EMOTIONAL ASPECTS OF THE ONLINE INFORMATION

RETRIEVAL PROCESS

by

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ABSTRACT OF THE DISSERTATION

Emotional Aspects of the Online Information Retrieval Process

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The online information retrieval process is an experience that is influenced by and results in changes of the emotional states of the user. A logical extension in the development of information retrieval systems is an inclusion of emotional components with the aim of optimizing user experience. In order to develop systems capable of recognizing and intelligently responding to human emotions, it is necessary to develop a framework for measuring and analyzing user emotional experiences. We conducted a study that investigated patterns of emotional expressions around specific search events and examined the role of mood the online information retrieval session. The study discovered unique patterns of emotional expressions associated with the decision-making points of online search. The study also identified mood variations and their relationships to the search process and outcomes. In addition to improving our understanding of emotional aspects of information retrieval, the study tested instruments for measuring emotional expressions and mood that can subsequently be incorporated in the system design and testing process.

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1 Introduction

1.1 Background

Information search is an affective experience characterized by positive and negative feelings that impact attention, memory, performance, and judgments (Brave, Hutchinson & Nass, 2002). At the present time when an information seeker has multiple choices of electronic information, it is no longer enough for information systems to only retrieve relevant information. Systems should be capable of recognizing and reacting to searchers' emotions, maximizing positive and minimizing negative experiences, improving users' performance and wellbeing. In order to design such systems, it is necessary to understand searchers' emotions and their relations to systems and searchers' performance.

One of the earliest studies investigating affective aspects of the information search experience was the work of Carol Kuhlthau (1991, 1993). Kuhlthau observed information search behavior of high school students working on a term project and developed an information search model where students' feelings and thoughts were mapped to the actions and tasks they performed during the search. For example, Kuhlthau found that the feeling of uncertainty varied across different search stages and was typically felt at the initiation stage; confusion, doubt or frustration were associated with the exploration stage, and a sense of direction was experienced during the collection stage. While Kuhlthau's model has expanded our understanding of the long-term comprehensive search and brought attention to the searcher's affective experiences, it may not be useful for representing a shorter term information search, such as a single online search session.

A number of studies have attempted to investigate online search behavior along with its affective aspects. In such comprehensive studies of online search behavior affect has been shown to influence search strategies (Nahl & Tenopir, 1996), performance (Nahl & Meer, 1997; Wang, Hawk & Tenopir, 2000; Nahl (1998) and satisfaction (Nahl 2004, 2005). A number of studies focused on exploring the causes of certain emotions experienced during online search. They found that positive emotions were usually associated with satisfactory search results (Tenopir, Wang, Zhang, Simmons, & Pollard 2008), successful completion of the search (Bilal & Kirby, 2002), use of online system (Bilal, 2000; Bilal & Bachir, 2007b), interest in the process and documents (Kracker, 2002; Kracker & Wang, 2002; Lopatovska & Mokros, 2007). Negative emotions were associated with frustrating aspects of systems, uncertain search tasks and confusing search strategies (Tenopir, et al. 2008), software failures (Bilal, 2000), uncertainty prior to the search (Bilal & Bachir, 2007b), difficulties in finding the answer and inadequate knowledge of the system (Bilal & Kirby, 2002).

Despite numerous studies investigating causes and effects of emotions during online search, a model of online searching similar to Kuhlthau's work in long-term information seeking is lacking. Understanding emotions experienced at the various stages of online information retrieval and relating them to searcher's actions can lead to modifications in user and system performance necessary to maximize positive search experiences.

1.2 Problem Statement

There has been an increased interest in emotional dimensions of human computer interaction (Picard, 1997; Julien, McKechnie, & Hart, 2005). Terms like "affective computing" (Picard, 1997) and "emotional design" (Norman, 2004) refer to the importance of incorporating emotions in the design of effective and pleasurable systems that are natural for humans to understand and use (Picard, 2003). An increased number of information science studies highlight the importance of emotions in human information behavior (Nahl & Bilal, 2007). It is only logical to extend this line of research and suggest the need to address emotions in the designs of information systems.

We propose use of the term "affective information retrieval (IR) system" to refer to an IR system design that is attuned to searchers' emotional needs. We can build a definition of this term on the definitions of relevant concepts – "affective computing" and "IR system". If "affective computing" is

> "computing that relates to, arises from, or deliberately influences emotions. <…> [affective computing] includes giving a computer the ability to recognize and express emotions, developing its ability to respond intelligently to human emotions, and enabling it to regulate and utilize its emotions." (Picard, 1997, p. 3)

and IR system is defined as

> "a system that is capable of storage, retrieval and maintenance of information" (Kowalski & Maybury, 2000, p.2) and is designed to retrieve "information which may act as a supplement to human conscience and unconscious mental conditions in a given situation (Ingwersen, 1992, p. 35)

then we can define an affective IR system as a system for information storage, retrieval and maintenance capable of recognizing, and intelligently responding to human emotions.

In order to design affective IR systems, we need to understand the connection between users' emotional experiences and their online searching behaviors. Information science (IS) and human computer interaction (HCI) literature reflect the research community's interest in the relationships between emotional experiences and (a) system design and performance; (b) user's characteristics; (c) search task; (d) search strategies and performance; (e) motivation to continue search; and (f) overall satisfaction and support of the system. However, we did not find reports of studies that examined relationships between emotions and specific online search behaviors, such as mouse clicks and URL selections, that would allow us to map specific search actions with the particular emotional patterns (similar to Kuhlthau's model). We therefore designed a study that focused on examining emotive patterns around specific search behaviors and also examined the effects of the general mood on search performance and outcomes. In order to conduct our inquiry, we had to expand the self-report methods traditionally applied in the Library and Information Science (LIS) studies of affect and use real-time physiological and behavioral measures from HCI and psychology research.

1.3   Research Questions

Our study investigated patterns of emotional expressions around a selected set of search behaviors and examined the effects of mood on search performance and outcomes. Specifically, the study addressed the following research questions:

1. What patterns of emotional expressions of seven basic universal emotions (neutral[1], fear, anger, disgust, happiness, sadness, and surprise) can be observed immediately before and immediately after three types of search decisions (selection, text manipulation and (re-) examination) represented by seven search behaviors[2]: left button single, left button double, right button single, middle button mouse clicks, mouse up and down scroll and Google and non-Google page changes?

2. What are the relationships between users' emotions and their search performance (represented by search duration, query length, time examining search results, number of queries, number of viewed hits, number of result pages requested per session), and moods and search outcomes (manifested in the quality of search results) and search performance?

3. What are the relationships between users' individual characteristics (frequency of searching the internet, pleasantness of the search experience, interest in the search task, familiarity with similar searches, clarity about the search goal, and satisfaction with search results) and their emotional expressions during the search?

1.4   Objectives and Scope of the Study

The study pursued the following objectives:

1. To identify emotional expressions around search behaviors

2. To understand the role of mood in the search process

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[1] Neutral state represents absence of the other 6 emotional expressions as a true neutral expression or as the eMotion software's inability to classify the expression to other categories.
[2] Each examined search behavior represents a higher-level intention to change the search status (see Section 3).

3. To develop a model of the relationships between emotional expressions, search behaviors, mood and search performance.

The main goal of the study is to understand whether particular search behaviors are characterized by the unique emotive patterns that can be automatically identified by the system and whether particular emotional states can be inferred from the observed search behaviors. Addressing this goal can ultimately lead to the development of affective IR systems. The secondary goal of the study is to understand whether mood as a relatively long-term affective variable that cannot be easily changed during the short online interaction has any effect on the search performance and outcomes; in other words, does the mood matter and should affective IR try to address mood in its systems' designs.

To achieve our goals, we identified emotive patterns around search behaviors that can be automatically detected by a computer program. We measured moods before and after each search and correlated them with the search performance and search results.

2 Literature review

This section reviews how disciplines that study emotions define them, what methods are available for emotion research, and how emotions and other affective phenomena are traditionally studied in the context of human computer interaction, and, specifically, online searching.

2.1 Frameworks for studying emotions

Many disciplines are interested in emotion, including psychology, decision making, engineering, and computer science. Psychology has the longest history of emotion research and has developed a solid foundation for studying emotion. The following sections will review definitions of emotions and methods for studying emotions developed primarily in psychology research. Definitions and methods of studying emotion in LIS and HCI will also be reviewed.

2.1.1 Definitions of emotion

There is no agreement on a definition of emotion in the literature. Kleinginna and Kleinginna (1981) collected more than 90 definitions of emotions. Emotions have been defined as states of emotional feeling (Johnson-Laird & Oatley, 1989), as feeling states involving positive or negative affective valence (Ortony, Clore, & Collins, 1988), as states of automatic arousal (Schachter & Singer, 1962), or changes in the activation of action dispositions (Frijda, 1986). In addition to the lack of agreement on the definition of emotion, there is also no agreement about its relationships with mood, affect, feeling and other terms.

The classical theories about emotion can be grouped into two classes. One class invokes cognition as a necessary factor and tries to explain the subjective manifestations of emotional experiences. The other class emphasizes somatic factors and seeks to describe emotional expressions and perceptions of emotional expressions (Zajonc, 1984). The major figure in the cognitive area is Richard Lazarus who stressed the importance of cognitive evaluations in establishing the meaning of stimuli and the way of coping with

them (Lazarus, 1984). Major figures in the somatic area include Silvan Tomkins, Robert

Plutchik and Paul Ekman. Tomkins (1984) considers affect system as the primary

motivation system that can amplify any other state (e.g., interference with breathing

causes terror that leads to the struggle for air). Plutchik (1984) stresses the evolutionary

link of emotion with instinctive behavior in animals. Ekman (1984) treats emotions as

specific physiological expressions evolved to deal with prototypical life events.

Two dominant views on structuring emotions include continuous and discrete approach.

The continuous approach assumes the existence of two or more dimensions that describe

and distinguish between different emotions (Barrett & Russell, 1999). The two most

accepted emotional dimensions include valence (negative/positive) and arousal

(calm/excited). Support for the dimensional emotion theories comes from physiological

correlates, such as heart rate and skin conductance levels which correlate with emotional

stimuli.

The discrete approach claims the existence of universal basic emotions. The arguments

for the existence of basic emotions include cross-cultural universals for facial expressions

and antecedent events, and presence of these emotions in other primates. Experiments in

many countries, including countries isolated from media, show that people express and

recognize basic emotions the same[3] (Ekman & Friesen, 2003). There is no agreement on

which emotions qualify as basic, but the list typically includes fear, anger, disgust,

happiness, sadness, and surprise (Plutchik, 1980; Ekman, 1992). Other emotions are seen

as combinations of these basic emotions or as socially learned variants of these emotions

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[3] Except for New Guineans who could not recognize the difference between fear and surprise

(e.g., grief, guilt and loneliness are all variants of basic sadness, Bower, 1992). The theory of basic universal emotions implies the existence of distinguishable emotions that are not likely to significantly vary from culture to culture. This means that a) emotional experiences can be measured on all stages of human interaction with systems; b) accurate translations of emotional expressions and prediction based on these translations can be made; and c) systems can incorporate characters depicting basic emotions that users can accurately recognize.

There is no agreement about the definition of emotion in HCI research; the use of both discrete and continuous approaches to emotion is evident. For example, Klein, Moon, and Picard (2002) and Scheirer, Fernandez, Klein, and Picard (2002) developed studies that investigated effects and manifestations of frustration, a discrete emotion. Peter and Herbon (2006) advocated continuous nature of emotions in at least 2-dimentional spaces - arousal and valence. The authors suggested adopting this view for the use in HCI since it allows classifying different emotional states within arousal-valence space without necessarily labeling them. Muller (2004) points out that with the existence of two theories of emotion, the experimental findings cannot be interpreted with confidence. For example, in the Scheirer et al. (2002) study, the change of physiological measures was attributed to changing levels of frustration, while it can only point to the changing levels of arousal.

LIS studies of emotions, affect and feelings rarely define these phenomena. We found the following definition of emotion that is based on all emotive concepts discussed in the LIS literature (Dervin & Reinhard, 2007):

> "...emotion conceptualized as: being caused by or arising out of situations, tasks, or contexts or their subparts; being attributes of persons – their personalities, demography, genetics, physiology, or past experiences; being causes of inhibiting or activating motivations; causing or leading to specific actor goals or activities; being encoding traces left in information, message, or text packages; and serving as states of being that have informational value." (Dervin & Reinhard, 2007, p. 55)

This definition summarizes the major lines of emotion research in LIS, including investigations of the emotions' causes and effects, relationships between searchers' individual characteristic and emotional variables, and motivational aspects of emotions discussed in Section 2.2.

In summary, the review of emotion research makes it clear that while there is no agreement on the definition of emotion, researchers are actively studying the role of emotional aspects of human computer interaction.

2.1.2 Methods for studying emotion

A number of methods are available for studying emotions. LIS studies of emotion traditionally use self-report and often retrospective measures for studying affect, such as think aloud protocols, questionnaires, pre- and post- session interviews, and diaries. HCI studies often collect real-time neuro-physiological measures associated with emotions, such as blood pressure or heart rate. We review neuro-physiological, observer and self-report measures of emotions that are collected during (real time) or after (retrospective) affective experiences (Larsen & Fredrickson, 1999).

2.1.2.1 Neuro-physiological methods

Neuro-physiological methods involve monitoring body responses to emotional stimuli. Researchers can infer the presence of emotion by collecting brain activity images, pulse rate, blood pressure or skin conductance. The procedures for collecting neuro-physiological measures vary from a simple sensor on a finger for monitoring pulse rate and skin conductance to more invasive sensors for cardiography, blood pressure monitoring and electroencephalogram.

LIS literature does not mention studies that use neuro-physiological real time measures of emotion. However, these measures are widely used for studying emotion in HCI research. Bamidis, Papadelis, Kourtidou-Papadeli, Pappas, and Vivas (2004) reviewed several neurophysiological measures used in HCI studies, including electroencephalography (EEG) and magnetoencephalography (MEG) for measuring brain activity. The limitations of using these measures include inability to map neurophysiological data to specific emotions (e.g., frustration), difficulties in translating temporal micro resolutions (milliseconds) to temporal units relevant to emotional responses, reliance on non-transparent measurement instruments (e.g., sensors that constrain movements). The authors stress that the major benefits of the neurophysiological measures include detection of responses that cannot be detected by subjective or physiological readings.

Wilhelm, Pfaltz, and Grossman (2006) report the results of developing a LifeShirt sensor system that can be used for monitoring cardiovascular, respiratory, metabolic and other physiological effects of physical or emotional stress. The system collects comprehensive

set of physiological measures, is wearable and relatively unobtrusive. The system might help to identify specific emotion signatures and identify affective states from physiological signals (especially when the system is individually calibrated).

Picard, Vyzas, and Healey (2001) devise a method based on computer classification of emotions based on facial muscle tension, blood volume pressure, skin conductance, and respiration data.

Partala, Surakka, and Vanhala (2006) tested the method of detecting positive and negative emotions by capturing activity of two facial muscles. Electrodes were connected to participants' mouth area muscles responsible for smiling and to the brow area muscles responsible for frowning expressions. Participants were given picture and video stimuli designed to solicit positive and negative experiences. The method was reasonably accurate in estimating user's subjective affective experience based on the facial muscles activations.

Scheirer, Fernandez, Klein, and Picard (2002) investigated physiological and behavioral changes associated with frustration. The experiment was designed to frustrate users by occasionally "freezing" mouse movements. Participants' blood pressure and skin conductivity were measured and correlated with frustrating episodes. The study concluded that blood volume pressure decreased and skin conductivity increased during frustrating episodes. The findings suggest practical ways of designing systems capable of recognizing user's affective states. Mooney, Scully, Jones, and Smeaton (2006) used neuro-physiological methods to examine the role of searchers' emotional states in

improving data indexing for and within the search process. Users' physiological

responses to emotional stimuli were recorded using a range of metrics (galvanic skin

response, skin temperature, etc.). The study provides evidence in favor of using neuro-

physiological signal processing for studying searchers' emotions.

Proponents of the neuro-physiological methods argue that while these methods require

the use of physical sensors, the sensors do not invade user's privacy and monitor short-

term changes not measurable by other means (Scheirer et al., 2002). The method is

criticized for limiting participants' mobility and causing distraction of emotional

reactions. Neuro-physiological methods are limited to measuring the presence of

emotion, without distinguishing between specific emotions, such as anger or fear. In

addition, use of neuro-physiological methods requires special expertise and equipment.

2.1.2.2 Observer methods

Observer methods rely on third-person recognition and coding of emotions manifested in participants' facial expressions, vocal changes, verbal content and bodily movements. An expert observer trained in Specific Affect Coding System (SPAFF) or Facial Action Coding System (FACS) (Larsen & Fredrickson, 1999) or a computer program based on classifying bodily or facial expressions with specific emotions can distinguish an array of positive and negative emotions by analyzing observable vocal, facial and bodily changes. The major benefit of using observer reports of emotions is that it provides an unobtrusive method of collecting data. However, the methods are limited to analysis of present expressions of emotional states, and cannot be independently used for studying the meaning of emotions, emotional memories or predictions.

One of the observer methods for studying emotions that has the highest accuracy rate is Facial Action Coding System (FACS). Research indicates that emotions are shown primarily in the face, not in the body (Ekman & Friesen, 2003). FACS is based on recognizing facial expressions of six universally recognized emotions: fear, surprise, sadness, happiness, anger, disgust, and their 33 combinations. Intensity of emotion can also be determined by the presence and degree of changes in all facial areas associated with emotion. For example, sadness is usually expressed through the brow, eye and mouth areas. In sadness, the inner corners of brows are drawn up, skin below the eyebrow is triangulated with the inner corner up, upper eyelid inner corner is raised, corners of lips are down or the lip is trembling (Ekman, 2003).

While FACS requires observer training, the benefits of the method include a) high

reading accuracy rates; 2) use of non-obtrusive and common laboratory equipment, such

as video camera; 3) high validity that is confirmed by correlations with physiological

measures (e.g., increased heart rate that coincides with surprise and disgust). Another

benefit of FACS is it can be programmed into computer systems to automatically

recognize user emotions (Picard, 1997; Cohn, & Kanade, 2007).

Automatic facial expression analysis systems directly interpret the observed facial

expressions and classify them into six or seven basic emotion categories (Essa &

Pentland, 1997; Kimura & Yachida, 1997; Lanitis., Taylor, Cootes, 1997; Hong, Neven,

& von der Malsburg, 1998). In interpreting facial expressions, some systems analyze

appearance changes in the features of the face, such as the corners of the mouth,

eyebrows (Sebe, Lew, Sun, Cohen, Gevens, & Huang, 2007), and others analyze the

feature vectors derived from segmented regions of the face, such as eye/mouth region

(Essa 1995; Essa & Pentland, 1997). Facial recognition systems also use different

classification schemes (Jaimes & Sebe 2007). Static classifiers process each image

individually to one of the facial expression categories, while dynamic classifiers process

an image sequence (or a set of video frames), and apply classification by analyzing the

temporal patterns of the extracted regions or features. The existing facial analysis systems

provide a quick, unobtrusive, and relatively accurate solution for interpreting emotional

expressions. However, one of the major drawbacks of such systems is their inability to

account for context and to perform a context-dependent interpretation (Jaimes & Sebe,

2007). Facial expression recognition should also not be confused with the human emotion

recognition (Fasel & Luettin, 2003).

Other methods might include moment-based observations of physical expressions of

pleasure or pain (Redelmeier & Kahneman, 1996). Such ratings are based on participants'

vocalization and physical expressions in addition to facial expressions (Eich, Brodkin &

Reeves, 1999). Observing and measuring pupil size is another method of gauging

whether participants are experiencing positive, negative or neutral emotions. Partala and

Surakka (2003) captured subjects' pupil size while participants listened to negative

(couple argument), positive (baby laughing) and neutral (office background) sounds. The

findings indicate that positive and negative sounds caused participants' pupils to dilate,

while neutral sounds did not impact on pupil size.

LIS studies of emotion and affect use several observation techniques. The studies often

use screen logging software to capture online search actions, which is a way of observing

and coding users' search action. For example, Bilal and Bachir (2007a) examined

navigation behavior of children using video logging software. In the study that examined

the role of uncertainty in the information seeking model (Wilson, Ford, Ellis, Foster, &

Spink, 2002), searchers were audiotaped and search transaction logs were recorded.

Several studies that investigated affective states of children who used search engines

(Bilal, 2000; Bilal 2002; Bilal & Kirby (2002), captured participants' searches using

screen capturing software. In a comprehensive study of web use, Wang, Hawk and

Tenopir (2000) captured screen shots of the search process.

Facial expression analysis was used in a study of search in digital libraries (Lopatovska & Cool, 2008). The authors found that during the search, participants' faces expressed primarily dislike and variations of this emotion, while in one participant most of the positive emotions corresponded with the time when an assistant entered the room. The study also found a wide variation in individual levels of emotional expressivity (e.g., one subject's face expressed 57 intense emotions, while other subject's face expressed only 9 emotions during the same period of search time). Arapakis, Jose and Gray (2008) applied automatic facial expression analysis to infer users' affective states during performance of the various search tasks. The findings indicate a progressive transition from positive to negative valence as the degree of task difficulty increases.

