly designed Medicare fee formula that dates to a 1997 budget law.
Medicare - Centers for Medicare & Medicaid Services
www.cms.gov/Medicare/Medicare.html
People with Medicare, family members, and caregivers should visit Medicare.gov, the Official U.S. Government Site for People with Medicare, for the latest information ...
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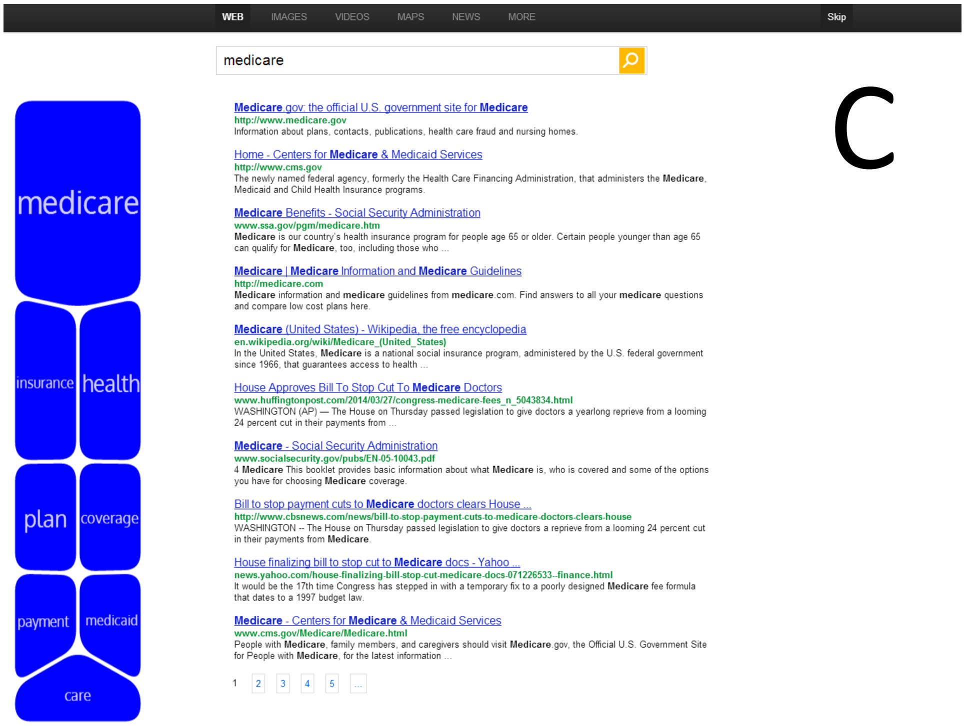
WEB IMAGES VIDEOS MAPS NEWS MORE
Skip
medicare
medicare
insurance
health
plan
coverage
payment
medicaid
care
Medicare.gov: the official U.S. government site for Medicare
http://www.medicare.gov
Information about plans, contacts, publications, health care fraud and nursing homes.
Home - Centers for Medicare & Medicaid Services
http://www.cms.gov
The newly named federal agency, formerly the Health Care Financing Administration, that administers the Medicare, Medicaid and Child Health Insurance programs.
Medicare Benefits - Social Security Administration
www.ssa.gov/pgm/medicare.htm
Medicare is our country's health insurance program for people age 65 or older. Certain people younger than age 65 can qualify for Medicare, too, including those who ...
Medicare | Medicare Information and Medicare Guidelines
http://medicare.com
Medicare information and medicare guidelines from medicare.com. Find answers to all your medicare questions and compare low cost plans here.
Medicare (United States) - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Medicare_(United_States)
In the United States, Medicare is a national social insurance program, administered by the U.S. federal government since 1966, that guarantees access to health ...
House Approves Bill To Stop Cut To Medicare Doctors
www.huffingtonpost.com/2014/03/27/congress-medicare-fees_n_5043834.html
WASHINGTON (AP) — The House on Thursday passed legislation to give doctors a yearlong reprieve from a looming 24 percent cut in their payments from ...
Medicare - Social Security Administration
www.socialsecurity.gov/pubs/EN-05-10043.pdf
4 Medicare This booklet provides basic information about what Medicare is, who is covered and some of the options you have for choosing Medicare coverage.
Bill to stop payment cuts to Medicare doctors clears House ...
http://www.cbsnews.com/news/bill-to-stop-payment-cuts-to-medicare-doctors-clears-house
WASHINGTON -- The House on Thursday passed legislation to give doctors a reprieve from a looming 24 percent cut in their payments from Medicare.
House finalizing bill to stop cut to Medicare docs - Yahoo ...
news.yahoo.com/house-finalizing-bill-stop-cut-medicare-docs-071226533--finance.html
It would be the 17th time Congress has stepped in with a temporary fix to a poorly designed Medicare fee formula that dates to a 1997 budget law.
Medicare - Centers for Medicare & Medicaid Services
www.cms.gov/Medicare/Medicare.html
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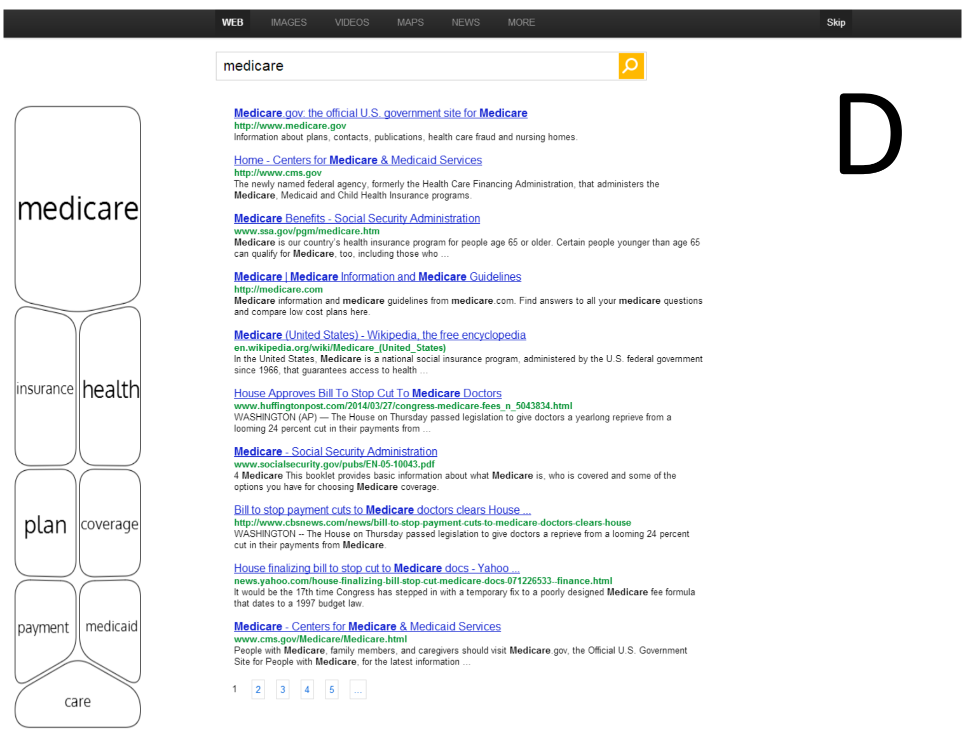
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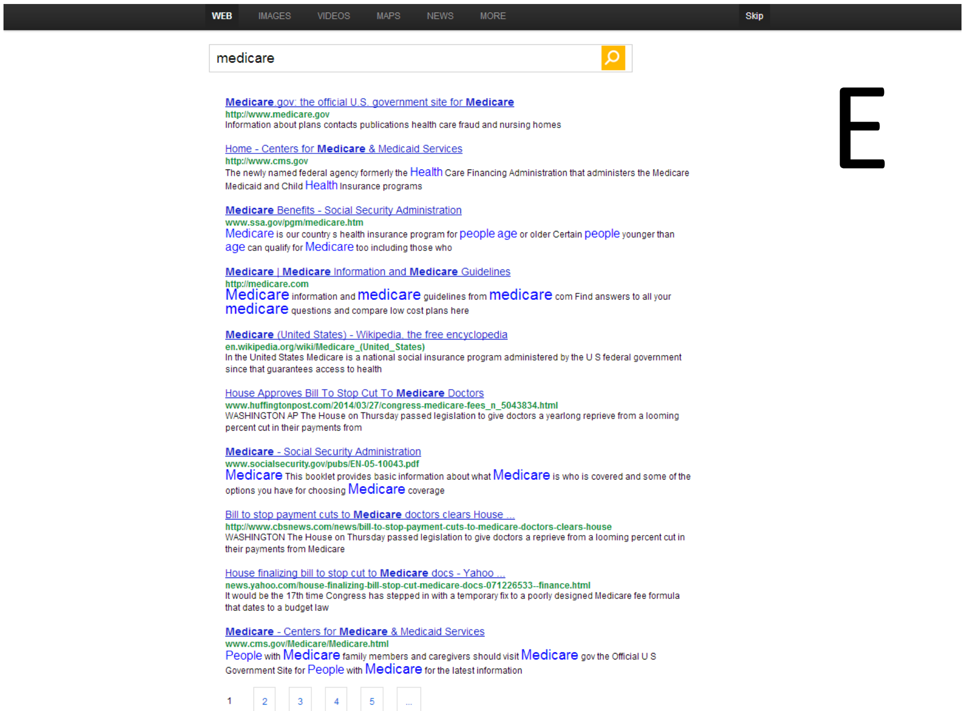
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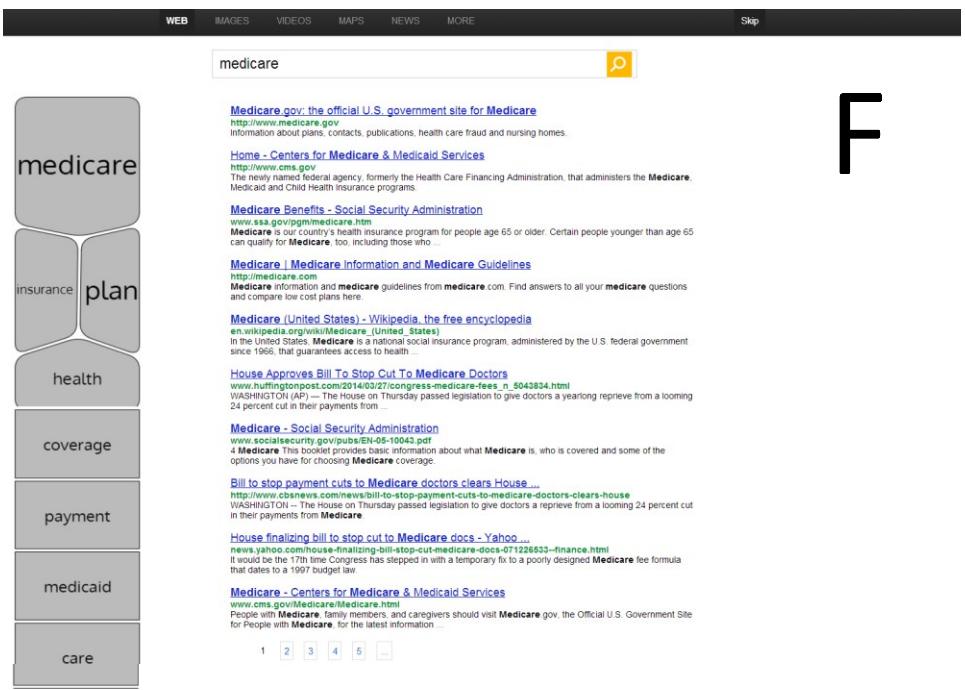
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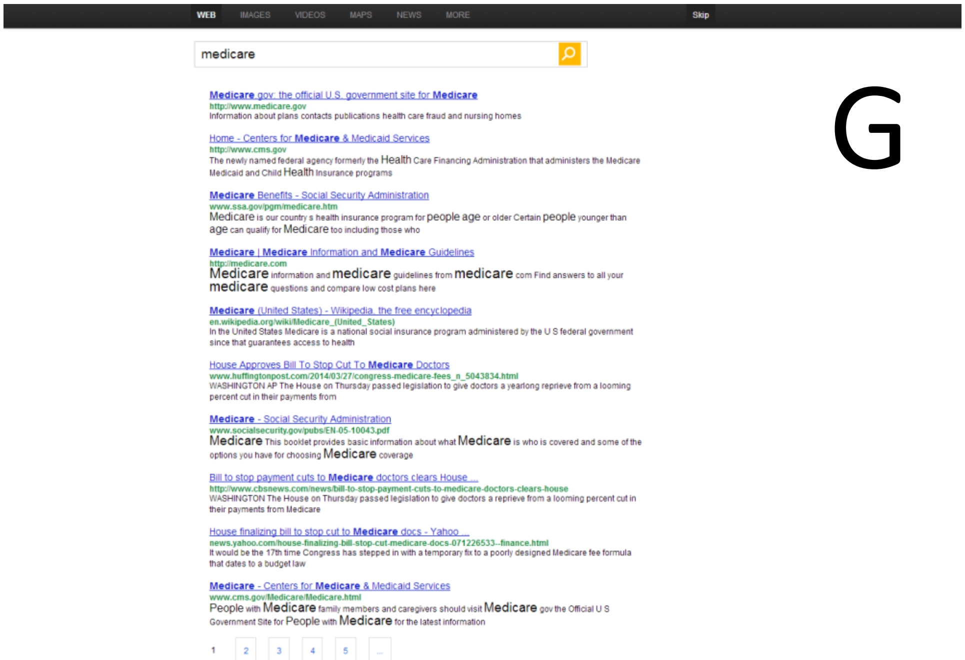