In addition to capturing participants' online behavior using screen logging software, most of the LIS studies use self-report methods (e.g. questionnaires, interviews) to obtain data about participants' emotional states and examine the relationships between search actions and emotions.

Capturing human-computer interactions using observation technique is common in HCI research on emotion. Klein et al. (2002) captured user online behavior in a simulated computer game in which users were intentionally frustrated. In the above mentioned study of frustrating online use episodes, Scheirer et al. (2002) recorded mouse clicks in addition to measuring blood volume pressure and skin conductivity. The authors found that the number of mouse clicks increased during frustrating episodes.

2.1.2.3 Self-report methods

Self-report measures of emotional states are based on participants' accounts of their

moods and feelings before, during or after lived episodes. The self-report methods are

widely used in psychology and LIS research and include questionnaires, think aloud

protocols, diaries and interviews. The methods rely on an assumption that individuals are

able and willing to recognize and report their emotions. The reliability and validity of the

self-report measures are evident from high correlations of the subjective reports to the

quality of the physical stimuli and neurological activities of the brain (Kahneman, 2000).

Momentary self-reports are considered more accurate then retrospective reports;

however, certain techniques are available for improving the accuracy of retrospective

reports. While self-reports may be subject to participant's bias, they are efficient and

easiest techniques for measuring emotions. In addition, they are the primary means of

gauging the meaning of emotional expressions collected by the use of observation and

neuro-physiological methods. We will review several self-report methods in more detail.

A common self-report technique for studying emotions is asking participants to rate their

feelings on a single emotional dimension. A studied dimension can represent a global

affective state (e.g. "How are you feeling now?" where the answers vary from "extremely

negative" to "extremely positive") or a specific emotion (e.g. "How angry do you feel?"

where the answers vary from "extremely angry" to "not at all angry").

Such real-time self-reported ratings are popular in hedonic psychology studies of

emotional reactions on aversive or pleasant stimuli. Schreiber and Kahneman (2000)

asked participants to rate pleasantness or unpleasantness of their experiences while

listening to a set of noises. Redelmeier and Kahneman (1996) obtained moment-based

ratings by asking patients to indicate the level of experienced pain during a colonoscopy

procedure. Fredrickson and Kahneman's (1993) experiments involved evaluations of

pleasure or displeasure during the short pleasant or disturbing films. Kahneman,

Fredrickson, Schreiber, and Redelmeier (1993) collected evaluations of the pleasantness

and unpleasantness of experiences while manipulating the temperature of the water in

which participants emerged their hands.

The major findings linked to the use of this method in hedonic psychology research are

the Peak-End and Duration Neglect rules. The Peak-End rule suggests that the global

evaluation of experience depends on the most extreme affect during the episode and

affect experienced at the end of the episode. Because individuals tend to evaluate better-

end experiences more highly, adding a period of diminishing discomfort (or a better

ending) to an aversive experience improves the overall evaluation of experience

(Schreiber & Kahneman, 2000; Redelmeier & Kahneman, 1996; Kahneman, et al. 1993).

The preference for longer aversive experiences in which the total amount of pain is

higher, but the ending of the experience is improved is called Duration Neglect rule. The

Peak-End and Duration Neglect rules illustrate human inability to normatively evaluate

total experiences by considering both the quality and the quantity of the episodes.

Knowledge of the rules that determine global evaluations helps to improve experiences

by manipulating pleasant and unpleasant stimuli.

The specific methods of measuring moment-based dimensions of emotional experiences include single-item uni- and bipolar scales. The single-item self-reported real-time measures are simple to implement and do not cause participants' fatigue. They are adequate for measuring hedonic quality of experience, but do not fully represent the complexity of emotion. Particular concerns for using the measures include measurement reactivity (measure alters the measured experience) and independence (each measure occasion is independent from the other) (Larsen & Fredrickson, 1999).

The studies of pain often use unipolar verbal or numerical rating scales. Use of the verbal scale requires participants to report their experiences as no pain, mild, moderate or severe pain (Eich, Brodkin, & Reeves, 1999). Use of numerical rating scales requires participants to place a mark on a continuum between 0 (no pain) and 10 or 100 (pain as bad as it can be). The visual analog scale is one of the most popular bipolar scales in the hedonic psychology research. The visual analog scale is designed to have a neutral (0) point in the middle and extreme positive and negative anchors on the opposite ends of the scale. Visual analog scales were used for measuring pleasantness of the sounds (Schreiber & Kahneman, 2000), short films (Fredrickson & Kahneman, 1993), and medical procedure (Redelmeier, Katz & Kahneman, 2003).

The general guidelines for the moment-based one- or two-dimensional scale include a) use of a common scale (ordinal or better) across experiences and individuals so that the reports can be compared; and b) a distinct neutral point where experiences are neither positive, nor negative (Kahneman, 2000). The strengths of such moment-based self-

report scales include their ability to a) represent the sign and the strength of affective

experience with the simple underlying structure; b) reliably relate reports of subjective

experiences to the physical stimuli across subjects; and c) be validated with the

neurological activity of the brain. However, the measure is limited to the two-

dimensional representation of affect, and does not capture specific emotions (such as

anger or fear).

Another method for obtaining moment-based emotional data is ecological momentary

assessment (EMA) (Stone, Shiffman, & DeVries, 1999). The method relies on the

moment-based reports of what is happening in individuals' typical environments. Three

characteristics defining the method include studying subjects in the environment they

typically inhabit; collecting reports about momentary or near-immediate states; collecting

many momentary reports during the course of the day to examine fluctuation of

phenomena over time and examine phenomena's relationship to environmental variables.

Application of the EMA method enables studying the dynamics of individuals'

experiences in their natural environment and eliminating retrospective recall bias

common in retrospective self-report measures. The limitations include costs associated

with the special equipment needed to collect momentary report (e.g., PDAs) and burden

to participants' who are asked to frequently interrupt their routines to report on their

experiences.

Another method, Day Reconstruction Method (DRM), is a retrospective measure similar

to the EMA. It requires participants to first reconstruct recent experience, and then

evaluate it. The DRM was used in a study of daily life experiences of 909 employed

French women (Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004). The DRM

involves reviving participants' memories of the previous day by reconstructing the

episodes of that day (participants are asked to think of an episode as a scene in the film).

Participants are then asked to rate each episode on a 6 point Likert-type scale using

twelve affect descriptors: 10 Impatient for it to end; 2) Happy; 3) Frustrated/annoyed; 4)

Depressed/blue; 5) Competent/capable; 6) Hassled/pushed around; 7) Warm/friendly; 8)

Angry/hostile; 9) Worried/anxious; 10) Enjoying myself; 11) Criticized/put down; 12)

Tired. The DRM is less costly than the EMA, it is easy to implement in an experimental

or natural study. The method is also similar to post-search interview techniques in use in

the information seeking research. Rieh (2002), for example, asked information searchers

to recall their past searches and identify criteria they used for judging quality of the found

sources. Kracker and Wang (2002) asked participants to recall the most recent or

memorable experiences in researching and writing a paper in the study of anxiety and

students' perceptions of research.

Asking participants to rate their feelings on a single emotional dimension is also used in

LIS studies of emotion. Nahl (2004) investigated the role of affect in web searching of

senior college students by administering pre- and post- search questionnaires asking

participants to rate various aspects of the search, including levels of frustration, anxiety,

self-efficacy, optimism. In the study that investigated relationships between affective

coping skills, negative emotions of frustration and irritation and success in search tasks

(Nahl, 2005), participants rated their emotions on the affective self-report scales.

In addition to measuring feelings using a single emotional dimension scales, LIS research uses other self-report methods for studying emotions, including 1) journals or log sheets kept during and about the search process; 2) think aloud reports; 3) pre- and post-search questionnaires, including standardized tests; and 4) one-on-one and group interviews.

One of the earliest studies that identified searchers' emotional states was Kuhlthau's (1991) research on students' information seeking behavior. The emotion data was collected by asking participants to record their feelings and thoughts related to information seeking in a journal. Analysis of the data collected by journals and questionnaires led to development of the six stage information seeking model that identified relationships between search process, participants' feelings, thoughts, and actions.

Meghabghab (1995) observed inexperienced school librarians learning to search online databases. Subjects were asked to document their actions, feelings and thoughts on log sheets and work activity sheets. Data analysis showed that cognitive difficulties were accompanied by dissatisfaction with self, frustration, and feeling of being defeated. A negative phase associated with the beginning of the search was followed by a positive phase of improved self-confidence, less doubt and hopes for successful search.

In a study that examined developmental steps of acquiring expertise with a search engine Nahl (1998), participants were asked to keep logs of their cumulative searches and provide weekly self-ratings on satisfaction scales.

James and Nahl (1996) examined the semester-long affective development of senior

college students who were learning the internet. The students were asked to record their

cognitive and affective information processing activities in "self-witnessing" reports.

Affective states experienced by children and graduate students' during online search were

compared in a study by Bilal and Kirby (2002). Self-report data was collected through

journals (for students) and interviews (for children).

Think aloud methods were used in several LIS studies that investigated the role of

affective variables in search behavior. Nahl and Tenopir (1996) observed searching

behavior of novice users of a database by recording their think-aloud reports, including

interactions with the study monitor, in addition to using screen logging software. Wang

and Soergel (1998) examined document selection criteria, including evaluations of

document's emotional values. Participants, 25 self-selected faculty members, were asked

to read and think aloud while selecting documents.

Tenopir, et al. (2008) observed how academic users interact with the ScienceDirect

system by collecting think-aloud protocols that captured participants' affective and

cognitive verbalizations.

Pre- and post-search questionnaires about users' affective states, demographic

information and prior experiences are frequently used in LIS research in conjunction with

other methods. In the above mentioned research of students' information seeking

behavior (Kuhlthau, 1991), participants completed questionnaires about their perception of the six areas of library use in addition to keeping journals of their information seeking experience. In addition to collecting think aloud protocols, the above mentioned study by Tenopir et al. (2008) administered pre- and post search questioners soliciting participants' demographic information, prior experiences with the system and comments. In a comprehensive study of web use, Wang, Hawk and Tenopir (2000) asked participants, 24 graduate students, to fill out a pre-search questionnaire identifying their web experience. Mentis (2007) examined memories of frustrated search experiences by administering open-ended online questionnaire where participants were free to define and describe their frustrating experiences. Most frustrating experiences were identified at the outcome stage. Mentioned causes of frustration included bugs in software, system's freeze/crash, auto formatting, slow system response and other external issues that interrupted users' cognitive flow of task achievement.

A study that investigated subjective variables of the information search process administered questionnaires between search tasks (Gwizdka & Lopatovska, in press). The questionnaires collected data on the happiness levels, satisfaction with and confidence in the search results, feeling lost during search, familiarity with and interest in the search topic, estimation of task difficulty. The study found that participants who reported positive feeling before the search felt positive throughout the search, but also had worse search outcomes and lower satisfaction, suggesting that, perhaps, it pays off to feel some 'pain' during the search in order to 'gain' quality outcomes

Use of standardized tests is also frequent in LIS studies of affect to measure participants' emotive states and predispositions. In a comprehensive study of web use, Wang et al. (2000) asked participants, 24 graduate students, to fill out a pre-search questionnaire identifying their web experience, the State Trait Anxiety Inventory (STAI, forms Y1 and Y2) to measure affective states, and the Embedded Figure Test to measure cognitive styles. STAI consists of two forms: S-anxiety which measures individual general tendency of feelings, and T-anxiety which measures individual's current feelings. High scores on the tests indicate high levels of anxiety, the scores range from a minimum of 20 to a maximum of 80.

Kracker (2002) researched student anxiety and perceptions of research using State Trait Anxiety Inventory test (STAI Y-1) and the critical incident technique that required students to recall specific research assignment and describe their feeling and thoughts associated with the process. Form STAI Y-1 was used to clarify statements given by participants about their most memorable or the most recent research assignments.

Onwuegbuzie and Jiao (2004) examined relationships between search performance, anxiety levels and research achievement; students were asked to fill out several questionnaires related to their emotional states, including Library Anxiety Scale, Hope Scale, Procrastination Assessment Scale, Multidimensional Perfectionist Scale and others prior to engaging in the search task.

In the study of effects of emotion control on the web searching behavior and performance (Kim, 2008), participants were asked to take a Problem-Solving Inventory test prior to engaging in the search tasks.

Another popular technique of studying affect in LIS is the interview. In the reviewed studies, interviews with participants were conducted before and after they performed search tasks. While most of the studies conducted one-on-one interviews, a few studies used group interviews to collect data on users' emotional experiences. In a longitudinal study of uncertainty involved in information seeking, Wilson et al. (2002) administered pre- and post-search interviews.

Bilal and Bachir (2007a) conducted individual pre-search interviews to generate children's profiles, including their demographic information, prior experience, reading habits and preferences.

Participants' affective states were captured in the exit one-on-one interviews in the several studies of children's use of a search engine (Bilal, 2000; Bilal, 2002; Bilal & Kirby, 2002).

Julien (2007) examined library customers' experiences with internet public stations using interview data. The study suggests 3 affective aspects of information experiences: a sense of empowerment and control; a sense of normal, everyday experience; a sense of frustration by those who do not believe that they are information literate.

In a study of anxiety and perceptions of research, Kracker (2002) used the critical incident technique that required students to recall specific research assignment and describe their feelings and thoughts associated with the process.

2.1.3 Designs of the studies investigating emotion

A large number of study designs that are used to investigate emotion can be grouped into two broad categories – naturalistic and experimental. Naturalistic studies collect emotional experience data in or about participants' routine practices. Naturalistic designs are used in psychology and LIS studies of emotion. Experimental designs are generally more prevalent in psychology, HCI and LIS studies of emotion and include collecting emotional experience data in an experimental setting. However, studies vary in the degree of control over experimental setting and variables.

Naturalistic studies usually require participants to report on their routine experiences that occurred in the natural environments. For example, Kuhlthau (1991) examined information behavior of students who worked on a school assignment. Julien (2007) interviewed library customers about their library experiences. Dervin and Reinhard (2007) asked participants to describing five recent situations in which they sought an answer to a question in academic, research, and personal life contexts using an online survey and phone interview. A study of student anxiety and perceptions of research used a critical incident technique that required students to recall specific research assignment and describe their feeling and thoughts associated with the process (Kracker, 2002). James and Nahl (1996) examined the semester-long affective development of senior

college students who were learning the internet. The students were asked to record their

cognitive and affective information processing activities in "self-witnessing" reports. The

described above study of emotional aspects of French women's lives (Kahneman et al.,

2004) asked participants to recall and rate their everyday experiences.

Emotion studies that opt for experimental designs administer tasks, and vary computer

performance and emotional stimuli to investigate participants' feelings associated with

the experimental procedures or stimuli. A number of LIS studies investigated users'

emotional experiences related to experimental search tasks (Arapakis, et al., 2008; Bilal,

2000; Bilal, 2002; Bilal & Kirby, 2002; Tenopir et al., 2006; Nahl & Tenopir, 1996; Nahl

& Meer, 1997; Kim, 2008). To investigate physiological and behavioral effects of

frustration, Klein et al. (2002) and Scheirer et al. (2002) varied computer performance by

occasionally "freezing" mouse movements. One of the popular experimental designs in

psychology and HCI include varying emotional stimuli, such as picture and video stimuli

(Partala, Surakka, & Vanhala, 2006), set of noises (Schreiber & Kahneman, 2000), short

pleasant or disturbing films (Fredrickson & Kahneman, 1993), temperature of the water

in which participants emerged their hands (Kahneman et al., 1993), and other stimuli to

solicit positive and negative experiences.

2.2   Emotions in Library and Information Science and Human Computer Interaction Research

2.2.1 Research on factors influencing emotional states

Library and Information Science (LIS) and Human Computer Interaction (HCI) literatures have identified several factors that influence emotions experienced during human computer interactions. These factors can be grouped into two broad categories: system-related and user-related. System-related factors can further be split into factors related to system design and system performance. User-related factors can be split into user performance, familiarity with a system, task or search process, user's moods and attitudes prior to the search, user's age, individual characteristics and cultural background.   We will start by reviewing the literature on system-related factors, followed by the literature on user-related factors that influence user emotions.

Several LIS studies identified system design features that affected emotional states of online searchers. A study of children's use of a search engine (Bilal, 2000) found that participants' positive feelings were associated with the ease of web browser use over other sources, such as print; positive feelings were also associated with the availability of keyword search option and graphics and overall fun of using the browser. In a study of children's interaction with the International Children's Digital Library, Bilal and Bachir (2007b) discovered that children had positive experiences with the digital library and liked the library for its educational and aesthetic aspects (e.g., children liked learning new things and seeing beautiful things). Positive feelings were also associated with the easiness of use and effective navigation. Negative feelings were associated with the

limited size of electronic collection. Kalbach (2006) analyzed designs of several web sites from the perspective of users' affective impressions and identified particular features of web design that help to reduce user uncertainty and build confidence during the search. An example of such a design feature is the British Broadcasting Company (BBC) search interface that includes "BBCi best link"[4] system of human-selected hits presented on top of the search results page.

Studies reported in the HCI literature examined three types of system design features influencing emotional experiences: 1) personalizable features, 2) features representing information 'producer', and 3) emotional feedback features. Most of the studies that examined emotional feedback features were performed with computer game systems.

Tractinsky (2004) reviewed studies that showed a link between personalized aesthetic interfaces and improved perceptions of usability and satisfaction. Blom and Monk (2003) suggested that users personalize their computers in order to improve feelings of control, ownership, fun, and release from boredom. Ward and Marsden (2004) did not find statistically significant differences between user's physiological reactions on well or poorly designed websites, which might suggest that aesthetical differences between systems might not greatly impact user emotions.

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[4] BBC search interface can be accessed from http://www.bbc.co.uk/ website or directly at http://search.bbc.co.uk/

Light (2004) examined user reactions on comment boxes, registration requests and other features representing information 'producer', and found that the presence of the provider's voice results in higher levels of users' trust.

Klein, Moon, and Picard (2002) reported the results of an experiment that simulated a computer game in which users were intentionally frustrated. The experiment showed that participants who received supportive messages from the system were able to better recover from negative emotional states and chose to stay in the game longer. The authors suggest that while it is not always possible to build systems that do not cause frustration, it is possible to design computers that try to mitigate the effects of frustration. This point is illustrated with examples of systems that can regulate users' emotions. For example, an older version of MATLAB program simulated the effect of active listening by responding with the sympathetic quip on user's 'f***' command; computer and robotic pets such as Furby and Tamagocchi foster emotional communication and arguably help regulating users' emotions; Internet sites and newsgroups[5] that allow users to post angry messages about their frustrating experiences with products and services enable users to vent their negative feelings. Tzeng (2004) examined effects of apologies for the failed computer game expressed through text and emoticons. Apologetic feedback and emoticons were found to enhance the aesthetics of game interaction and shorten psychological distance between the game and the player. Apologetic (sad) emoticons were found to communicate emotions more effectively than pure text. Brave, Hutchinson and Nass (2005) examined the effects of emotionally expressive computer agents on users' perceptions of computer games. The study used the game of black jack where dealers

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[5] The article lists alt.unixhaters and alt.fan.billgates as examples of 'public venting' websites

were represented by a human photograph and a blob text. The nature of the photograph

and the text represented neutral, sad and happy emotions directed towards participants'

wins or loses. Empathetic agents were perceived as likable, carrying, trustworthy,

supportive, and overall had positive effects on participants. The authors suggest modeling

affective computers after people in service roles who are trained to express happiness and

empathy regardless of their actual feelings[6].

Both the LIS and HCI literature examine system performance features that impact user

emotions. In the above-mentioned study of children's use of a search engine, Bilal (2000)

found that negative feelings of confusion and frustrations were associated with software

failures. But this study also found that these negative feelings did not have significant

impact on children's persistence and patient in searching the web. In a study of the main

causes and effects of frustrating computer interactions, Lazar, Jones, Hackley, and

Shneiderman (2006) determined that most of the frustrated experiences occurred during

system or application crashes, error messages, faulty connection, long download times,

and missing or hard to find features. Frustrated experiences caused primarily feelings of

anger at the computer, anger with self, determination to fix the problem or to resign from

the bad interaction.

LIS research of online searching behavior and HCI affective computing studies identified

the following user-related factors influencing emotional experiences: 1) searcher

performance, including search strategies, 2) success in task completion, 3) nature of task

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[6] Picard (1997) notes that while a software agent can be programmed to express unfelt or inaccurate
emotions, this should be done with caution not to undermine a person's trust.

and perceptions of task difficulty, 4) familiarity with a system, 5) moods and attitudes prior to and during the search, 6) user's individual characteristics, such as level of interest in a document or process, age and cultural background.

Tenopir, et al. (2006) examined relationships between affective feelings and cognitive behaviors during the online search. Their analysis showed that positive feelings were reported more frequently than negative feelings and were associated with thoughts about search results. Negative feelings co-occurred more often with the thoughts related to system, search strategy and task.