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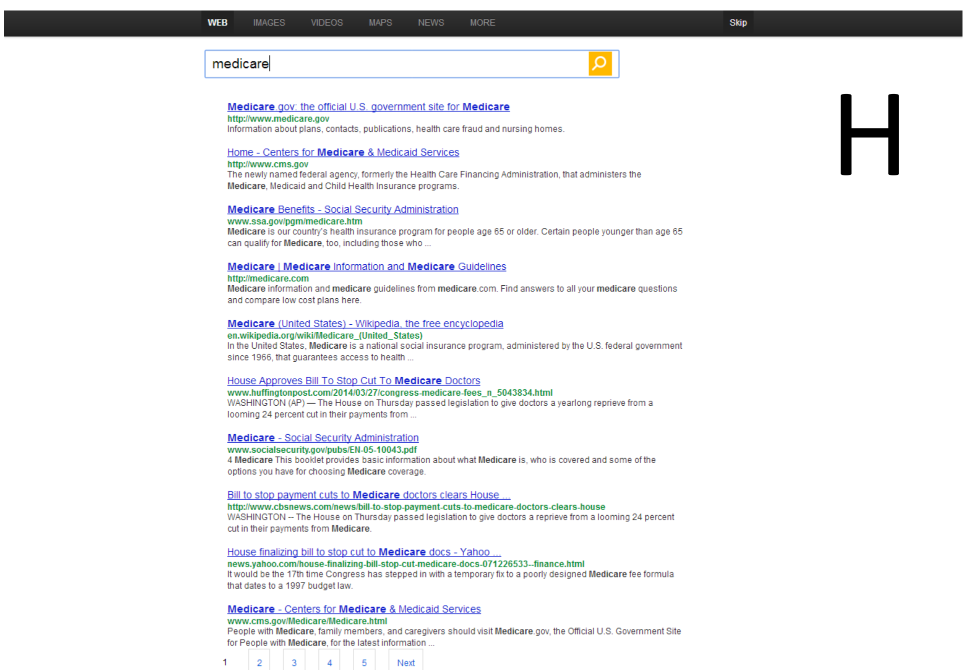
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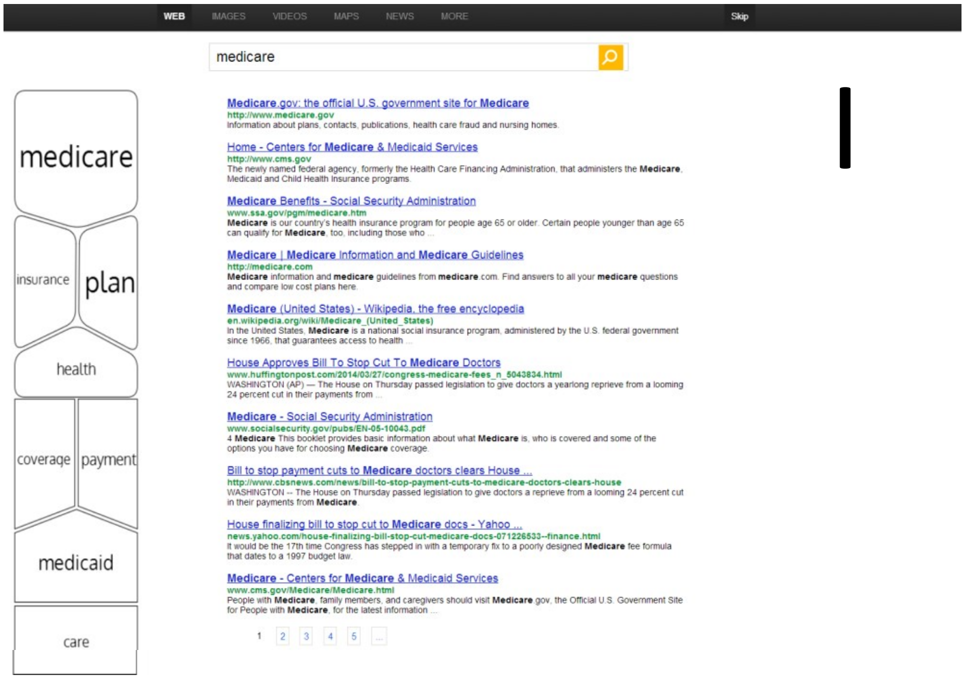
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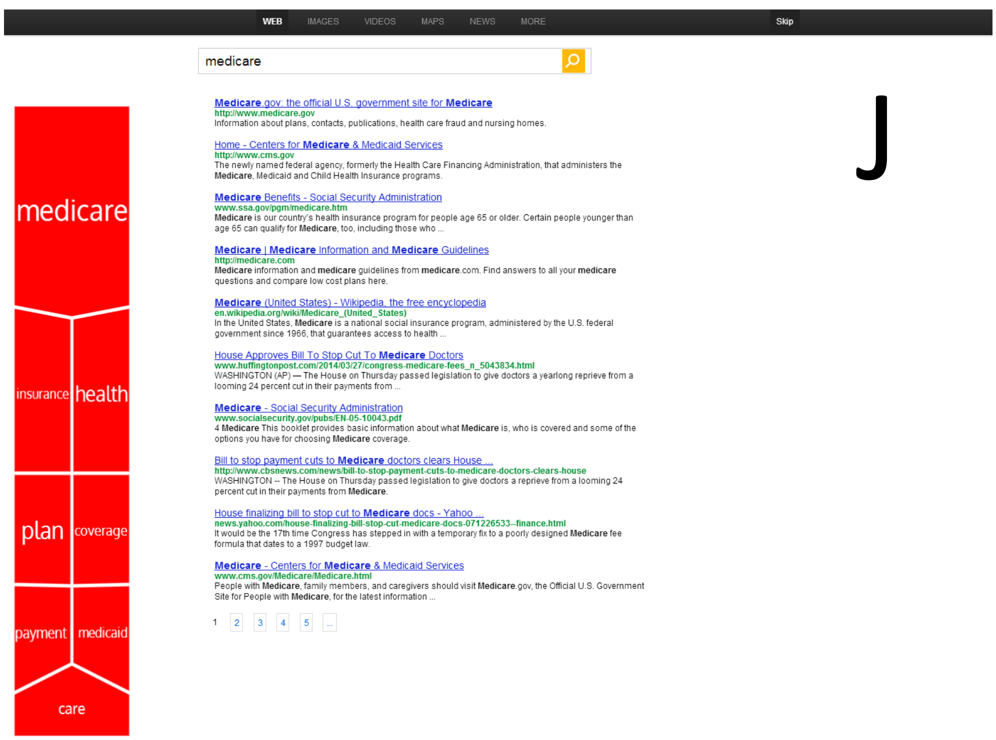
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