Bilal and Kirby (2002) compared the internet search behavior of adults and children and showed that both groups experienced satisfaction and comfort with the successful completion of the task, and frustration due to difficulties with finding the answer. Wang, et al. (2000) examined cognitive and affective aspects of search behavior on the web and found that successful search performance reduced negative feelings, such as anxiety. Gwizdka and Lopatovska (in press) found positive correlation between the use of less effective search strategies and low number of relevant results and low satisfaction levels after the search. In the mentioned above study of the digital library use, search performance was found not to have significant effect on emotions expressed during the search (Lopatovska & Cool, 2008).

Tzeng's (2004) HCI study of the effects of computer apologies found that the game's difficulty level was the most important predictor of participants' satisfaction with the

game. Playing an easier game resulted in better overall performance and generated

feelings of gratification and confidence in playing the game, better feelings about the

program and confidence in future success. Gwizdka and Lopatovska (in press) found that

searchers who perceived the search task as more difficult also felt more satisfied after the

search. Arapakis, et al. (2008) examined the effects of task difficulty on emotions and

found that as the task difficulty increased so did the negative valence of searchers'

emotions. Perceived difficulty was also found to influence uncertainty, expected effort

and motivation to complete the task in the study of senior college students' information

behavior (Nahl, 2005).

In a study of frustrating computer interaction, Lazar et al. (2006) found that frustration

levels were positively correlated with the amount of time it took to fix the problem, the

amount of time lost due to the problem and the importance of task, and negatively

correlated with the mood after the session.

A study of senior college students' search behavior (Nahl, 2004) found positive

correlation between self-efficacy and optimism and motivation for completing the task.

The author found that higher self-efficacy and optimism were associated with higher

satisfaction (the satisfaction rating was based on measures of relevance ratings of search

results and extent to which users felt they met their search goal). Positive feelings before

the search were also linked to the positive feelings reported after the search in the study

of relationships between subjective and objective aspects of online searching (Gwizdka &

Lopatovska, in press).

The study of children's interaction with the International Children's Digital Library (Bilal & Bachir, 2007b) discovered that negative feelings were associated with uncertainty prior to searching the system.

Kracker (2002) and Kracker and Wang (2002) focused on effects of educating students about Kuhlthau's Information Search Process (ISP) model. The authors discovered that positive emotions were associated with confidence and interest in the search process and the documents.

A study of affective valuation of electronic documents (Lopatovska & Mokros, 2007) found that interest in a document and document's stylistic properties were positively correlated with participants' self-reported feelings.

Bilal and Kirby (2002) found no difference between the feelings of adults and children in their study of internet search behavior. Both adults and children were asked to perform identical search tasks using Yahooligans!. Both groups were novice users of the Web. However, the experiment was conducted in two different settings: middle school library for students and University laboratory for adults. The authors discovered that while adults (graduate students) performed the search tasks more effectively and efficiently, they experienced the same feelings as young searchers. Both groups experienced frustration dues to inability to find relevant documents, inadequate knowledge of how to use the engine, inadequacy of search interface and other factors.

A HCI study that examined cross-cultural differences in recognizing affect from computer animated avatars (Kleinsmith, De Silva & Bianchi-Berthouze, 2006) found that affective avatars had different effects on people from different cultural backgrounds.

2.2.2 Research on effects of emotional states

Early studies of the role of affect in information seeking were performed in a library environment. While investigating the effects of library anxiety, Mellon (1988) found that negative emotions impeded information seeking and learning. The author suggested mitigating the negative effects of library anxiety by offering library instruction programs that are attuned to students' emotional needs. More recently, Onwuegbuzie and Jiao (2004) also examined college students' library anxiety and showed that it had a negative effect on research paper grades.

In the context of online search, emotional factors have been shown to influence 1) search performance and strategies; 2) search results; 3) acceptance and support of systems; 4) motivation; and 5) satisfaction.

Gwizdka and Lopatovska (in press) found that in situations in which searchers started the task in an unhappy state, they also felt more in control during the search and completed the task better, the searchers also experienced more positive feelings and a higher satisfaction after the search.

Nahl (1998) reviewed the information behavior literature covering cognitive and affective components of searching and found evidence of the effect of affective variables on search motivation, performance and satisfaction. Wang, et al., (2000) also examined cognitive and affective aspects of search behavior on the web and found reciprocal relationships between affect and search performance. The study findings showed that positive feelings supported subsequent interactions while negative feelings hindered the search.

In a study that explored affective and cognitive aspects of the searching behavior of novice users, Nahl and Tenopir (1996) found that hesitation, need for confirmation, fear, surprise and other feelings affected search strategies. For example, the authors suggest that confirmation seeking provides users with continuous motivation not to quit searching and surprise initiates a process of reconciling search expectations with reality.

Butler and Cartier (2005) examined effects of emotions on the learning process that includes researching, reading, writing, and presenting[7]. The authors found that low self-esteem, low interest in the process and high stress lead to avoidance of learning tasks and negatively impact learning process and success.

Nahl (2005) investigated the effects of affective variables on search behavior and found that self-efficacy and optimism counteracted the effects of negative emotions, such as irritation and frustration, associated with uncertainty and time pressure. Self-efficacy and optimism were also found to increase user support and acceptance of the system.

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[7] Though this model is developed in educational research, it is very similar to Kuhlthau's Information Seeking Model.

The effects of self-efficacy on search behavior were also studied by Nahl and Meer

(1997). The authors found positive correlation between students' self-efficacy and search

performance.

3 Conceptual Framework

3.1 Role of emotion in the online information retrieval process

Section 2.2 reviewed studies of emotions in human computer interaction and,

specifically, information retrieval contexts. The studies suggest causes and effects of

emotions on different stages of the information retrieval process. Figure 3.1 summarizes

findings from the previous research on affective aspects of information retrieval behavior

and integrates users' cognitive, behavioral and emotional states during a search.

levels:

cognitive	**1. information need/task** (interest, difficulty)	**4. changes of knowledge states**	**7. (not)addressing the need** (presence/quality of the answer)
action	**2. user prior to search** (individual characteristics: cultural background, age, knowledge level, etc.)	**5. searching IR system** (keyword search, browsing, use of navigation, evaluation of sources, etc.)	**8. search completion** (stopping; reiterating)
emotional	**3. prior emotional states** (e.g., mood, uncertainty or anxiety levels)	**6. changes in emotional states** (e.g., changes in uncertainty levels, self-efficacy, anxiety, optimism/pessimism, positive/negative emotions)	**9. satisfaction; building perceptions/attitudes**

Figure 3.1 **Model of emotional information search**

The model illustrates how emotional experiences influence and are influenced by other aspects of retrieval process.

The action level represents stages of the generic online search situation and includes searching and completion stages. Each search stage is associated with particular search behaviors that evolve over time and include multiple actions, including use of search tactics and system features, evaluation of information, and repeated searches (Bilal 2000; Bilal 2002; Bilal & Kirby, 2002).

Cognitive and emotional levels represent different internal states experienced by users during the search (Wang et. al., 2000, Bilal, 2000; Tenopir et. al., 2006; Nahl & Tenopir, 1996).

Relationships between various model components are represented by arrows. Emotional experiences during a search are affected by the user states prior to his/her active engagement in a search. These states are determined by users' individual characteristics, such as age (Bilal & Kirby, 2002) and cultural background (Kleinsmith et al., 2006), moods and attitudes prior to the search (Bilal & Bachir, 2007b; Picard et al., 2001, Gwizdka & Lopatovksa, in press), levels of self-efficacy (Nahl & Meer, 1997; Nahl, 2005), familiarity with a system (Bilal & Kirby, 2002) and the nature of search task (Nahl, 2004; Arapakis, et al., 2008).

During information retrieval, emotions were shown to affect search behaviors, such as search strategies (Nahl & Tenopir, 1996) and performance (Nahl & Meer, 1997; Wang et al., 2000; Nahl, 1998; Gwizdka & Lopatovska, in press). Emotions have been shown to be affected by the search process, such as search performance (Wang et al., 2000), use and performance of online systems (Bilal, 2000; Bilal & Bachir, 2007b; Tenopir, et al. 2006), interest in the process and documents (Kracker, 2002; Kracker & Wang, 2002; Lopatovska & Mokros, 2007).

Successful or unsuccessful search completion influences user emotional experiences (Tenopir, et al., Bilal & Kirby, 2002; Nahl, 2004). In turn, emotions influence decisions to continue or end the search (Klein et al., 2002; Parker & Berryman, 2007).

Our study attempted to verify and expand this model. The first research question focused on areas 5 and 6 in the model and examined the micro-level relationships between seven basic universal emotions and seven search behaviors (Figure 3.2):

> What patterns of emotional expressions of seven basic universal emotions
> (neutral, fear, anger, disgust, happiness, sadness, and surprise) can be observed
> immediately before and immediately after three types of search decisions
> (selection, text manipulation and (re-) examination) represented by seven search
> behaviors: left button single, left button double, right button single, middle button
> mouse clicks, mouse up and down scroll and Google and non-Google page
> changes?

Seconds before behavior	Search decisions/	Seconds after behavior
Facial expressions of emotions:	**behaviors:**	**Facial expressions of emotions:**
Neutral	<u>Selection:</u> left button single click, left button double click; Google URL change	Neutral
Fear	non-Google page changes	Fear
Anger	<u>Text manipulation</u>: right button single click	Anger
Disgust	<u>(Re)examination</u>: middle button mouse clicks,	Disgust
Happiness	wheel up mouse scroll,	Happiness
Sadness	wheel down mouse scroll	Sadness
Surprise		Surprise
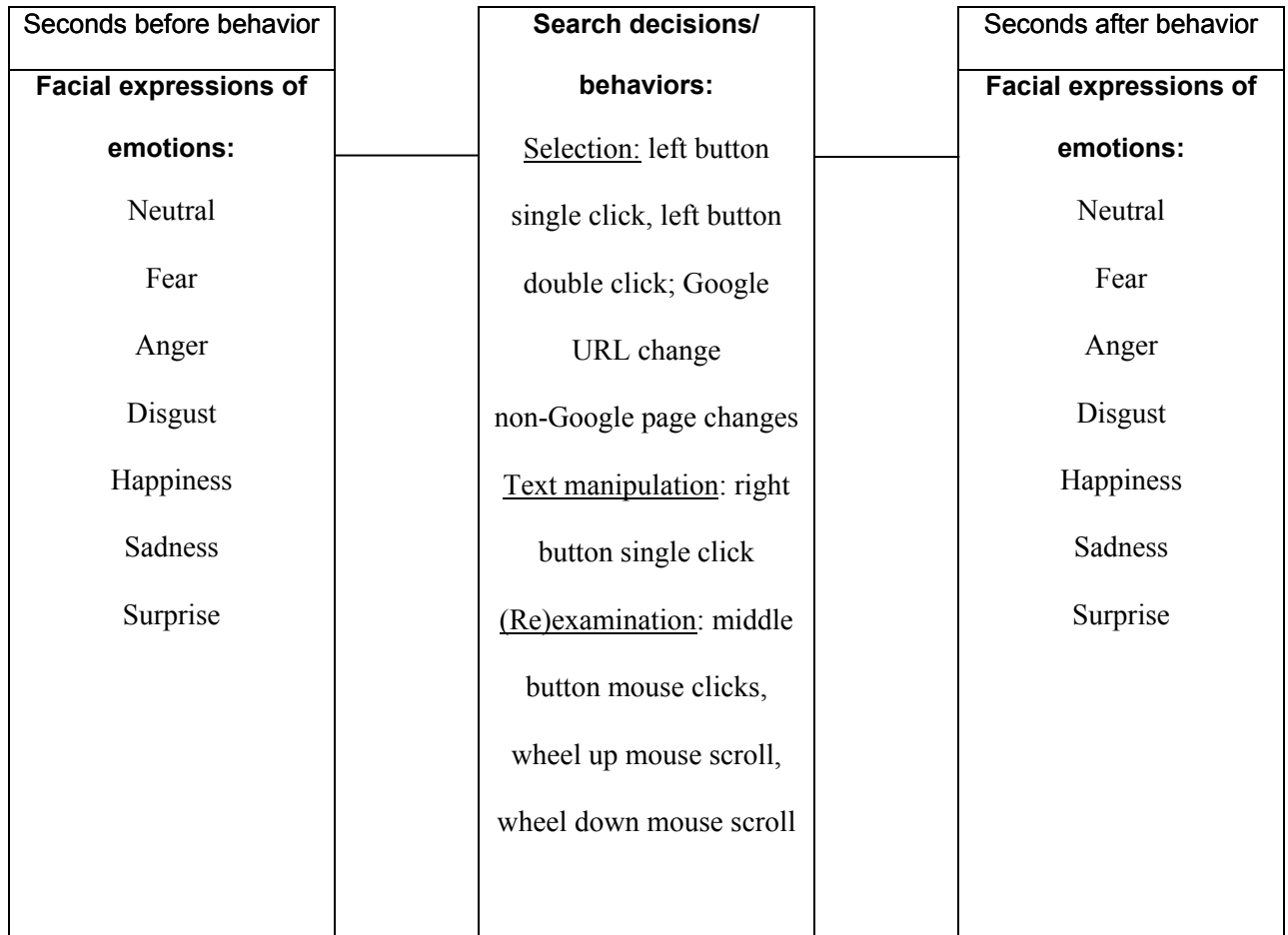
Figure 3.2 **Conceptual model investigated by Research Question 1.**

We focused on examining three types of search decisions that manifested themselves in various search behaviors. We looked at selection decisions, decisions to change existing screen view by left button single and double clicking, or by change to the URL; decisions to manipulate text by right button clicking; and decisions to examine or re-examine search results or documents by scrolling up or down the page. We selected these search decisions because they represent the most common tactical decisions faced by the

searchers and because these decisions are manifested by the most common search

behaviors, that are easily traceable by search log applications.

Research questions two and three examine all levels of the model of emotional

information search, but focus on selective affective concepts, individual characteristics

and search performance and outcomes. We examined the relationships between mood and

emotions and search performance and outcomes (Research question 2):

> What are the relationships between users' emotions and their search performance
>
> (represented by search duration, query length, time examining search results,
>
> number of queries, number of viewed hits, number of result pages requested per
>
> session), and moods and search outcomes (manifested in the quality of search
>
> results) and search performance?

We also examined effects of individual searcher's characteristics on the mood and

emotions during the search (Research Question 3):

> What are the relationships between users' individual characteristics (frequency of
>
> searching the internet, pleasantness of the search experience, interest in the search
>
> task, familiarity with similar searches, clarity about the search goal, and
>
> satisfaction with search results) and their emotional expressions during the
>
> search?

The dotted arrows in Figure 3.3 illustrate the relationships that were not discussed in the

research questions, but were examined as part of the data analysis (e.g., the patterns of

searchers' mood before and after each search task, effect of search performance on search

outcomes, effect of task type on the mood during the search)
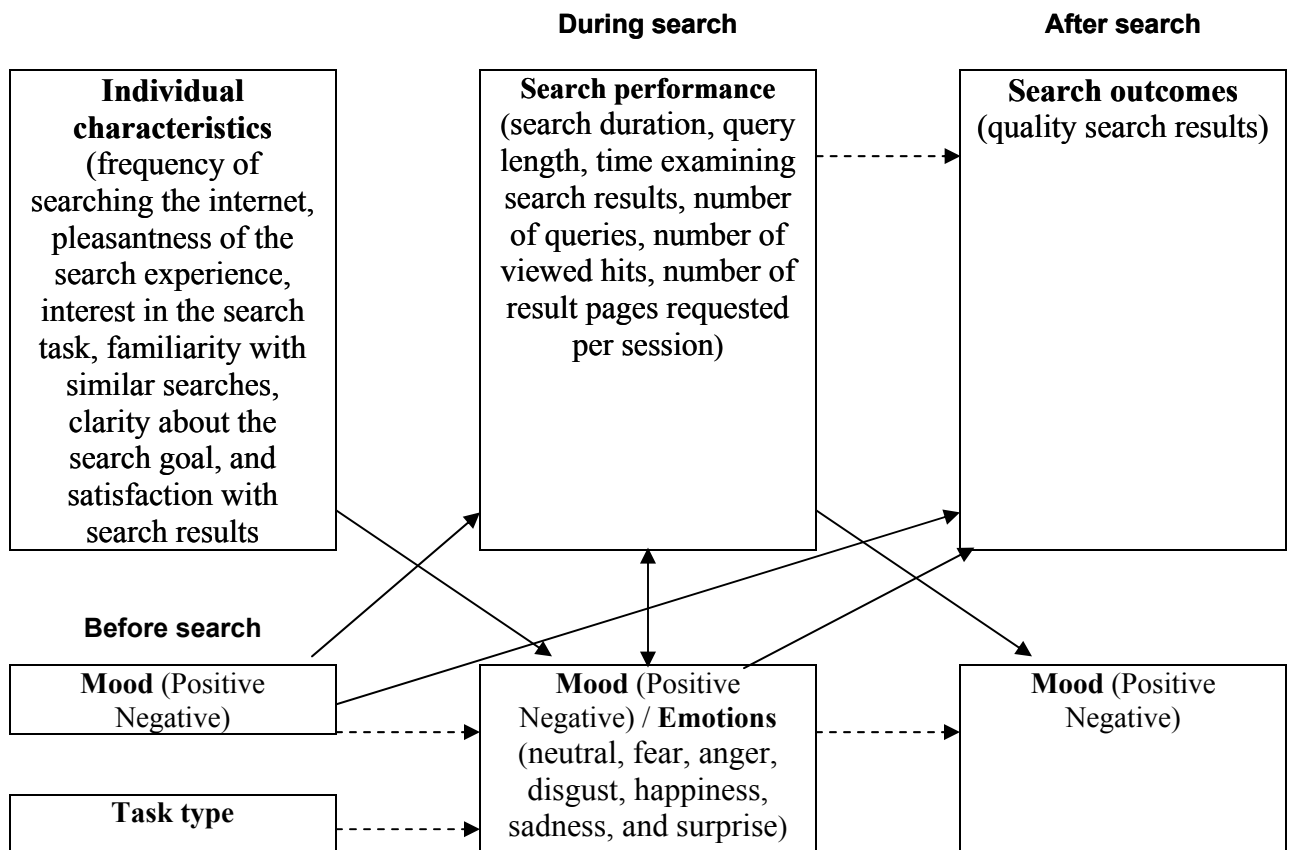
Note: Arrows represent relationships between constructs.

Figure 3.3 **Conceptual model investigated by Research Questions 2 and 3.**

3.2 Major Concepts: Emotion and Mood

Though the concept of emotion is intuitively well understood (especially when it is

discussed in relations to cognitive and sensorimotor aspects of information retrieval,

Nahl, 2007), is it almost never explicitly defined in the LIS literature. Lack of a definition

does not stop researchers from studying emotion's properties and effects (just as the lack

of a unified definition of "information" does not stop information scientists from studying

its properties and effects). Emotional states investigated in the previous studies have been

referred to as "emotions", "affect", "feelings", "subjective states". Emotion research

theorists distinguish between these concepts and define emotion as a reaction to

affectively important events (Frijda, 1994), feeling as conscious subjective experience of

emotion (VandenBos, 2006), and affect as hedonic experience of pleasure or pain (Frijda,

1999). We felt that the selection and use of terminology and particular theories should

determine the nature and method of inquiry into emotion and mood.

Section 2.1 reviewed several theoretical approaches to emotion, including discrete and

continuous theories of emotions. Discrete emotions theories are useful for studying

decisions involved in the search process since various discrete emotions are associated

with the stages of decision process (e.g., like or dislike assist in preference construction,

fear and disgust enable rapid choices under time pressure, anticipated regret or

disappointment help to focus attention on relevant aspects of a decision problem, Hans-

Rüdiger & Gisela, 2008). A discrete emotions approach is useful in identifying specific

emotions associated with information retrieval and leads to development of interfaces

that minimize negative emotions (e.g., frustration, anxiety) and maximize positive

emotions (e.g., joy). Dimensional emotion theories might be helpful for understanding the quality of information experience, such as its moment-based or overall arousal and valence levels (e.g., a rating of pleasurable/unpleasurable search experiences).

We based our definition of emotion based on Frijda's (1999) definition of emotional experience since this definition highlights all aspects of emotion included in our study. Frijda (1999) argues that emotional experience consists of affect, awareness of the emotional object and further appraisal of that object, action readiness and automatic arousal. Affect is defined as hedonic experience of pleasure or pain, like or dislike that helps to mediate between stimulus perception and further action readiness. Affective reactions motivate seeking of the pleasant stimulus and avoidance of the painful or unpleasant stimulus. Emotions are felt to be "about" something, they involve a particular relationship to the stimuli (this relationship also distinguishes emotion from mood). Emotions involve appraisal of stimulus and implications for dealing with it. Another component of emotion is action readiness, a motivation to change behavior.

In order to answer the first research question, we needed to determine the duration of the emotional expressions (see Section 1.3). We examined the literature about emotion duration and did not find any consistent theories about duration of emotion. Instead, we found that authors disagreed about the relationships between emotion duration and 1) the type of emotion (Scherer, 1988); 2) emotion intensity (Sonnemans and Frijda, 1994); and 3) cultural background and personality types (Scherer, 1988; van Goozen, van de Poll, & Sergeant, 1994). However, most of the authors agree that emotion duration can vary from

a few seconds to several days and can depend on the type of the experienced emotion[8]

(Scherer, 1988; Sonnemans & Frijda, 1994). Because the main focus of our study was not

investigation of the emotion phenomenon, but recognition of patterns of emotional

expressions around the search events, we focused on the literature about the duration of

emotional expressions. Because the study used the facial recognition method based on

Ekman's (2003) research, we also used his estimates for the duration of individual facial

expressions of emotions (Ekman & Friesen, 2003).

Our research is also based on the assumption that emotions lead to and are caused by

search behaviors (see Research Question 1, Section 1.3). This assumption implies that a

search behavior, such as a particular type of a mouse click, happens when a searcher

decides to change the status quo, regardless of a specific stimulus leading to this decision.

For example, disgust with the existing stimulus should lead to a rapid decision to change

the status quo (Hans-Rüdiger & Gisela, 2008), happiness with the existing stimulus

should lead to its continuous use (such as scrolling down the page that contains helpful

information). Some emotions should be caused by certain search behaviors, for example,

a click might lead to a surprised reaction or an increased happiness with the changed

situation. Table 3.1 summarizes specific search behaviors that we examined and

describes their meaning as the search decision making points.

---

[8] Scherer et al, 1986 found that fear is one of the shortest lasting emotions and lasts from a few seconds up to a maximum of an hour, while sadness can last from one day to several days.

Table 3.1 *Search behaviors and represented decision points*

Search behavior	Variable name	Decision Type	Decision point represented by search behavior*
Mouse clicks: Left button down	L Button Down	Selection	Decision to change the current view by clicking on a Search button, URL or another application, changing the page focus (scrolling up/down the page, bringing one page on top of the other), etc.
Left button double	L Button Double	Selection	Same as Left button down, might also represent the personal preference in clicking and/or impatience to get to the action results
Right button down	R Button Down	Text manipulation	Decision to manipulate found text (copy, paste, save, etc.)
Middle button down	M Button Down	(Re)examination	Scrolling technique, see Wheel up/down
Wheel scroll down (total)	Wheel-	(Re)examination	Decision to review additional sources/information
Wheel scroll down on Google	Wheel-Google	(Re)examination	Decision to scroll down the results page in search of links

result pages	results		that look promising
Wheel scroll down on non-Google, target pages	Wheel-non-Google	(Re)examination	Decision to scroll down the target page in search of an answer
Wheel scroll up (total)	Wheel+	(Re)examination	Decision to return to the previously seen information, might be indicative of a thorough examination of result(s)
Wheel scroll up on Google result pages	Wheel+ Google results	(Re)examination	Decision to scroll up the results page to re-examine results or query
Wheel scroll up on non-Google, target pages	Wheel+ non-Google	(Re)examination	Decision to re-examine information on the target page for careful examination or search for navigation features
URL changes: Google page change	Google	Selection	Submission of a query and review of Google search results immediately after the submission
Non-Google page change	Non-google	Selection	Selection of one of the Google retrieved results and review of

			a document immediately after the selection

* The explanation of the decision points were informed by the analysis of the Morae video recordings of the search screens and searchers' actions.

In summary, based on the reviewed emotion theories and the goals of our study, we assumed that emotions are discrete and transitory feelings that lead to and are caused by search behaviors and can be expressed by facial muscles (Ekman, 2003) over the duration of up to 5-10 seconds (Ekman & Friesen, 2003).

Another affective concept that we examined in the study was mood (see Research Question 2, Section 1.3). The decision for including the mood concept in the study was informed by previous research that found effects of mood on human computer interactions. Bilal and Bachir (2007b) found that moods and attitudes prior to the search affected the search process. Lazar et al. (2006) found that frustration levels during the search were negatively correlated with the mood after the session. In the study of a single subject's reactions on identical stimuli over a period of time, Picard et al., (2001) found that features of different emotions on the same day clustered more tightly than the features of the same emotions on different days. We controlled a mood variable to investigate whether it impacts searching patterns and explains individual variance between subjects.

Mood is a relatively long lasting feeling that, unlike emotion, is not felt "about" anything (Morris, 1999). We examined mood during the online search to find out whether this long-term affective state that is not easily modified during the course of a one-time search session, has any effect on the search performance and outcomes.

4 Methodology

We used experimental methodology to investigate emotional aspects of online information retrieval. The major advantage of experimental setting over naturalistic study was the ability to control some of the variables that affect emotions and to record every aspect of the online search, including user search behaviors and emotional reactions, system performance and other variables. The major disadvantage of the experimental methods is that the study takes place in an artificial setting that might impact participants' interest, motivation and other emotional states. Some of these disadvantages were mitigated by the experimental procedure that included offering rewards for participation, giving participants search scenarios that might be similar to their routine search activities and asking them to search familiar information systems.

4.1 Constructs, Variables and Methods of Obtaining Variables

The study investigated the behavior and the relationships between several constructs included in the research questions. Table 4.1 below lists the constructs, their definitions and specific variables representing each construct, and ways of collecting data during the experiment.

In order to answer research question 1, we had to investigate the relationships between emotional expressions and search behaviors. In order to detect the presence of emotional expressions, video recordings of searchers' faces were made and expressions of seven universal expressions (neutral, fear, surprise, sadness, happy, anger and disgust) were automatically detected by eMotion Recognition software, public release 1.65. eMotion is a facial recognition software package that is based on the facial recognition (FACS) framework developed by Paul Ekman (Ekman, 2003, 1984, 1992; Sebe et al,, 2007). It analyzes appearance changes in the facial features and classifies each video frame individually to one of the facial expression categories (see Appendix E for the sample of the eMotion file output). eMotion's face tracking algorithm is based on a simplified version of Ekman's FACS (Sebe et al., 2007; Valenti, Sebe, & Gevers, 2007).. The software analysis video stream by constructing a 3 dimensional wireframe mesh over the recorded face, noting the positions of certain facial features (e.g., eye brow, corner of a mouth and eyes, etc), and feeding the readings into the classifier developed from a subset of the Cohn-Kanade database. The software produces an output that includes a video frame ID, time stamp and a probability with which the analyzed facial expression is classified as either neutral, fear, surprise, sadness, happiness, anger or disgust. (Appendix E). An earlier study that used eMotion software only considered facial expressions that received a classification probability of .90 (Arapakis et al., 2008). To eliminate noise in the data, we also used the threshold of .90% probability or higher for including coded facial expression into our analysis.

Search behaviors performed to change the content of a screen (e.g., mouse clicks) are usually studied by analyzing transaction logs (Jansen, 2006; Peters, 1993). It is possible to generate transaction logs and record searcher's actions in both experimental and natural settings. For example, studies that investigate query formulation during web searches often analyze log files generated during hundreds of natural searches (Stenmark, 2008; Jansen, Spink & Saracevic, 2002; Rieh & Xie, 2006; Huang, Shen, Chiang, & Lin, 2007). Studies exploring multiple aspects of the search process and its relationships with cognitive and affective factors usually generate log files in an experimental setting. For example, in a study of cognitive, affective and physical behaviors of web searchers, Wang et al. (2000) and Bilal and Kirby (2002) recorded keystrokes and screen actions during experimental sessions. Because the goal of our research is to identify search behavior patterns in comparable search settings, a controlled experimental setting was more appropriate. We recorded mouse clicks and URL changes using TechSmith Morae Recorder version 2.0.1. The following search behaviors were recorded and extracted from the Morae log file: Left button down, Left button double, Right button down, Middle button down, Wheel down/-, Wheel up/+, Google results page change, Non-Google target page change (Table 4.1).

While we expected to see patterns in the relationships between emotional expressions and search behaviors, we did not find enough evidence from previous research to test a specific hypothesis. This made our investigation of the first research question to a large extent exploratory in nature.

Research question two investigated relationships between participants' mood and their search performance and outcomes. Mood was measured using the Positive Affect and Negative Affect Schedule (PANAS) (see Appendix A). The PANAS is comprised of two 10-item scales that measure positive affect (extent to which the person feels enthusiastic, active, and alert) and negative affect (extent to which the person experiences subjective distress, including anger, contempt, disgust, guilt, fear, and nervousness). The PANAS has demonstrated high reliability and internal and external validity; it is brief and easy to administer (Watson, Clark, & Tellegen, 1988). The instrument is frequently used in psychology and other fields (Crawford & Henry, 2004; Mackinnon, Jorm, Christensen, Korten, Jacomb, & Rodgers, 1999; Thompson, 2007). Numeric responses on a scale of 1 to 5 to the ten PA and ten NA items are added to derive individual PA and NA scores ranging between 10 and 50.

Two more concepts that address research question 2 are searchers' performance and outcomes of their search. A number of previous studies explored the relationships between emotions or affect and search performance. Search performance variables are almost always viewed as indicators of searching skills. However, search performance can either be viewed as a process (Nahl & Tenopir, 1996; Nahl, 1998; Parker & Berryman, 2007), or an end-result of search (Gwizdka, 2008). Both Bilal (2000) and Kim (2008) viewed search performance as a set of navigation techniques. For example, back-and-forth movements between already visited pages are regarded as redundant and inefficient techniques. Linear navigation, such as use of jump tools, is regarded as a more efficient

way of revisiting pages (Bilal 2000; Kim, 2008). Time to complete the task and time spent on reviewing results were also viewed as search performance variables (Bilal & Kirby, 2002). Several studies linked emotions with end-results of search performance. Butler and Cartier (2005) found that low self-esteem or low interest result in poor achievement, and high stress during the inquiry negatively impact results.

Our study investigated variables that represent search performance as both a set of particular search behaviors and as a quality of end-results. All performance variables, except the quality of end-results, were extracted from transaction logs recorded by the Morae software during searches, and included

1. Time spent on a search task, defined as time when participants looked directly at the search screen or/and were actively engaged in searching, and not the times when participants filled out questionnaires, read the search tasks or interacted with experimenter (variable name TaskTime).

2. Total number of URLs visited (variable name AllURLs).

3. Number of viewed hits, defined as a clicked on URL from a search results' page (Jansen & Spink, 2003); (variable name ReviewedHits).

4. Number of result pages requested per session, or, in other words, the number of times a user submitted a query to a search engine, possibly indicating user's interactivity levels (Stenmark, 2008) (variable number GooglePages).

5. Number of unique queries per session, which may indicate levels of user's interactivity (Chen & Cooper, 2001) (variable name UniqueQueries).

6. Query length, defined as the number of words in a query, were word is "any unbroken string of characters" (Jansen et al., 2000, p.211) entered into the web browser search box; the variable possibly indicates searchers' sophistication levels (Stenmark, 2008); variable name QueryLength.

7. Time examining each search results' page in a search session (variable name TviewResults).

8. Time examining each selected document, defined as time from clicking on the URL from a search engine results' page to returning back to the search engine (Jansen & Spink, 2003). The length of time spent viewing the documents can be linked to knowledgeable or thorough users (Stenmark, 2008) (variable name TReadHits).

Search outcomes were defined as the end-result of the search, as the written answers to the search task questions that participants provided at the end each search. Each participant produced two answers, or search results, to the two search tasks posed during the experiment. Search tasks were presented to participants as search scenarios requiring them to find information for a friend and then write their answers in an email format. The text of participants' answers was subsequently given to independent judges (previously done by Gwizdka, 2008, and others) who evaluated the general quality of answers based on answers' completeness, trustworthiness, and presentation using a 3-point scale, where 0=poor, .5=average, and 1=good.

Research question three examined relationships between searcher's individual characteristics and their emotional expressions during the search.

We selected the following searchers' individual characteristics because they were found

to be linked with affective variables in prior research. Emotional experiences were shown

to be influenced by 1) frequency of searching the web and familiarity with similar

searches as indicators of searcher's experience with similar systems/tasks (Meghabghab,

1995; Bilal & Kirby, 2002; Nahl, 2004); 2) interest in the process or documents (Kracker,

2002; Kracker & Wang, 2002; Lopatovska & Mokros, 2007); 4) clarity about the search

goals and information that was needed to be found as indicators of participants'

comprehension of the search task and possibly their feeling of being confused or lost

(Gwizdka & Lopatovska, in press); and 5) and satisfaction with search results (Nahl,

2004, 1998; Bilal & Kirby, 2002). The individual characteristic's variable that we did not

encounter in previous LIS research and we added based on the methods used in

psychology (Kahneman, 2000) was the general subjective evaluation of the search

experience variable.

We used pre- and post-task questionnaires to collect individual characteristics data

(Appendix B).

Table 4.1 *Research Questions and Corresponding Study Constructs and Variables*

Research Questions (R.Q.)
R.Q.1. What patterns of emotional expressions of seven basic universal emotions (neutral, fear, anger, disgust, happiness, sadness, and surprise) can be observed immediately before and immediately after three types of search decisions (selection, text manipulation and (re-) examination) represented by seven search behaviors: left button

single, left button double, right button single, middle button mouse clicks, mouse up

and down scroll and Google and non-Google page changes?

4. R.Q.2. What are the relationships between users' emotions and their search performance

(represented by search duration, query length, time examining search results, number of

queries, number of viewed hits, number of result pages requested per session), and moods

and search outcomes (manifested in the quality of search results) and search performance?

R.Q.3. What are the relationships between users' individual characteristics (frequency of

searching the internet, pleasantness of the search experience, interest in the search

task, familiarity with similar searches, clarity about the search goal, and satisfaction

with search results) and their emotional expressions during the search?

R.Q.	Construct	Definition	Variables	Collection method
R.Q. 1	Emotional expressions	Facial muscle expressions of seven universal emotions (Ekman, 2003)	Seven types of facial expressions of the following emotions: 1. Neutral (coded and used only when coincides with decision point) 2. Fear 3. Surprise 4. Sadness 5. Happiness	Video recordings of participants face analyzed by the eMotion emotion-recognition software

			6. Anger 7. Disgust	
R.Q.1.	Search behaviors representing decision points	Searchers' interactions with computer equipment over the course of search (Jansen, 2006; Stenmark, 2008; Wang, Hawk, & Tenopir, 2000)	The following six types of mouse clicks: 1. Left button down 2. Left button double 3. Righ button down 4. Middle button down 5. Wheel down/- 6. Wheel up/+ Two types of URL changes: 1. Google results page 2. Non-Google target page	Morae generated log file
R.Q.2.	Mood	Positive Affect (PA) and Negative Affect (NA) measured using PANAS questionnaire (Watson, Clark, & Tellegen, 1988).	1. PA scores collected before each search task and after a complete search experience 2. NA scores collected before each search task and after a complete search experience	PANAS questionnaire (Watson et al., 1988)
R.Q.2.	Search	Combinations of	1. Time spent on a search	Morae

	performance	search behaviors that are indicative of participants' searching skills (Bilal and Kirby, 2002; Stenmark, 2008)	task 2. Total number of URLs visited 3. Number of viewed hits 4. Number of result pages requested per session 5. Number of unique queries per session 6. Query length 7. Time examining search results page 8. Time examining a document	generated log file
R.Q.2.	Search outcomes	End-result of the search: written answers to the search task questions that participants provided at the end each search	A score representing the total quality of the answer	Three independent judges scored participants' answers
R.Q.3.	Individual characteristics	Self-reported information about internal experiences, states and judgments	1. Frequency of the internet searching 2. Overall subjective evaluation (pleasantness)	Pre- and post-task questionnaires

			of the search experience	
			3. Interest in the search task	
			4. Familiarity with similar searches	
			5. Clarity about the information needed to address the search task	
			6. Satisfaction with search results	

Due to the nature of the research questions, different units of analysis were used to address the research questions. The first research question examined emotional patterns around search behaviors, therefore the unit of analysis was search behavior. For example, when we analyzed emotional expressions around Wheel Up scroll, the unit of analysis was Wheel Up scroll and the sample was based on all the Wheel Up scroll clicks made by all 30 participants (total number of clicks is 1940). For the research questions two and three, we examined participants' moods, emotions, individual characteristics, search performance and outcomes related to the two search tasks they performed. Because each participant performed two search tasks, the unit of analysis was participant during the two performed tasks (total number of 60).

4.2 Sample

Our study investigated searches' emotions during the search process. We did not find previous studies that would suggest the existence of variation of emotive patterns

exhibited by different demographic groups during search. Considering the current state of

knowledge about the role of emotions in online searching, search behavior of any

population was of interest to us. We recruited a group of thirty six undergraduate students

enrolled in a psychology course. Six cases were incomplete and had to be discarded

resulting in the thirty complete cases (N=30). The average age of participants was 19

years old; thirteen of the participants were males, while seventeen were women. The

ethnic distribution of participants was diverse, with whites and Asians accounting for the

majority of participants. Most of the students participating in the study were enrolled in

the natural science majors, followed by social science, and a relatively large number of

undecided majors. All but one of the participants reported online searching to be at least a

daily activity. Table 4.2 offers descriptive statistics on the participants.

Table 4.2. *Descriptive statistics of the research sample*

Variable	Value	Percent
Age	Min: 18	
	Max: 23	
	Mean: 19	
Gender	Female: 17	57%
	Male: 13	43%
Ethnicity	White: 12	40%
	Asian: 11	36%
	Hispanic: 3	10%
	African American: 2	7%
	Mixed: 2	7%

Major	Natural science: 10	33%
	Social science: 9	30%
	Undecided: 8	27%
	Humanities: 3	10%
Frequency of online searching	Several times a day: 24	80%
	Once a day: 5	17%
	Several times a week: 1	3%
Total # of cases	30	100%

4.3 Data collection

4.3.1 Task

The participants were given two search tasks during the course of the experiment.

Varying search tasks' topics and difficulty levels were necessary for examining the

effects of perceived difficulty and interest in a task on emotions and search behaviors

(Research Question 3).

The two search scenarios that were given to participants were informed by the work of R.

W. White (2004) who classified a set of tasks based on complexity levels. Search tasks

devised by White were used in other studies (White, Ruthven, & Jose, 2005; Bell &

Ruthven, 2004). We pre-tested White's tasks in a pilot experiment. We selected the two

tasks that received the most consistent difficulty evaluations from participants: a search

scenario about university enrollment and a music piracy scenario. The music piracy task

was judged as more complex then the enrollment task and on average took participants

longer to complete in the pilot study.

The original text of the two search tasks from White study is included below.

A low complexity task was defined as a task that provided subjects with more

information. "Subjects generally found tasks in this category the more 'clear' and

'simple' than those from other categories" (White, 2004, p. 185):

> "A friend has recently been applying to various universities and courses but has been complaining that they are finding it difficult to attain a place due to the rising numbers of students. You were unsure if their assessment was correct so you have decided to find out how the size of the student population changed over the last 5 years and how it is expected to change in the coming 5 years."

A high complexity task was defined as a vaguely formulated task requiring information

from multiple sources. "Subjects found these tasks difficult and classified tasks in this

category as least 'clear' and 'simple'" (White, 2004, p. 185):

> "Your friend has just finished reading a copy of a national newspaper in which there is mention of Internet music piracy. The article stresses how this is a global problem and affects compact disc sales worldwide. Unaware of the major effects you decide to find out how and why music piracy influences the global music market."

The final text of the search tasks was slightly modified for the purposes of our study

(Appendix B).

Search tasks were rotated using a Latin square design so that half of the participants

received the more difficult task first, another half received the easier task first.

4.3.2 Experiment setting

The experiment took place in the Interaction Laboratory of the School of

Communication, Information and Library Studies at Rutgers University. The room where

the experiment took place did not have windows; the ceiling light was adjusted to

minimize screen reflections. The room had a computer desk with two monitors and a

keyboard, and a second table where participants read the consent forms.

A Dell Precision T3400 workstation (Intel Core2 QuadCPU (Q6600@2.40 GHz), 4 GB

of memory, Windows XP Professional (service pack 3), three 500GB hard drives (the

total of 1500GB) was used to run experimental session. There were two monitors on the

computer desk. One monitor was positioned directly in front of the user. This primary

monitor was used for searching and only displayed the Google search engine in Windows

Internet Explorer version 7. All participants' search actions and screen shots of this

monitor were recorded using TechSmith Morae Recorder version 2.0.1. Two web

cameras were positioned above and below the primary search monitor to video record

searchers' faces. The video stream captured by the camera that was positioned on top of

the monitor was saved as an AVI video file and was used as the primary source for the

eMotion facial expression analysis. The video stream from the camera that was

positioned under the primary monitor was saved as part of the Morae Recorder program

for backup. The second computer monitor was used to display the text of instructions,

search scenarios and pre- and post- tasks questionnaires. Participants' interactions with

the second monitor were not recorded.

The experimenter was not present at the lab during the search sessions so as not to interfere with the search experience and to create as natural a search environment as possible.

4.3.3 Procedure

Each participant was scheduled for an individual session lasting no more than two hours.

Upon arrival to the lab, participants were greeted by the experimenter and given an Informed Consent Form (Appendix D). Participants read the form and listened to the experimenter's explanation of the experimental procedure.

Participants were asked to sit at a computer terminal. The experimenter described the experimental session flow and explained the function of the two monitors (one monitor for the survey, another monitor for searching in Google).

To ensure that the participant's face was properly exposed to the recording web cameras, the experimenter asked participants not to lean on the desk. Participants were asked to take as much or as little time as necessary to find information on the two search tasks. At this point, the experimenter left the room.

Participants' actions during the session were guided by the online questionnaire (Appendix B) that solicited demographic information, presented the text of two search tasks and instructions on how to search and provide answers, and asked about

participant's internal states before and after each search task. Participants were left alone in the lab for the duration of the two search sessions and were asked to call for the experimenter when they finished filling out the questionnaire after their second search.

Upon return to the lab, the experimenter debriefed and interviewed the participants. Participants were shown a Morae recording of their search sessions. The Morae recording of the screen activities was fast-forwarded to refresh participants' memories of the search and solicit detailed comments about the search process (Appendix C). The post-search interview included questions about searchers' specific activities during the search and what they felt about the things they were doing or finding. The questionnaire also asked participants to investigate the extend to which participants were disturbed by the lab setting, extend to which they were clear about the experimental instruments and tasks, their primary motivation to participate in the study, and their general mood that day. The post-search interview was audio recorded.

At the end of the experimental session, participants were given course credit for participation in a study.

5 Results

5.1 Data analysis for Research Question 1: emotional expressions and search behaviors

The following section describes data analysis methods that were used and results that were obtained to answer the following research question:

> What patterns of emotional expressions of seven basic universal emotions (neutral, fear, anger, disgust, happiness, sadness, and surprise) can be observed immediately before and immediately after three types of search decisions (selection, text manipulation and (re-) examination) represented by seven search behaviors: left button single, left button double, right button single, middle button mouse clicks, mouse up and down scroll and Google and non-Google page changes?

5.1.1 Emotional Expressions

Most of the participants reported not feeling very intense emotions during the search (the mean answer to the questionnaire question "How intense were the feelings you experienced during the search?" on a scale of 1-5 was 2). Participants also reported not controlling their feelings or their expression (mean answer to questions" To what extent did you try to control your feelings by reducing their intensity and shortening their duration?" and "To what extent did you try to control the expressions of your feelings?" on a scale of 1-5 was 1).

Several randomly selected video files were manually analyzed using FACS framework to validate eMotion readings. Automatic and manual coding agreed about 60% of the time. Most of the discrepancies occurred due to the software's inability to interpret contextual gestures. For example, in situations when participants chewed their lips or scratched their faces, the software often interpreted these gestures as changes of emotion (e.g., mouth movements during lip chewing could be interpreted as a constant change from happy to sad expressions).

The eMotion data were saved into a text file that included video frame ID, time (in milliseconds), and probability of emotion presence based on facial analysis (see Appendix D for a sample of the eMotion output file). In order to normalize expression distribution across subjects who spent different amounts of time searching and expressed different numbers of emotions, we divided the sums of the 7 emotions by the number of frames in the video recording (proxy for the search duration). Emotional expressions with

above .90% recognition probability, normalized for the time difference and number of

emotional occurrences were used in the analysis. Appendix D illustrates the difference

between the original eMotion dump file and the file prepared for the analysis.

We analyzed distribution of emotional expressions across all participants. The most

frequently expressed emotion was surprise (even more frequent than 'neutral'), followed

by neutral, sad, fear, happy, disgust and anger. Figures 5.1 and 5.2 contain two

illustrations of the distribution of total emotional expressions that occurred during 30

searches. The X axes separates the total averages (the sums of individual subjects'

emotions) in no particular order (though the neutral is listed first it did not happen before

happy emotion). The Y axes represents adjusted frequency of each type of emotion.
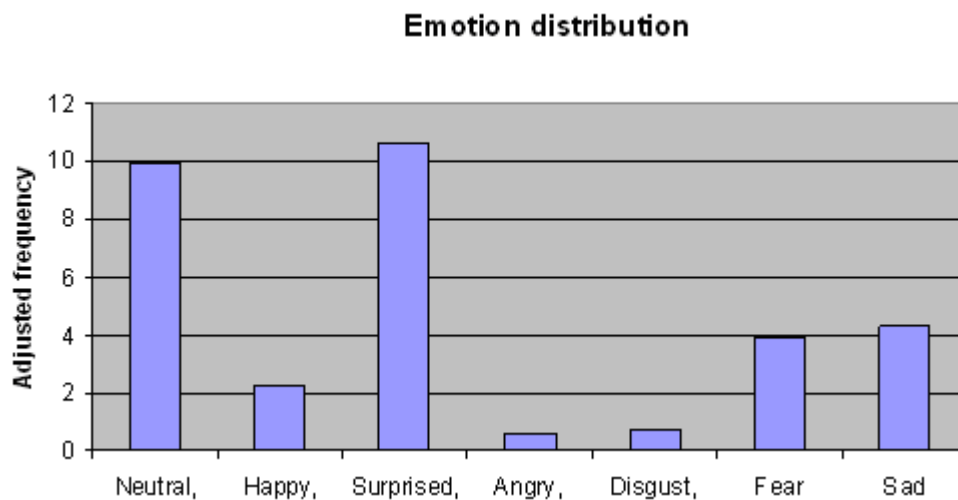
Figure 5.1 **Distribution of emotional expressions per subject (each line represents emotional expressions' distribution of an individual searcher)**

Emotion Distribution (per subject)
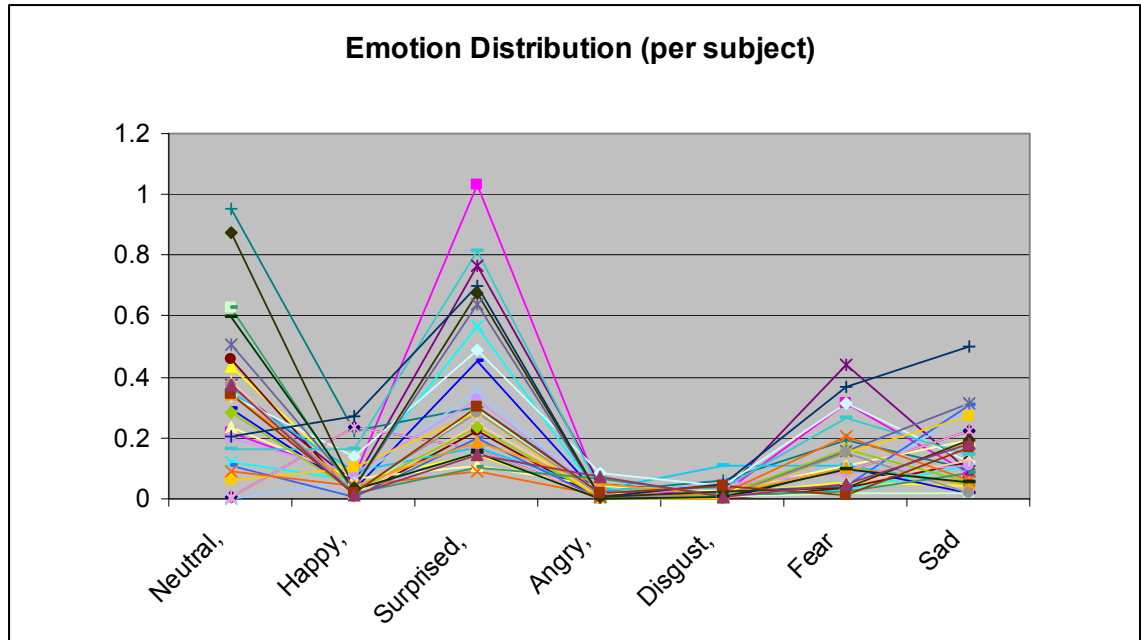
Figure 5.2 **Distribution of emotional expressions per subject (each line represents emotional expressions' distribution of an individual searcher)**

5.1.2 Emotional Expressions around Search Behaviors

The following search behaviors were extracted from the Morae log file: left button down, left button double, right button down, middle button down, wheel scroll up, wheel scroll down, Google URL change, non-Google URL change. The eMotion output files and Morae log files were integrated using the respective time stamps (video frame time stamp for eMotion data and event time stamp for Morae data).

We used the Ekman and Friesen (2003) framework (see Section 3.2) to determine duration of the intervals we needed to examine to detect emotional patterns before and after search events. We started our analysis by examining the eMotion readings and

found that very few emotional expressions lasted less than 1 second (emotional

expressions that registered only for fractions of a second usually corresponded to

transitional expressions between other emotional expressions). We found that some

emotions, such as fear, happiness and disgust, registered for about 1 or more seconds,

while others, such as surprise, could have registered for 2 and more seconds.

We started our analysis by examining three 1 second intervals before and after the event,

resulting in the overall time of 6 sec around the event. We did not identify significant

variations of emotional expressions within these intervals. Because we did not see

significant fluctuation of emotional expressions within a 3 second interval before and a 3

second interval after the event, we decided to expand our time intervals. For example,

using a 3 second interval, we found that a dominant emotion within this interval before a

certain event is anger; we needed to expand the time intervals before an event to see

whether other emotions occurred before anger.

We then selected five 3 second intervals before the event and five 3 second intervals after

the event (Table 5.1).

Table 5.1 *Examined time intervals before and after search events*

Interval abbreviation	Time before/after event
t-5	15-12 sec before event
t-4	12-9 sec before event
t-3	9-6 sec before event
t-2	6-3 sec before event
t-1	3-0 sec before event
t+1	0-3 sec after event
t+2	3-6 sec after event
t+3	6-9 sec after event
t+4	9-12 sec after event
t+5	12-15 sec after event

Examination of emotional expression patterns within these intervals allowed us to observe significant changes in the distributions of emotional expressions around selected search behaviors. We did not, however, find significant variations of emotional expressions within a 30 second interval around the URL change.

We analyzed distributions of all seven emotional expressions: neutral, happy, surprise, angry, disgust, fear, and sad, per each 3 second interval before and after the click and the URL change. We started analysis by calculating probabilities of each emotional expression occurrence within 3 second interval. We then calculated means and medians of emotions' expression distribution per 3 second interval, and performed oneway ANOVA to compare each emotion's means between ten time intervals before and after the event. The detailed description of the findings follows.

Left button down was one of the most frequent events recorded in the search log files (N=2839). The Table 5.2 and a Figure 5.3 below illustrate that surprise and neutral expressions occurred most frequently, followed by sad and fear expressions.

Table 5.2 *Distribution of emotional expressions around Left Button Down Click*

	EventTime	t-5	t-4	t-3	t-2	t-1	t+1	t+2	t+3	t+4	t+5
					L Button Down (N=2839)*						
Medians	**Neutral**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.24	0.24	0.27	0.28	0.29	0.29	0.31	0.27	0.28	0.26
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Means**	**Neutral**	**0.24**	0.24	0.24	0.23	0.22	**0.21**	0.21	0.21	0.22	0.22
	Happy	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06
	Surprise	**0.37**	0.37	0.38	0.39	0.40	0.40	**0.40**	0.39	0.39	0.38
	Angry	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Disgust	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02
	Fear	0.14	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.13	0.14
	Sad	0.14	0.14	**0.13**	0.13	0.14	0.15	0.15	**0.16**	**0.15**	0.15

* values represent probabilities of expression occurrence

** values in bold represent means that were statistically significantly different from others

Figure 5.3 **Distribution of average emotional expressions around Left Button Down Click**

The one-way ANOVA revealed that the means of the following emotions differed significantly in the time intervals around the left button down click: neutral (F(9, 28379) = 3.138, $p < .05$), surprise (F(9, 28379) = 2.413, $p < .05$) and sadness (F(9, 28379) = 3.447, $p < .05$).

The Tukey post-hoc test revealed that

1. Neutral expressions measured in a t-5 interval (15-13sec before the click) were statistically significantly more frequently than neutral expressions measured in the t+1 interval (0-3 sec after the click) (*p=.043*).

2. Surprise expressions that occurred in a t-5 interval were statistically significantly less frequently than surprise expressions during the t+2 interval (*p=.043*).

3. Sadness expressions during the t-3 interval were statistically significantly less frequently than expressions that occurred during the t+3 (*p=.056*) and t+4 (p=*.089*) intervals.

In summary, analysis of variance of 7 emotions around the Left Button Click indicated that the probability of neutral expressions after the click decreased while the probability of surprise and sad expressions increased after the click.

Left button double click was not a very frequent event (N=86 across all 30 participants). Surprise and neutral expressions were the most frequent, followed by the sad and fear expressions (Table 5.3 and Figure 5.4).

Table 5.3 *Distribution of emotional expressions around Left Button Double Click*

		L Button Double (N=86)*									
	EventTime	**t-5**	**t-4**	**t-3**	**t-2**	**t-1**	**t+1**	**t+2**	**t+3**	**t+4**	**t+5**
Medians	**Neutral**	0.04	0.27	0.09	0.00	0.00	0.00	0.02	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.22	0.14	0.18	0.21	0.34	0.30	0.31	0.19	0.21	0.18
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sad	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.01	0.00	0.02
Means**	**Neutral**	0.33	0.40	0.37	0.31	0.25	0.22	0.30	0.30	0.27	0.26
	Happy	0.03	0.04	0.05	0.05	0.05	0.04	0.05	0.03	0.06	0.07
	Surprise	0.35	0.31	0.32	0.36	0.39	0.37	0.40	0.35	0.34	0.33
	Angry	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.03
	Disgust	**0.02**	**0.02**	**0.01**	**0.02**	**0.02**	0.01	0.02	0.05	**0.04**	0.04
	Fear	0.13	0.09	0.12	0.13	0.13	0.12	0.07	0.10	0.10	0.10
	Sad	**0.12**	**0.12**	**0.11**	**0.13**	**0.16**	**0.23**	**0.16**	**0.16**	**0.17**	**0.18**

* values represent probabilities of expression occurrence

** values in bold represent means that were statistically significantly different from others

Figure 5.4 **Distribution of average emotional expressions around Left Button Double Click**

The one-way ANOVA revealed that the means of the following emotional expressions differed significantly in the time intervals around the left button double click: disgust ($F(9, 854) = 1.912, p < .05$), and sad ($F(9, 854) = 2.239, p < .05$).

The Tukey post-hoc test revealed no statistically significant differences in the disgust and sad expressions across the ten time intervals. However, the LSD post-hoc test indicated that

1. Disgust expressions during t+3 were statistically significantly different from the expressions during t-5 (*p=.043*) t-2 (*p=.047*), and t-1 (*p=.044*) intervals; and t+4 disgust expressions were also different from the expressions that occurred during the t-5 (*p=.004*), t-4 (*p=.029*), t-3 (*p=.020*), t-2 (*p=.005*), t-1 (*p=.005*), t+1 (*p=.011*) and t+2 (*p=.012*) intervals. Based on the signs of the mean differences, disgust expressions increased in the intervals after the event.

2. Sad variables during t+1 interval there were statistically significantly more sad expressions than during t-5 (*p=.036*), t-4 (*p=.021*), t-3 (*p=.015*), t-2 (*p=.038*), and t-1 (*p=.040*) intervals; sad expressions during t+2 interval were more frequent than during t-3 (*p=.052*), expressions during t+3 were more frequent than during t-4 (*p=.047*) and t-3 (*p=.034*), sad expressions during t+4 were more frequent than during t-4 (*p=.034*) and t-3 (*p=.025*) intervals, sad expressions during t+5 were more frequent than during t-4(p=.031) and t-3 (*p=.022*) intervals.

Overall, these findings suggest that disgust expressions increased after left button double click while sad expressions peaked during the t+1 interval (0-3 seconds after the click) and generally increased after the click.

Right button down click was not a very frequent event (N=90) during the searches. The most frequent expressions around this type of click were surprised, neutral, and sad (Table 5.4 and Figure 5.5).

Table 5.4 *Distribution of emotional expressions around Right Button Down Click*

	R Button Down (N=90)*									
	EventTime	**t-5**	**t-4**	**t-3**	**t-2**	**t-1**	**t+1**	**t+2**	**t+3**	**t+4**	**t+5**
Medians	**Neutral**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.11	0.11	0.10	0.10	0.02	0.08	0.08	0.12	0.10	0.08
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sad	0.01	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Means**	**Neutral**	0.27	0.27	0.25	0.25	0.26	0.26	0.27	0.29	0.28	0.33
	Happy	0.09	0.07	0.11	0.10	0.11	0.10	0.08	0.08	0.08	0.06
	Surprise	0.31	0.30	0.30	0.32	0.29	0.31	0.32	0.31	0.31	0.30
	Angry	0.04	0.06	0.04	0.05	0.06	0.06	0.06	0.03	0.03	0.04
	Disgust	0.04	0.02	0.02	0.03	0.03	0.02	0.04	0.03	0.03	0.03
	Fear	0.07	0.09	0.11	0.11	0.11	0.10	0.10	0.11	0.13	0.08
	Sad	0.18	0.19	0.17	0.13	0.14	0.15	0.14	0.16	0.14	0.16

* values represent probabilities of expression occurrence

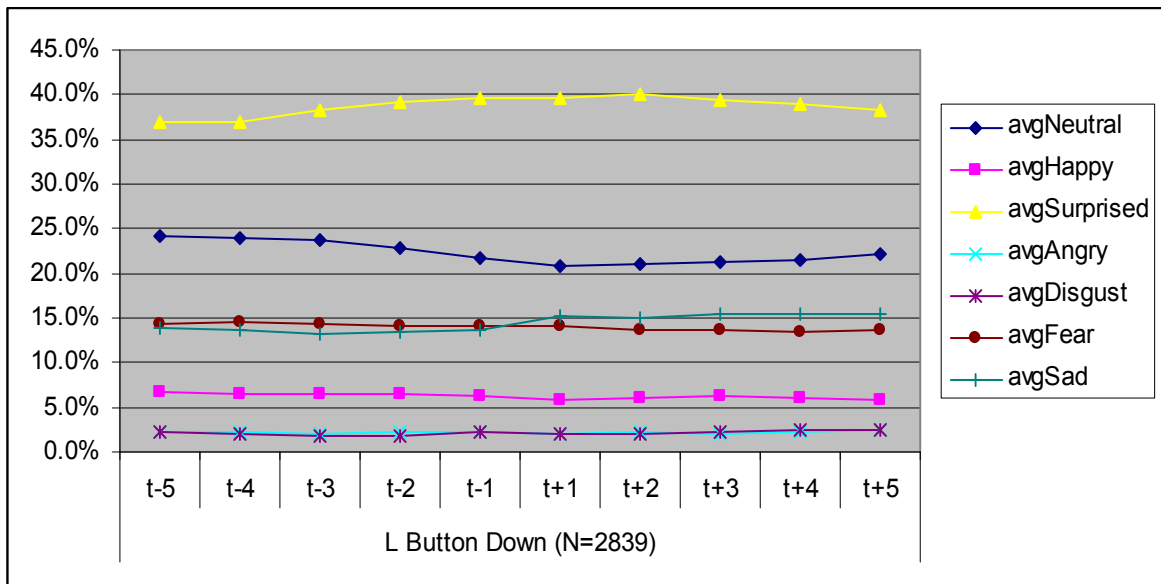** values in bold represent means that were statistically significantly different from others
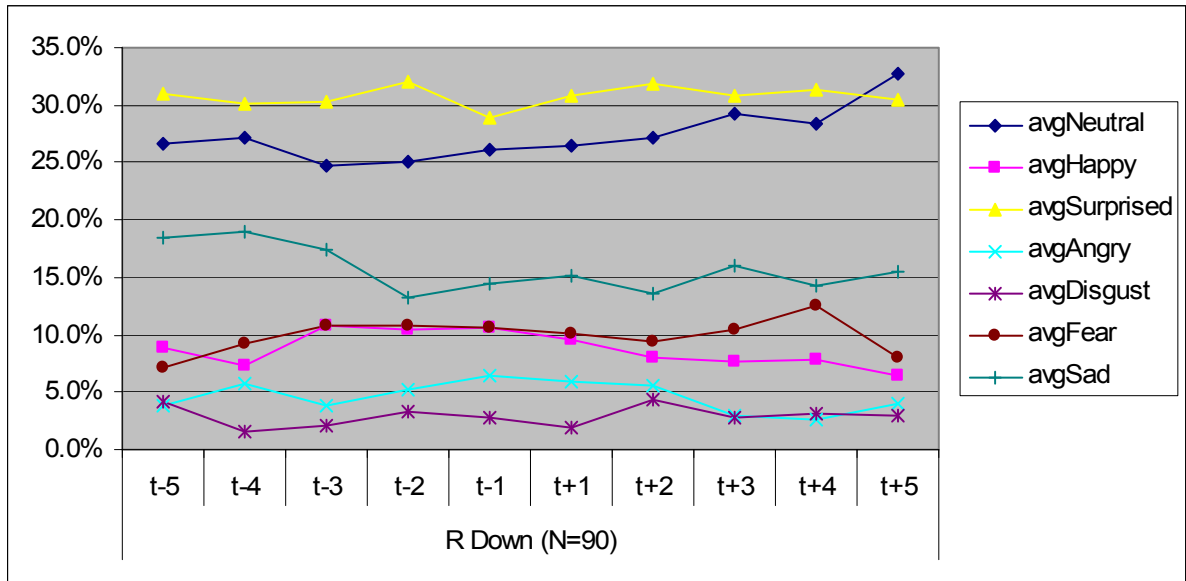
Figure 5.5 **Distribution of average emotional expressions around Right Button Down Click**

The one-way ANOVA revealed that none of the emotions' means differed significantly in the time intervals around the right button down click.

Wheel down scroll was one of the most frequently recorded events in the search log files. Surprise expressions occurred the most frequently around this type of click, followed by the expressions of fear and surprise (Table 5.5 and Figure 5.6).

Table 5.5 *Distribution of emotional expressions around Wheel Down Click*

		Wheel- (N=6495)*									
	EventTime	**t-5**	**t-4**	**t-3**	**t-2**	**t-1**	**t+1**	**t+2**	**t+3**	**t+4**	**t+5**
Medians	**Neutral**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.29	0.32	0.29	0.30	0.35	0.34	0.32	0.31	0.31	0.33
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
	Sad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Means**	**Neutral**	**0.14**	**0.15**	**0.15**	**0.14**	**0.14**	**0.14**	**0.14**	0.16	**0.17**	0.16
	Happy	0.06	0.06	**0.06**	**0.06**	0.05	**0.05**	**0.06**	**0.05**	**0.05**	0.06
	Surprise	0.42	**0.43**	**0.41**	0.41	**0.43**	**0.43**	**0.41**	**0.40**	**0.41**	0.42
	Angry	**0.02**	**0.02**	**0.02**	**0.03**	**0.03**	**0.04**	**0.05**	**0.04**	**0.03**	**0.03**
	Disgust	**0.02**	**0.02**	**0.02**	0.02	**0.03**	0.03	**0.02**	**0.02**	**0.02**	**0.02**
	Fear	**0.18**	**0.18**	**0.18**	0.18	0.18	0.19	**0.20**	**0.20**	0.19	**0.20**
	Sad	**0.17**	**0.16**	**0.16**	**0.15**	**0.14**	**0.12**	**0.13**	**0.13**	**0.13**	**0.13**

* values represent probabilities of expression occurrence

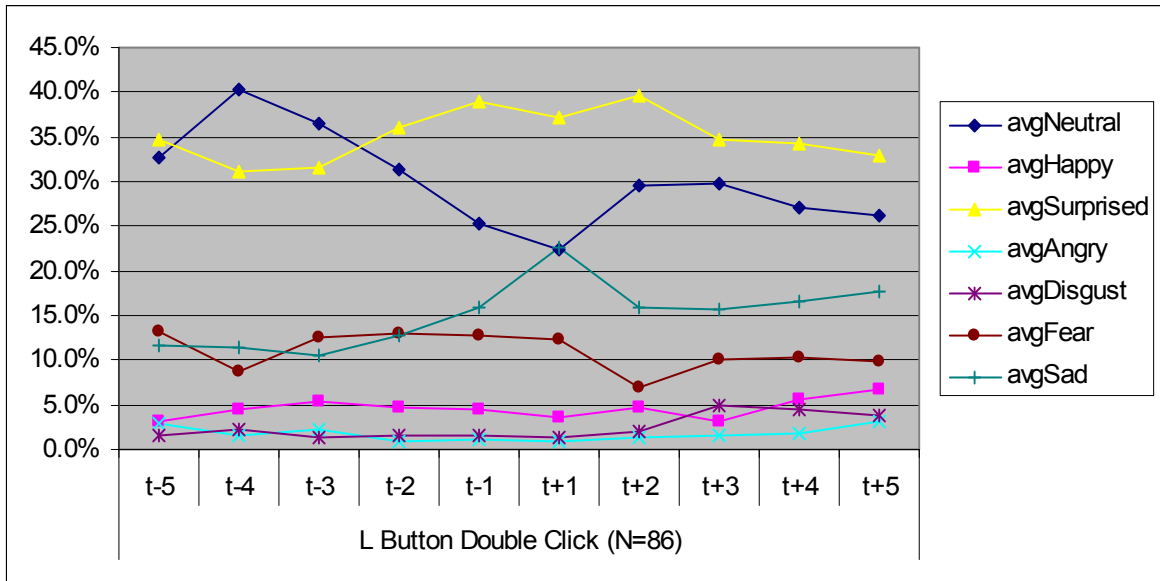** values in bold represent means that were statistically significantly different from others
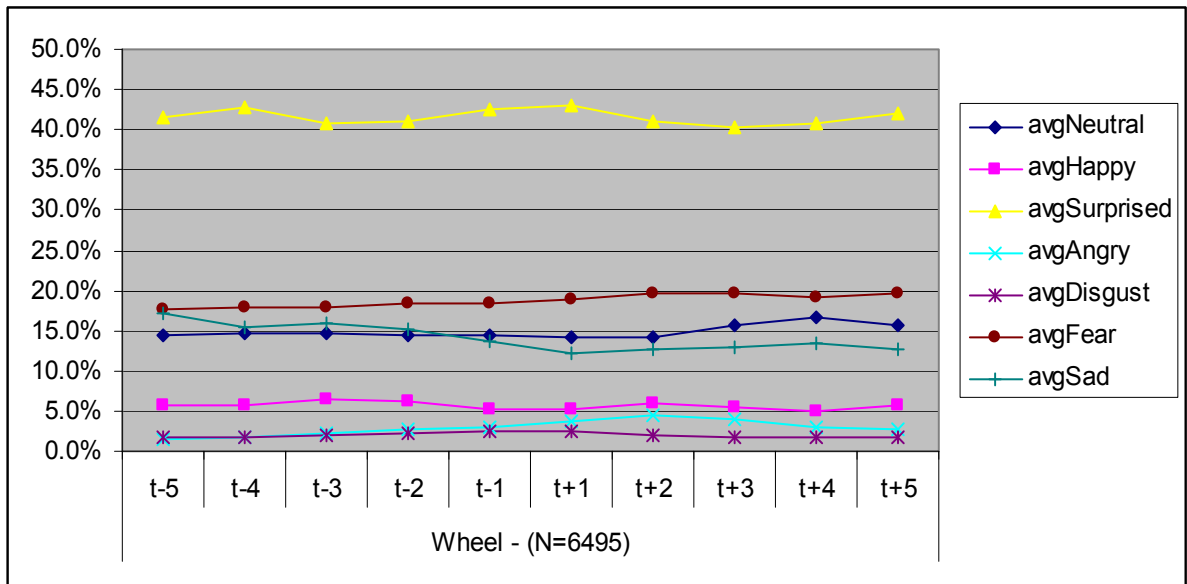
Figure 5.6 **Distribution of emotional expressions around Wheel Down Click**

The one-way ANOVA revealed that the means of all seven emotions differed significantly in the time intervals around the click: neutral ($F(9, 64938) = 4.7558, p < .05$), happy ($F(9, 64938) = 4.455, p < .05$), surprise ($F(9, 64938) = 3.648, p < .05$), angry ($F(9, 64938) = 30.907, p < .05$), disgust ($F(9, 64938) = 6.764, p < .05$), fear ($F(9, 64938) = 4.289, p < .05$), and sad ($F(9, 64938) = 24.733, p < .05$).

The Tukey post-hoc test revealed that:

1. Neutral expressions measured during the t+4 interval occurred more frequently than during t-5 (*p=.001*), t-4 (*p=.007*), t-3(p=.011), t-2 (*p=.000*), t-1 (*p=.001*), t+1 (*p=.000*), and t+2 (*p=.000*) intervals.

2. Happy expressions were less frequent during the t+4 interval compared to the t-3 (*p=.000*), t-2 (*p=.005*), and t+2 (*p=.041*) intervals; they were also more frequent during the t-3 interval than during the t+1 (*p=. 002*) and t+3 (*p=.022*) intervals.

3. Surprise expressions were less frequent in the t+3 interval than during the t-4 (p=.029) and t-1 (p=.046) intervals, and more frequent during the t+1 interval than during the t-3 (p=.039), t+2 (p=.050), t+3 (p=.002), and t+4 (p=.040).

4. Angry expression during the t-5 were less frequent than during t-2 (p=.001), t-1 (p=.000), t+1 (p=.000), t+2 (p=.000), t+3 (p=.000), t+4 (p=.000), and t+5 (000); during t-4 angry expressions were less frequent than during t-2 (p=.003), t-1 (p=.000), t+1 (p=.000), t+2 (p=.000), t+3 (p=.000), t+4 (p=000), and t+5 (p=.001) intervals; during t-3 angry expressions were less frequent than during t+1 (p=.000), t+2 (p=.000), t+3 (p=.000), and t+4 (p=.033);

expressions during t-2 were more frequent than during t-5 (p=.001) and t-4 (p=.003), and less frequent than during t+1 (p=.000), t+2 (p=.000), and t+3 (p=.000) intervals; expressions during t -1 occurred less frequently than during t+1 (p=.050), t+2 (p=.000), and t+3 (p=.000) intervals; they were also less frequent during the t+1 than during the t+2 (p=.029), but more frequently than during the t+5 (p=.002), angry expressions were more frequent during the t+2 than during the t+4 (p=.000), and t+5 (p=.000); and more frequent during the t+3 interval than during the t+4 (p=.003), and t+5 (p=.000) intervals.

5. Disgust expressions were more frequent during the t–1 interval than during t-5 (p=.000), t-4 (p=.000), t-3 (p=.002), t+2 (p=.030), t+3 (p=.001), t+4 (p=.000), and t+5 (p=.000); they were also more frequent in a t+1 than within t-5 (p=.002), t-4 (p=.001), t-3 (p=.012), t+3 (p=.007), t+4 (p=.001), and t+5 (p=.000) intervals.

6. Fear expressions are less frequent during the t-5 than during t+ 2 (p=.004), t+3 (p=.007), and t+5 (p=.007), less frequent during t-4 than during t+2 (p=.033) interval, and less frequent during the t-3 interval than during t+2 (p=.026), t+3 (p=.047), and t+5 (p=.045) intervals.

7. Sad expressions were more frequent during t-5 interval than during t-4 (p=.010), t-2 (p=.002), t-1(p=.000), t+1 (p=.000), t+2 (p=.000), t+3 (p=.000), t+4 (p=.000), and t+5 (p=.000) intervals; more frequent during t-4 than during t-1 (p=.016), t+1 (p=.000), t+2 (p=.000), t+3 (p=.000), t+4 (p=.001), and t+5 (*p=.000*) intervals, more frequent during t-3 than t-1 (*p=.000*), t+1 (*p=.000*), t+2 (*p=.000*), t+3 (*p=.000*), t+4 (*p=.000*), and t+5 (*p=.000*) intervals,

Overall, around wheel down scroll, neutral expressions occurred most frequently in the

t+4 intervals (within 9-12 seconds after the click), frequency of happy expressions

dropped after the click, surprise peaked right after the click (0-3 seconds), anger

expressions increased after the click and subsided by the 13-15 second after the click,

disgust expressions increased right before (3-0 seconds) and right after (1-3 seconds) the

click, fear expressions increases right before the click and remain frequent after the click;

sad expressions decreased before the click and continued decreasing after the click.

Wheel down clicks performed during viewing of the Google search result pages (N=727)

were less frequent compared to the wheel down clicks during viewing of the non-Google

pages (Table 5.6 and Figure 5.7).

Table 5.6 *Distribution of emotional expressions around Wheel Down Click on Google Results*

	EventTime	t-5	t-4	t-3	t-2	t-1	t+1	t+2	t+3	t+4	t+5
					Wheel– Google results (N=727)*						
Medians	Neutral	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.22	0.25	0.31	0.28	0.32	0.30	0.31	0.25	0.18	0.20
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Means**	Neutral	0.22	0.21	0.19	0.17	0.18	0.20	0.17	0.18	0.19	0.17
	Happy	0.10	0.10	0.12	0.11	0.09	0.10	0.11	0.12	0.10	0.11
	Surprise	0.38	0.40	0.41	0.40	0.42	0.41	0.40	0.38	0.36	0.37
	Angry	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
	Disgust	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.01
	Fear	0.14	0.13	0.14	0.14	0.15	0.13	0.12	0.13	0.13	0.15
	Sad	0.13	**0.13**	**0.12**	0.15	**0.14**	**0.14**	**0.17**	0.17	**0.19**	0.17

* values represent probabilities of expression occurrence

** values in bold represent means that were statistically significantly different from others

The one-way ANOVA revealed that the means of the sad emotional expressions differed significantly in the time intervals around the wheel down scroll during review of the Google results pages ($F(9, 7259) = 5.143$, $p < .05$).

The Tukey post-hoc test revealed that sad expressions measured in a t+2 interval were statistically significantly more frequent than expressions measured in the t-4 (p=.047) and t-3 (*p=.008*) intervals; t+3 interval were statistically significantly frequent than expressions measured in t-3 (*p=.025*) intervals; t+4 frequent than during t-5 (p=.003), t-4 (p=.002), t-3 (p=.005), t-1 (p=.038), and t+1 (p=.017); more frequent during t+5 than during t-3 (p=.015) intervals.

Overall, analysis of the variance of emotional expressions around the Wheel down clicks

on Google results pages indicated that the probability of sad expressions increased after

the click.

Among scrolls up and down, wheel down scrolls on the non-Google pages were the most

frequent search behavior (N=5768) (Table 5.7).

Table 5.7 *Distribution of emotional expressions around Wheel Down Click on non-Google Pages*

	Wheel- non-Google (N=5768)*									
	EventTime	t-5	t-4	t-3	t-2	t-1	t+1	t+2	t+3	t+4	t+5
Medians	Neutral	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.30	0.33	0.29	0.30	0.35	0.35	0.32	0.31	0.32	0.36
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.02
	Sad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Means **	Neutral	**0.13**	**0.14**	**0.14**	**0.14**	**0.14**	**0.14**	**0.14**	**0.16**	**0.16**	**0.16**
	Happy	**0.05**	**0.05**	**0.06**	**0.05**	**0.05**	**0.05**	0.05	**0.05**	**0.04**	0.05
	Surprise	0.42	0.43	**0.41**	**0.41**	0.43	**0.43**	**0.41**	**0.41**	0.42	0.42
	Angry	**0.02**	0.02	0.02	**0.03**	**0.03**	**0.04**	**0.05**	**0.04**	**0.03**	**0.03**
	Disgust	**0.02**	**0.02**	**0.02**	0.02	**0.03**	**0.03**	0.02	**0.02**	**0.02**	**0.02**
	Fear	**0.18**	**0.19**	**0.18**	0.19	0.19	0.20	**0.21**	**0.21**	0.20	0.20
	Sad	**0.18**	**0.16**	**0.16**	**0.15**	**0.14**	**0.12**	**0.12**	**0.13**	**0.13**	**0.12**

* values represent probabilities of expression occurrence

** values in bold represent means that were statistically significantly different from others

The one-way ANOVA revealed that the means of all seven expressions differed

significantly in the time intervals around the wheel down scroll during review of the non-

Google pages: neutral ($F(9, 57669) = 6.278, p < .05$), happy, ($F(9, 57669) = 5.365, p <$

$.05$), surprise ($F(9, 57669) = 3.483, p < .05$), angry ($F(9, 57669) = 31.257, p < .05$),

disgust (F(9, 57669) = 8.273, $p < .05$), fear (F(9, 57669) = 5.232, $p < .05$), and sad (F(9,

57669) = 34.473, $p < .05$).

The Tukey post-hoc test revealed that

1. Neutral expressions measured in a t-5 interval (15-13sec before the click)
    were statistically significantly less frequent than neutral expressions measured
    in the t+3 (*p=.011*), t+5 (p=.009) intervals; expressions during t-5 (p=.000), t-
    4 (p=.000), t-3 (p=.005), t-2 (p=.000), t-1 (p=.001), t+1 (p=.000), t+2 (p=.000)
    were less frequent than during t+4 interval; and less frequent during t+1 than
    during t+3 (p=.031) and t+5 (p=.025) intervals.

2. Happy expressions that occurred in a t-3 interval were more frequent than
    during t-1 (p=.042), t+1 (p=.001), t+3 (p=.001) and t+4 (p=.000) intervals;
    during t-2 interval expressions were more frequent than during t+1 (p=.049),
    t+3 (p=.047), and t+4 (p=.001) intervals; during t+4 happy expressions were
    less frequent than during t-5 (p=.007), t-4 (p=.028), t-3(p=.000), t-2 (p=.001),
    and t+2 (p=.015).

3. Surprise expressions that occurred in a t+1 interval were statistically
    significantly more frequent than surprise expressions during the t-3 (*p=.017*),
    t+2 (*p=.037*), and t+3 (*p=.007*) intervals.

4. Angry expressions during the t-5 interval were less frequent than during t-2
    (*p=.000*), t-1 (*p=.000*), t+1 (*p=.000*), t+2 (*p=.000*), t+3 (*p=.000*), t+4
    (*p=.000*), and t+5 (*p=.000*) intervals; during t-4 intervals expressions were
    less frequent than during t-2 (*p=.002*), t-1 (*p=.000*), t+1 (*p=.000*), t+2

(*p=.000*), t+3 (*p=.000*), t+4 (*p=.000*), and t+5 (*p=.001*); and less frequent during t-3 than during t+1 (*p=.000*), t+2 (*p=.000*), t+3 (*p=.000*); during t-2 angry expressions were less frequent than during t+1 (*p=.010*), t+2 (*p=.000*), t+3 (*p=.000*); less frequent during t-1 than during t+2 (*p=.000*), t+3 (*p=.001*); more frequent during t+1 than t+5 (*p=.002*) intervals; expressions that occurred during t+2 were more frequent than during t+4 (*p=.000*), t+5 (*p=.000*); and during t+3 they were more frequent than during t+4 (*p=.002*) and t+5 (*p=.000*) intervals.

5. Disgust expressions were more frequent during t-1 interval than during t-5 (p=.000), t-4 (p=.000), t-3 (p=.000), t+3 (*p=.000*) t+4 (*p=.000*), t+5 (*p=.000*) intervals; during t+1 expressions were more frequent than during t-5 (p=.000), t-4 (p=.000), t-3 (p=.000), t+3 (*p=.001*) t+4 (*p=.000*), and t+5 (*p=.000*) intervals

6. Fear expressions during the t-5 interval were less frequent than during t+2 (*p=.000*), t+3 (*p=.001*), t+4 (*p=.041*), and t+5 (*p=.007*) intervals; during t-4 interval expressions were less frequent than during t+2 (*p=.008*) and t+3 (*p=.032*) intervals; and during t-3 interval expressions were less frequent than during t+2 (*p=.003*) and t+3 (*p=.012*).

7. Sad expressions during the t-5 interval were more frequent than during t-4 (p=.006), t-2 (*p=.000*), t-1 (*p=.000*), t+1 (*p=.000*), t+2 (*p=.000*), t+3 (*p=.000*), t+4 (*p=.000*), and t+5 (*p=.000*) intervals; more frequent during t-4 interval than during t-1 (*p=.002*), t+1 (*p=.000*), t+2 (*p=.000*), t+3 (*p=.000*), t+4 (*p=.000*), and t+5 (*p=.000*) intervals; more frequent during t-3 interval

In summary, analysis of variance of emotional expressions around the Wheel down on non-Google pages indicated that the probability of neutral expressions increased after the click, happy and sad expressions decreased after the click, surprise expressions increased right after the click, angry expressions peaked in the 3-6 second interval after the click, disgust expressions peaked around the click (between 3 second before and 3 second after the click), fear expressions increased after the click.

Total number of wheel up mouse scrolls was a relatively large (N=1940). Surprise, neutral, fear and sad expressions occurred most frequently within the examined time intervals (Table 5.8 and Figure 5.7).

Table 5.8 *Distribution of emotional expressions around Wheel Up Click*

	Wheel+ (N=1940)*									
	EventTime	**t-5**	**t-4**	**t-3**	**t-2**	**t-1**	**t+1**	**t+2**	**t+3**	**t+4**	**t+5**
Medians	**Neutral**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.25	0.18	0.23	0.24	0.29	0.33	0.28	0.29	0.29	0.27
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.02	0.02	0.03	0.02	0.00	0.01	0.00	0.01	0.00	0.00
	Sad	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Means**	**Neutral**	0.19	0.19	0.19	0.19	0.16	0.17	0.19	0.19	0.19	0.19
	Happy	0.07	0.07	0.07	0.07	**0.08**	**0.08**	0.06	**0.06**	0.07	0.07
	Surprise	0.38	0.37	0.38	0.38	0.39	0.40	0.39	0.39	0.38	0.38
	Angry	0.02	**0.01**	0.02	**0.01**	0.02	**0.03**	0.02	0.02	**0.02**	0.02
	Disgust	**0.02**	**0.03**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**
	Fear	**0.19**	**0.19**	**0.20**	**0.19**	**0.18**	**0.17**	**0.16**	**0.17**	**0.16**	**0.15**
	Sad	**0.13**	**0.13**	**0.13**	0.16	0.15	**0.14**	0.15	**0.16**	**0.17**	**0.17**

* values represent probabilities of expression occurrence

** values in bold represent means that were statistically significantly different from others

Figure 5.7 **Distribution of average emotional expressions around Wheel Up Click**

The one-way ANOVA revealed that the means of the following emotions differed significantly in the time intervals around the wheel up scroll: happy ($F(9, 19390) = 2.927$, $p < .05$), angry ($F(9, 19390) = 3.307$, $p < .05$), disgust ($F(9, 19390) = 6.555$, $p < .05$), fear ($F(9, 19390) = 6.555$, $p < .05$), and sad ($F(9, 19390) = 6.175$, $p < .05$).

The Tukey post-hoc test revealed that

1. Happy expressions were more frequent during t-1 than during t+3 (p=.016) interval, and more frequent during t+1 then during t+3 (p=.000) interval.

2. Angry expressions were more frequent during the t+1 interval than during t-4 (p=.001), t-2 (p=.003), and t+4 (p=.007) intervals.

3. Disgust expressions during t-4 were more frequent than during t-5 (p=.000), t-3 (p=.000), t-2 (p=.000), t-1 (p=.002), t+1 (p=.000), t+2 (p=.010), t+3 (p=.000), t+4 (p=.000), t+5 (p=.000) intervals.

4. Fear expressions during t-5 were more frequent than during t+2 (p=.050), t+5 (p=.001); more frequent during t-4 than during t+4 (p=.019), t+5 (p=.001); more frequent during t-3 than during t+1 (p=.012), t+2 (p=.001), t+3 (p=.004), t+4 (p=.000), t+5 (p=.000) intervals; more frequent during t-2 (p=.005) and t-1 (p=.028) than t+5 intervals.

5. Sad expressions were less frequent during t-5 compared to t+4 (p=.006), and t+ 5 (p=.000); less frequently during t-4 compared to the t+3 (p=.037), t+4 (p=.003), t+5 (p=.000), less frequently during t-3 than during t+3 (p=.011), t+4 (p=.001), t+5 (p=.000), and less frequently during t+1 than t+4 (p=.024), t+5 (p=.002).

In summary, happy expressions decrease after the wheel up scroll, angry expressions peaked 0-3 seconds after the click, disgust peaked during t-4 interval (12-9 seconds before the click), fear expressions decreased after the click, and sad expressions generally increased after the click.

Wheel up scrolls during viewing of the Google result pages (N=423) were less frequent than during view of the non-Google pages (Table 5.9).

Table 5.9 *Distribution of emotional expressions around Wheel Up Click on Google Results*

	Wheel+ Google results (N=423)*									
	EventTime	**t-5**	**t-4**	**t-3**	**t-2**	**t-1**	**t+1**	**t+2**	**t+3**	**t+4**	**t+5**
Medians	**Neutral**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.24	0.27	0.35	0.33	0.36	0.40	0.29	0.12	0.23	0.23
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Sad	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Means**	**Neutral**	0.19	0.18	0.17	0.15	0.16	0.17	0.18	0.15	0.19	0.19
	Happy	0.11	0.11	0.09	0.08	0.10	0.11	0.09	0.09	0.08	0.08
	Surprise	0.38	0.40	0.43	0.44	0.44	0.42	0.41	0.37	0.37	0.36
	Angry	0.02	**0.01**	**0.00**	**0.00**	0.02	**0.03**	**0.01**	0.02	0.01	**0.01**
	Disgust	0.02	0.02	**0.01**	0.02	0.02	0.02	0.03	**0.04**	**0.04**	**0.01**
	Fear	**0.17**	**0.17**	**0.19**	**0.16**	0.12	**0.10**	0.10	0.14	**0.12**	**0.12**
	Sad	**0.12**	**0.12**	**0.11**	**0.15**	**0.15**	**0.15**	**0.17**	**0.20**	**0.19**	**0.22**

* values represent probabilities of expression occurrence

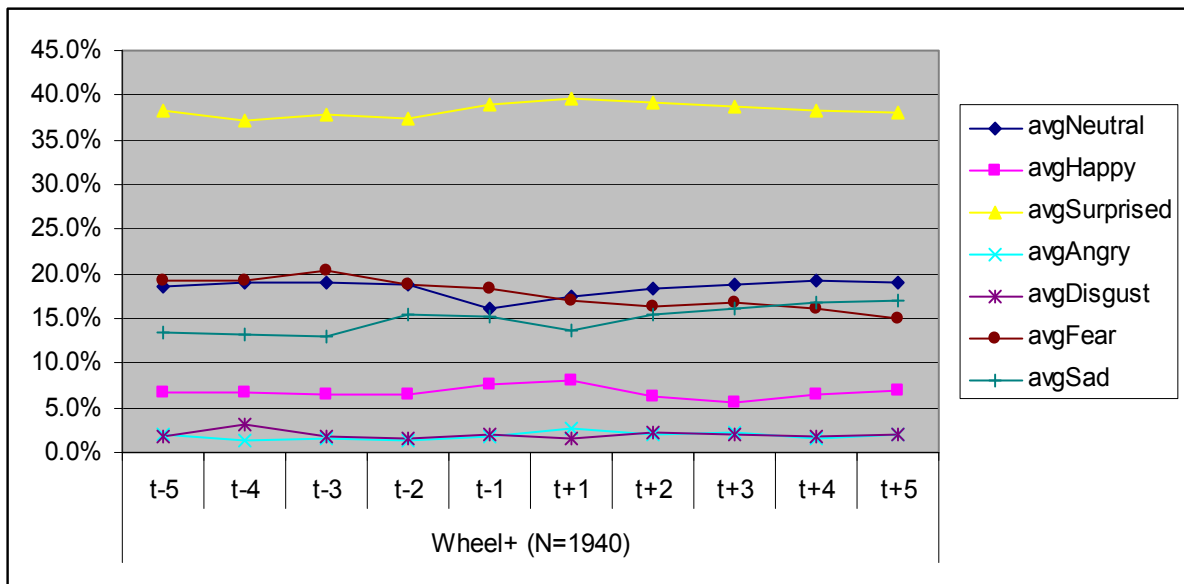** values in bold represent means that were statistically significantly different from others

The one-way ANOVA revealed that the means of the following emotional expressions differed significantly in the time intervals around the wheel up scroll during review of the

Google results pages: angry ($F(9, 4215) = 4.680$, $p < .05$), disgust ($F(9, 4215) = 4.233$, $p < .05$), fear ($F(9, 4215) = 6.226$, $p < .05$) and sad ($F(9, 4215) = 7.860$, $p < .05$).

The Tukey post-hoc test revealed that

1. Angry expressions were more frequent during t+1 interval than during t-4 (p=.001), t-3 (*p=.000*), t-2 (*p=.000*), t+2 (*p=.015*), and t+5 (*p=.011*) intervals.

2. Disgust expressions were more frequent during t+3 interval than during t-3 (p=.002) and t+5 (*p=.013*) intervals; more frequent during t+4 than during t-3 (*p=.001*) and t+5 (*p=.007*) intervals; and less frequent during t+5 (*p=.000*) than during t+3 (*p=.013*) and t+4 (*p=.007*) intervals.

3. Fear expressions during t+1 interval were less frequent than during t-5 (p=.008), t-4 (p=.006), t-3 (p=.000), and t-2 (p=.019) intervals; less frequent during t+2 than during t-5 (p=.006), t-4 (p=.005), t-3 (p=.000), and t-2 (p=.014) intervals; less frequent during t+4 than during t-3 (p=.006) interval; and less frequent during t+5 than during t-3 (p=.005) interval.

4. Sad expressions measured in a t+2 interval were statistically significantly more frequent than expressions measured in the t-3 (p=.033) intervals; more frequent during t+3 than during t-5 (*p=.001*), t-4 (*p=.001*), and t-3 (*p=.000*) intervals; more frequent during t+4 than during t-5 (*p=.007*), t-4 (*p=.007*), and t-3 (*p=.001*) intervals; more frequent during t+5 than during and t-5 (*p=.000*), t-4 (*p=.000*), t-3 (*p=.000*), t-2 (*p=.003*), t-1 (*p=.004*), and t+1 (*p=.004*) intervals.

In other, analysis of variance of emotional expressions around the Wheel up on Google results pages indicated that the probability of angry expressions peaked right after the

click, disgust peaked between 6 to 12 seconds after the click, fear expressions decreased

and sad expressions increased after the click.

Wheel up scrolls during the review of the non-Google pages were fairly frequent

(N=1517) (Table 5.10).

Table 5.10 *Distribution of emotional expressions around Wheel Down Click on non-Google Pages*

	EventTime	t-5	t-4	t-3	t-2	t-1	t+1	t+2	t+3	t+4	t+5
	Wheel+ non-Google (N=1517)*										
Medians	**Neutral**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.25	0.17	0.21	0.20	0.27	0.30	0.28	0.31	0.31	0.29
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.03	0.03	0.04	0.02	0.02	0.03	0.00	0.01	0.00	0.00
	Sad	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
Means**	**Neutral**	0.19	0.19	0.20	0.20	0.16	0.17	0.19	0.20	0.19	0.19
	Happy	0.05	0.06	0.06	0.06	**0.07**	**0.07**	0.05	**0.04**	0.06	**0.07**
	Surprise	0.38	0.36	0.36	0.36	0.38	0.39	0.39	0.39	0.38	0.38
	Angry	0.02	0.01	0.02	0.02	0.02	0.03	0.02	0.02	0.01	0.02
	Disgust	**0.02**	**0.04**	**0.02**	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	**0.02**
	Fear	**0.20**	**0.20**	**0.21**	0.20	**0.20**	0.19	0.18	0.18	**0.17**	**0.16**
	Sad	0.14	0.14	0.14	0.16	0.15	0.13	0.15	0.15	0.16	0.16

* values represent probabilities of expression occurrence

** values in bold represent means that were statistically significantly different from others

The one-way ANOVA revealed that the means of the following emotional expressions

differed significantly in the time intervals around the wheel up scroll during review of the

non-Google pages: happy, ($F(9, 15165) = 3.982, p < .05$), disgust ($F(9, 15165) = 9.026, p$

$< .05$), and fear ($F(9, 15165) = 3.926, p < .05$).

The Tukey post-hoc test revealed that

1. happy expressions that occurred in a t+3 interval were less frequent that

   during t-1 (p=.006), t+1 (p=.000), and t+5 (p=.001) intervals.

2. Disgust expressions were more frequent during t-4 interval than during t-5

   (p=.000), t-3 (p=.000), t-2 (*p=.000*), t-1 (*p=.000*), t+1 (*p=.000*), t+2 (*p=.000*),

   t+3 (*p=.000*), t+4 (*p=.000*), and t+5 (*p=.000*) intervals.

3. Fear expressions during the t+4 interval were less frequent than during t-3

   (*p=.030*) intervals; during t+5 interval expressions were less frequent than

   during t-5 (p=.015), t-4 (p=.018), t-3 (p=.001), and t-1 (*p=.009*) intervals.

In other words, analysis of variance of emotional expressions around the Wheel up on

non-Google pages indicated that the probability of happy expressions varied around the

click, but peaked in the interval between 3 seconds before and 3 seconds after the click

and than between 12-15 seconds after the click, disgust peaked in the 12-9 seconds

interval before the click, and fear expressions decreased after the click.

Middle button down click, a variant of a scroll, only occurred thirteen times in the

searches of thirty participants. Among the most frequently occurring emotional

expressions were surprise and neutral expressions (Table 5.11 and Figure 5.8).

Table 5.11 *Distribution of emotional expressions around Middle Button Down Click*

	M Button Down (N=13)*									
	EventTime	t-5	t-4	t-3	t-2	t-1	t+1	t+2	t+3	t+4	t+5
	Neutral	0.38	0.42	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.00
Medians	Surprise	0.18	0.42	0.00	0.24	0.52	0.68	1.00	0.84	0.60	0.87
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00

	Sad	0.05	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Means	**Neutral**	**0.42**	0.44	0.43	0.17	0.16	0.05	**0.05**	**0.06**	0.08	**0.01**
	Happy	**0.03**	**0.03**	**0.11**	**0.12**	**0.10**	**0.08**	**0.14**	**0.10**	**0.12**	**0.09**
	Surprise	**0.37**	0.40	0.35	0.45	0.50	**0.65**	**0.58**	**0.62**	0.50	**0.68**
	Angry	0.01	0.00	0.02	0.02	0.00	0.03	0.00	0.00	0.00	0.01
	Disgust	**0.03**	0.01	0.01	**0.01**	**0.08**	0.01	**0.03**	**0.01**	**0.01**	0.03
	Fear	0.02	0.02	0.03	0.07	0.07	0.14	0.18	0.18	0.22	0.12
	Sad	0.13	0.10	0.06	0.15	0.10	0.04	0.01	0.03	0.07	0.07

* values represent probabilities of expression occurrence

** values in bold represent means that were statistically significantly different from others

Figure 5.8 **Distribution of average emotional expressions around Middle Button Down Click**

The one-way ANOVA revealed that the means of the following emotions differed significantly in the time intervals around the event: neutral ($F_{(9, 120)} = 2.956$, $p < .05$), happy ($F_{(9, 120)} = 2.713$, $p < .05$), surprise ($F_{(9, 120)} = 3.602$, $p < .05$), and disgust ($F_{(9, 120)} = 2.750$, $p < .05$).

The Tukey post-hoc test revealed that

1. Neutral expressions that occurred in the t-5 interval were statistically significant more frequently than expressions that occurred in t+2 (*p=.092*), t+3 (*p=.092*), and t+5(*p=.094*) intervals.

2. Happy expressions were more frequent during t+4 interval than during t-4 (*p=.039*), t-3(p=.039), t-2 (*p=.015*), t-1 (*p=.015*), t+1 (*p=.037*), t+2 (*p=.015*) and t+5 (*p=.033*) intervals.

3. Surprise expressions that occurred during t-5 were significantly less frequent than expressions that occurred during t+1(*p=.043*), t+2 (*p=.022*), t+3(*p=.011*), and t+5 (*p=.008*) intervals.

4. Disgust expressions during t-5 intervals occurred more frequently than expressions during t-2 (p=.012), t+3 (p=.012), t+4 (p=.012), and less frequently than during t-1(p=.012), t+2(p=.012), and t+5 (p=.040) intervals.

Overall, based on the ANOVA analysis, it seems that neutral expressions decreased closer to the middle button down click, happy expressions peaked around t+4 interval (9-12 seconds after the click), surprise expressions increased after the click, and the frequencies of disgust expressions varied around the click.

We did not find any statistically significant changes in emotional expressions around Google and non-Google page changes using ten three second intervals around the event.

We re-ran our analysis extending the time intervals around the event. The intervals were extended because URL change follows another type of behavior, such as a selective click,

and therefore is further away in time from the decision point than other search events. We

extended five 3 second intervals to five 6 second intervals, resulting in the average

probabilities of seven emotions 30 seconds before and 30 seconds after the event.   We

re-ran the ANOVA using the new time intervals around the Google and non-Google page

changes.

The one-way ANOVA on the emotional expressions around Google page changed

revealed no statistically significant differences in the five 6 second intervals around the

event (Table 5.12 and Figure 5.9).

Table 5.12 *Distribution of emotional expressions around Google Result Page Changes*

		Google (N=508) – 6 sec intervals*									
	EventTime	**t-5**	**t-4**	**t-3**	**t-2**	**t-1**	**t+1**	**t+2**	**t+3**	**t+4**	**t+5**
Medians	**Neutral**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.25	0.25	0.29	0.27	0.36	0.34	0.29	0.30	0.30	0.28
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.03
	Sad	0.04	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.02
Means**	**Neutral**	0.23	0.21	0.21	0.21	0.18	0.19	0.19	0.19	0.20	0.22
	Happy	0.07	0.08	0.08	0.08	0.07	0.06	0.07	0.07	0.07	0.06
	Surprise	0.36	0.36	0.39	0.36	0.39	0.40	0.36	0.37	0.38	0.37
	Angry	0.03	0.04	0.03	0.03	0.02	0.03	0.03	0.04	0.03	0.02
	Disgust	0.03	0.03	0.04	0.03	0.03	0.02	0.03	0.03	0.03	0.03
	Fear	0.13	0.14	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.14
	Sad	0.15	0.14	0.13	0.16	0.16	0.16	0.17	0.16	0.15	0.16

* values represent probabilities of expression occurrence

** values in bold represent means that were statistically significantly different from others
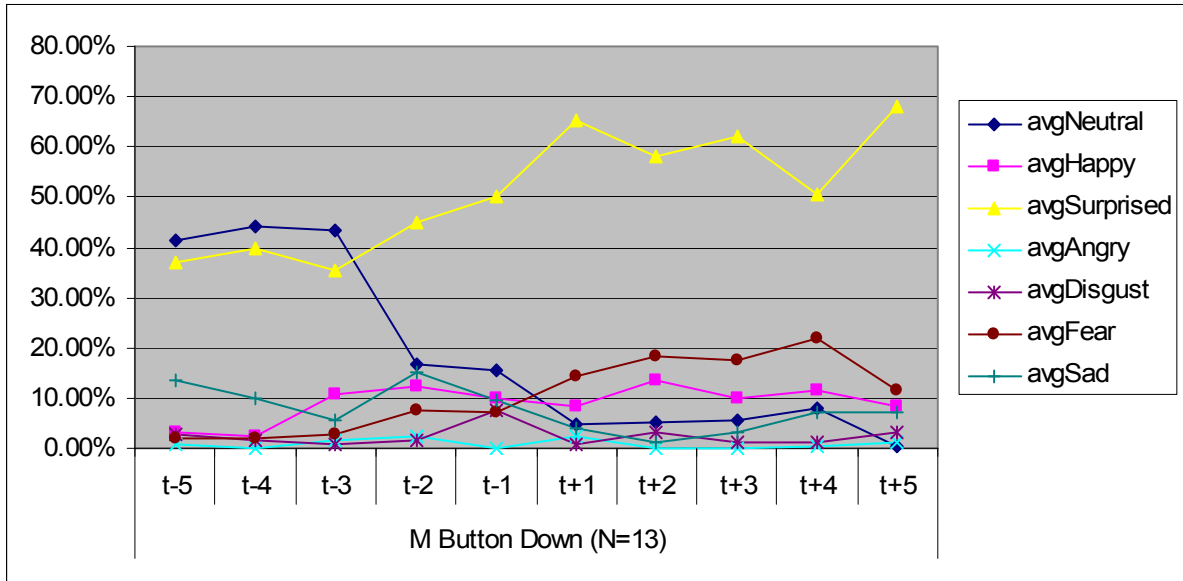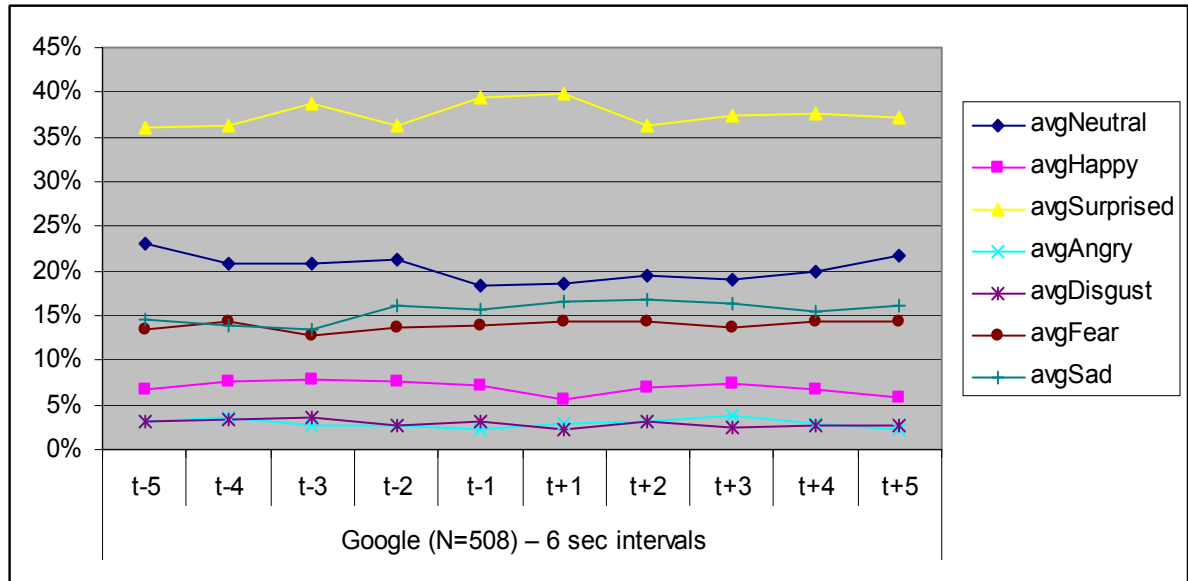
Figure 5.9 **Distribution of average emotional expressions around Google Result Page Changes**

The one-way ANOVA on the emotional expressions around non-Google page changes (Table 5.12 and Figure 5.10). indicated statistically significant change of happy expression ($F(9, 6570) = 2.851$, $p < .05$). The Tukey post-hoc test revealed that happy expressions were more frequent during t-3 than during t+3 (p=.027) interval, so they were more frequent before the page change than after the page change.

Table 5.13 *Distribution of emotional expressions around non-Google Page Changes*

	non-Google (N=658) – 6 sec intervals*									
	EventTime	**t-5**	**t-4**	**t-3**	**t-2**	**t-1**	**t+1**	**t+2**	**t+3**	**t+4**	**t+5**
Medians	**Neutral**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Happy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Surprise	0.29	0.28	0.28	0.29	0.34	0.35	0.32	0.26	0.28	0.30
	Angry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Disgust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Fear	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.02	0.03	0.03
	Sad	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.01	0.01	0.01
Means**	**Neutral**	0.20	0.19	0.18	0.18	0.16	0.15	0.16	0.18	0.19	0.20
	Happy	0.09	0.09	**0.10**	0.09	0.09	0.09	0.08	**0.07**	0.07	0.07
	Surprise	0.38	0.39	0.38	0.38	0.41	0.41	0.40	0.37	0.37	0.38
	Angry	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01
	Disgust	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Fear	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.18
	Sad	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.16	0.15	0.15

* values represent probabilities of expression occurrence

** values in bold represent means that were statistically significantly different from others
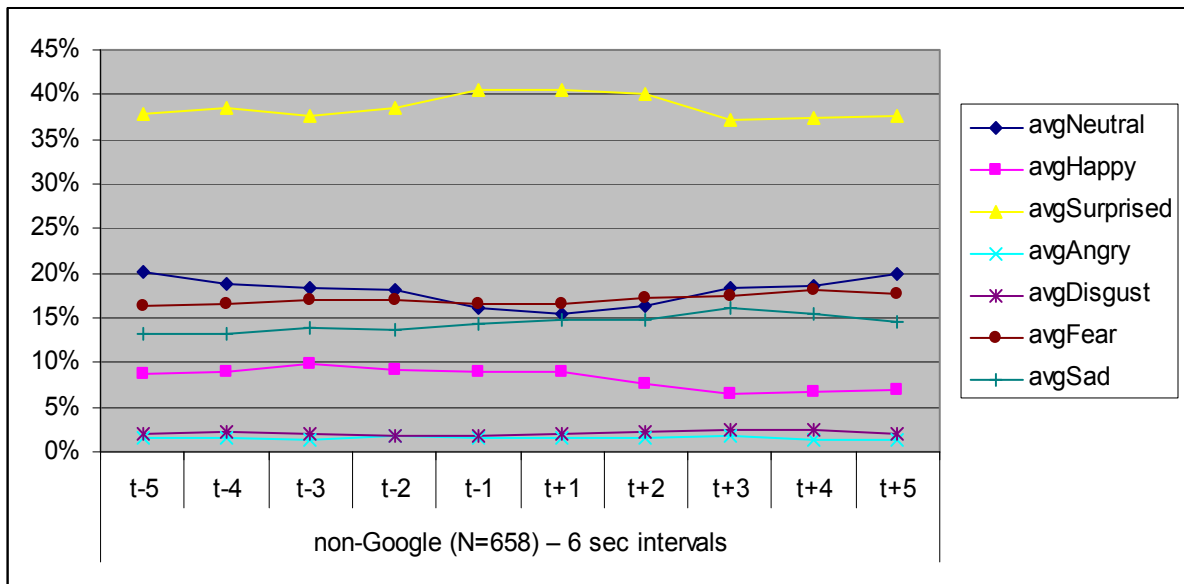
Figure 5.10 **Distribution of average emotional expressions around non-Google Page Changes**

5.1.3 Summary

The analysis of the emotional expressions and the search behaviors data can be summarized as follows:

1. The most frequent emotional expressions during the entire search are surprise and neutral.

2. The most frequent search behaviors were Mouse Wheel Down scroll and Left Down mouse click.

3. Every analyzed search behavior was characterized by a unique pattern of emotional expressions 15 seconds before and 15 seconds after that behavior. Table 5.14 below provides a summary of emotional expressions that varied significantly around the behavior and frequencies (high/low) of these expressions around each analyzed search behavior.

Table 5.14 *Summary of emotional expressions and their frequencies around each analyzed search*

behavior

Search behavior	Emotional expressions that significantly varied around the event	15-0 seconds before the event	0-15 seconds after the event
Left Mouse Down (N=2839)	**neutral**	high	low
	surprise	low	high
	sadness	low	high
L Button Double (N=86)	**disgust**	low	high
	sad	low	high (peaked 0-3 seconds after the click)
M Button Down (N=13)	**neutral**	high, decreased closer to the click	low
	happy	low	high, peaked around 9-12 seconds after the click
	surprise	low	high
	disgust	varied	
R Button Down (N=90)	None of the emotional expressions varied significantly		
Mouse Wheel – (N=6495)	**neutral**	low	high, peaked within 9-12 seconds after the click
	happy	high	low
	surprise	low	high, peaked right after the click (0-3 seconds)
	anger	low	high, peaked around 13-15 seconds after the click
	disgust	increased right before (3-0 seconds) the click	increased right after (1-3 seconds) the click
	fear	low	high
	sad	high	low
Wheel– Google results (N=727)	**sad**	low	high
Wheel- non-Google (N=5768)	**neutral**	low	high
	happy	high	low
	surprise	low	high

	angry	low	high, peaked in the 3-6 second interval after the click
	disgust	peaked around the click (between 3 sec before and 3 sec after the click)	
	fear	low	high
	sad	high	low
Mouse Wheel + (1940)	**happy**	high	low
	angry	low	high, peaked 0-3 seconds after the click
	disgust	high, peaked 12-9 seconds before the click	low
	fear	high	low
	sad	low	high
Wheel+ Google results (N=423)	**angry**	low	high, peaked in the 3-6 second interval after the click
	disgust	low	high, peaked between 6 to 12 seconds after the click
	fear	high	low
	sad	low	high
Wheel+ non-Google (N=1517)	**happy**	Peaked between 3 seconds before and 3 seconds after the change, then between 12-15 seconds after the click	
	disgust	high, peaked 12-9 seconds before the click	low
	fear	high	low
Google page change (N=508)	None of the emotional expressions varied significantly		
Non-Google page change (N=658)	None of the emotional expressions varied significantly		
		30-0 seconds before the event	**0-30 seconds after the event**
Google page change (N=508)	None of the emotional expressions varied significantly		
Non-Google page change (N=658)	**happy**	high	low

5.2 Data Analysis for Research Question 2: emotions, moods, search performance and outcomes

Research question 2 intended to investigate relationships between emotions, moods and search performance and outcomes.

> What are the relationships between users' emotions and their search performance (represented by search duration, query length, time examining search results, number of queries, number of viewed hits, number of result pages requested per session), and moods and search outcomes (manifested in the quality of search results) and search performance?

5.2.1 Emotions and search performance

We examined relationships between seven emotional expressions and search performance and outcomes variables by running canonical correlation analysis (CCA). The CCA method was chosen because it allowed us to examine linear relationships between two multidimensional dependent ("emotion") and independent ("performance") constructs (Sherry & Henson, 2005). Advantages of CCA include reduced probability of making a Type I error (which usually increases when multiple tests are performed instead of a single multivariate test). The test allows examining multiple dependent and independent variables that represent complex relationships where variables can have multiple causes and multiple effects. CCA is also a comprehensive technique that has been demonstrated to subsume ANOVA, MANOVA, multiple regression, discriminant analysis and other tests (Henson, 2000).

When interpreting the CCA results, we examine the p-value to see if the model is statistically significant; we also examine Wilk's λ to derive the effect size (effect size or $Rc^2 = 1 - \lambda$). When examining the contribution of measurable variables into the creation of the synthetic dependent and independent variables we interpret structure coefficients and function coefficients. Function coefficients are standardized coefficients that are used in the linear equations to combine the observed variable into the synthetic variable; function coefficients are analogous to beta weights in regression. Structure coefficient is the bivariate correlation between observed variable and a synthetic variable and is analogous to structure coefficient in multiple regression and factor analysis. The signs of structure coefficients inform interpretation of the relationships between the variables (e.g., negative sign indicates lower scores, fever actions, etc. while positive sign indicates higher scores, more actions, etc.) Squared structure coefficient is analogous to any r^2-type effect size and represents variance of a synthetic variable explained by an observed variable (Sherry & Henson, 2005).

CCA is a multivariate technique that requires a large sample size. Due to our medium sample size (30 participants performing 2 search tasks each, resulting in the total of 60 search tasks and moods around those tasks) , our analysis did not always produce statistically significant results. However, most of the produced models had large effect sizes that pointed to the existing relationships between variables. We made the decision to interpret CCA models that were not statistically significant, but had large effect sizes because the literature on the use of a CCA suggests that the model's effect size is an

important indicator of the existing relationships between the variables even when/if the model is not statistically significant (Henson, 2006).

We would also like to note that while we used CCA to examine the relationships between multiple dependent and multiple independent variables, use of other statistical techniques is possible. For example, use of Principle Component Analysis (PCA) as a secondary analysis could have revealed a better partitioning of the models.

We used CCA to correlate 7 emotional expressions with the following performance variables: results quality "Quality", search duration "TaskTime", query length "QueryLength", time examining search results "TviewResults", time examining target pages "TreadHits ", number of queries "UniqueQueries", number of viewed hits "ReviewedHits", number of result pages requested per session "GooglePages". The resulting model was not statistically significant; however, the effect size was relatively large at about 71% of variance explained. The analysis yielded seven functions, none of which were statistically significant, with squared canonical correlation (R_c^2) of .355 for the first function, squared canonical correlation (R_c^2) of .263 for the second function, (R_c^2) of .193 for the third function, (R_c^2) of .127 for the fourth function and squared canonical correlation below .10 for the remaining functions. The full model across all functions was not statistically significant using the Wilk's $\lambda = .29$ criterion, $F(56, 247.64) = 1.131$, $p = .261$. However, the full model r^2 type effect size was .71 which indicated that the seven canonical functions explained a large 71% of the variance shared between the variable sets.

We chose to interpret the first two functions that explained the largest amount of

variance. Table 5.15 below presents the standardized canonical function coefficients

(*Coef*), structure coefficients (r_s) and squared structure coefficients, or communalities (r_s^2) for the interpreted function.

Table 5.15 *CCA of performance and emotion variables*

Functions/ Variables	Function coefficient (coef)*	Structure coefficient (r_s)*	Communalities (r_s^2(%))
Function 1			
Independent synthetic variable			
Neutral	-.462	**-.698**	.49
Happy	**.533**	.480	.23
Surprise	-.223	-.165	.03
Anger	-.340	**-.555**	.31
Disgust	-.314	-.049	.00
Fear	-.135	-.087	.01
Sad	.271	**.626**	.39
Dependent synthetic variable			
TaskTime	**1.079**	.737	.54
ReviewedHits	-.005	.088	.01
GooglePages	-.002	.115	.01
UniqueQueries	**-.591**	.000	.00
QueryLength	.025	.221	.05
TviewResults	**-.640**	.066	.00
TreadHits	**.567**	.434	.19
Quality	-.072	.052	.00
Function II			
Independent synthetic variable			
Neutral	-.037	.016	.00
Happy	**-.688**	**-.679**	.46
Surprise	-.069	-.382	.15
Anger	.256	.014	.00
Disgust	-.048	-.443	.20
Fear	**-.504**	**-.708**	.50
Sad	**.622**	.201	.04

TaskTime	.104	.023	.00
ReviewedHits	-.422	-.402	.16
GooglePages	**1.022**	.020	.00
UniqueQueries	**-1.073**	**-.434**	.19
QueryLength	.336	.406	.16
TviewResults	.331	.328	.11
TreadHits	**-.601**	-.131	.02
Quality	.138	.129	.02

* interpreted coefficients appear in bold font

In interpreting Function 1, the strongest contributor to the dependent synthetic variable

was Happy. This was supported by a relatively strong structure coefficient. Judging by

the function coefficients, the strongest contributors to the independent synthetic variable

were Task Time, Unique Queries, Time Viewing Results and Time Reading Hits. This

conclusion was supported by structure coefficients of the Task Time and Time Reading

Hits variables and not supported by the structure coefficients of the Unique Queries and

Time Viewing Results. Our interpretation of the signs of the structure coefficients of the

dependent and independent variables indicated that more frequent happiness expressions

coincided with longer time spent on task, reading hits and reviewing results as well as

entering more unique queries.

In Function 2, the strongest contributors to the dependent synthetic variable were Happy,

Fear and Sad. This was supported by the structure coefficients. Judging by the function

coefficients, the strongest contributors to the independent synthetic variable were

GooglePages, Unique Queries, and Time Reading Hits. This conclusion was partially

supported by structure coefficients. Our interpretation of the function coefficients and the

signs of the structure coefficients of the dependent and independent variables indicated

that less frequent happiness and fear expressions and more frequent sad expressions

coincided with more Google pages reviewed, less unique queries and less time spent

reading hits.

Because the CCA model was not statistically significant, we also ran multiple linear and

curvilinear regressions to examine the relationships between different emotions and

search performance variables. Multiple linear regressions did not produce statistically

significant results at 95% confidence interval levels. However, curvilinear regressions in

some cases produced statistically significant relationships. Regressions run with

performance variables as independent and surprise, fear and anger as dependent variables

did not produce any statistically significant models. The highest effect size (R^2) of the

model predicting 1) surprise with performance variables was 3.5% for the cubic equation;

2) fear with performance variables was 3.9% for the cubic equation; 3) disgust with

performance variables was 4.8% for the cubic equation. The following multiple

regressions were statistically significant:

1. The model predicting happiness with performance variables yielded statistically

    significant results and effect size of 6.7% using logarithmic equation, and a not

    statistically significant result but a higher effect size ($R^2 = .090$) using quadratic

    and cubic transformations.

2. The model predicting sadness with performance variables yielded statistically

    significant results using logarithmic ($R^2 = .072$) and quadratic transformations (R^2

    $= .099$), and a not statistically significant result but a higher effect size ($R^2 = .114$)

    using cubic transformations.

3. The model predicting anger with performance variables yielded statistically

   significant results using logarithmic ($R^2 = .077$)

The results of the curvilinear regressions are partially consistent with the CCA model in that they confirm relationships between happiness and search performance variables.

5.2.2 Mood and search performance

On average, participants experienced more positive affect than negative affect (Table 5.16). Before starting the first search task, participants on average reported higher positive affect than after completing search tasks one and two (Table 5.16 and Figure 5.11). Positive (PA) and negative affect (NA) did not seem to be influenced by the search task's topic (Enrollment or Music Piracy) or the task difficulty level. For example, participants who researched the Enrollment task first followed by the Music Piracy task received an average PA score of 25 for the first task and 24 for the second, and participants who received the Piracy task first followed by the Enrollment task received an average PA score of 23 for the first task and 22 for the second (Table 5.16). This observation was further tested by running multiple regression analysis described in the next section.

Table 5.16 *Mood scores reported during the search (PA=positive affect; NA=negative affect)*

	before task 1		after task 1		after task 2	
	PA	NA	PA	NA	PA	NA
All task rotations						
Ave	34	20	24	14	23	13
Min	18	11	12	10	10	10
Max	50	36	40	28	41	27
Enrollment/Piracy rotation						
Ave	34	21	25	13	24	12
Min	18	11	12	10	11	10
Max	50	36	40	20	36	21
Piracy/Enrollment rotation						
Ave	33	20	23	15	22	15
Min	25	11	12	10	10	10
Max	40	30	35	28	41	27

Figure 5.11 illustrates the changes in participants' positive and negative affect reported before starting the search and after completion of the first and second search tasks.
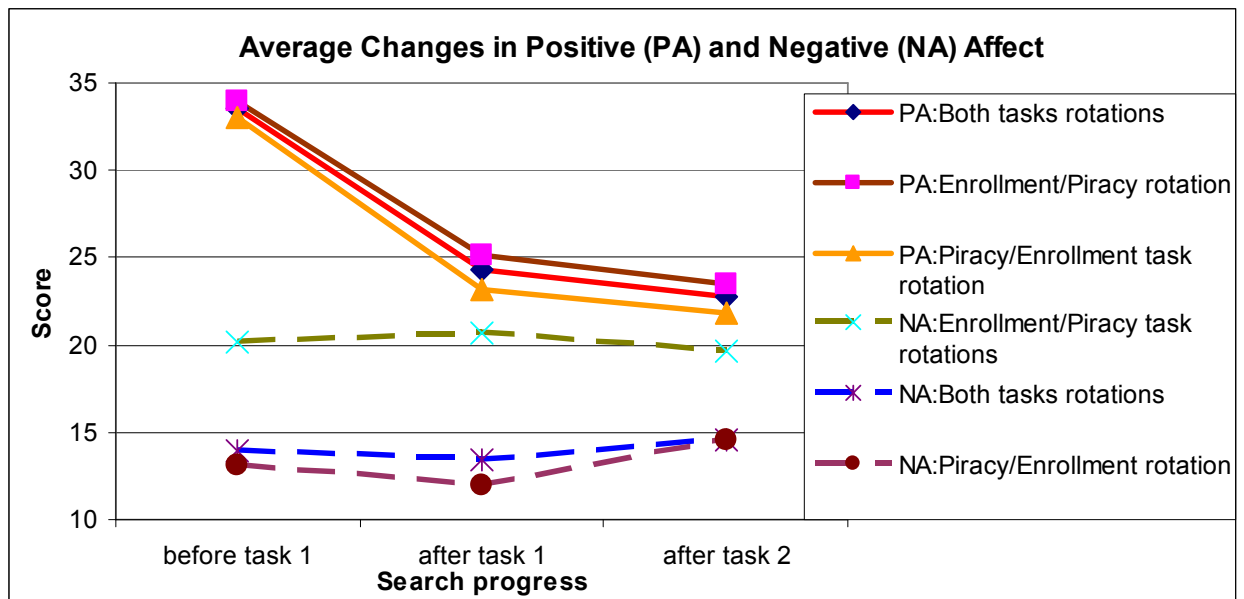
Figure 5.11 **Average changes in positive and negative affect during the Search**

5.2.2.1   Effect of pre-search mood on search performance

To examine relationships between performance variables and PA and NA scores reported

prior to the search, we conducted a CCA test. By using this statistical technique, we

examined the linear relationship between two multidimensional variables, in our case

performance (represented by TaskTime, AllURLs, ReviewedHits, GooglePages,

UniqueQueries, QueryLength, TviewResults, TreadHits, and Quality) and mood

(represented by positive (pre-PA) and negative (pre-NA) affect scores reported prior to

the search.)

The analysis yielded two functions, neither of which was statistically significant with

squared canonical correlation ($R_c{}^2$) of .333 for the first function and squared canonical

correlation ($R_c{}^2$) of .054 for the second function (which was not interpreted). The full

model across all functions was not statistically significant using the Wilk's $\lambda = .63$

criterion, $F(18, 98) = 1.408$, $p < .001$. However, the full model r^2 type effect size was .37

which indicated that the two canonical functions explained a moderate 37% of the

variance shared between the variable sets.

Table 5.17 below presents the standardized canonical function coefficients (*Coef*),

structure coefficients (r_s) and squared structure coefficients, or communalities ($r_s{}^2$) for

the interpreted function.

Table 5.17 *CCA of performance and mood variables*

Functions/ Variables	Function coefficient (coef)*	Structure coefficient (r_s)*	Communalities (r_s^2(%))
Function 1			
dependent synthetic variable			
Pre-PA	**1.023**	**.762**	0.58
Pre-NA	-.698	-.315	0.10
independent synthetic variable			
TaskTime	.363	**-.120**	0.01
AllURLs	**-18.799**	**-.303**	0.09
ReviewedHits	**9.070**	**-.408**	0.17
GooglePages	**10.348**	**-.096**	0.01
UniqueQueries	**1.151**	**-.022**	0.00
QueryLength	.281	.307	0.09
TviewResults	.017	-.099	0.01
TreadHits	-.204	.127	0.02
Quality	-.126	-.161	0.03

* interpreted coefficients appear in bold font

Looking at the function coefficients for the interpreted function, the strongest dependent variable was pre-PA. This conclusion was supported by structure coefficients. This indicates that pre-PA was the primary contributor to the synthetic mood variable. Judging by the function coefficients, the strongest contributors to the independent synthetic variable were AllURLs, ReviewedHits, GooglePages and UniqueQueries. This conclusion was partially supported by the structure coefficients, a result that can be attributed to the multicollinearity that these variables had with other variables (suggested by the signs of the structure coefficients). Our interpretation of the signs of the structure coefficients of the dependent and independent variables indicated that high PA scores correspond to the fewer AllURLs, ReviewedHits, GooglePages and UniqueQueries. In

other words, participants who reported better moods, visited fewer websites and entered fewer unique queries during the course of the search.

While we did not interpret the second function produced by the CCA, its function and structure coefficients suggested that the high pre-task NA correlated with less time spent on task, more Google Pages reviewed and more time spent reading hits.

We have noticed that the Quality variable was not a major or even moderate contributor to the performance synthetic variable in the two CCA functions. This fact suggested that pre-PA and pre-NA scores were not related to the quality of the search results. This observation was further confirmed by running individual linear regressions between pre-PA, pre-NA and Quality of search results variables, resulting in a small $R^2 = .018$, $F(2, 59) = .530$, $p = .592$, suggesting that the search outcomes are not influenced by the searchers' positive or negative moods.

Because the CCA model was not statistically significant, we ran a number of multivariate regressions between two types of mood (PA and NA) and performance variables that had strong function and structure coefficients in the CCA model. Linear and curvilinear regressions where Pre-PA and Pre-NA were predicting AllURLs resulted in not statistically significant models with the highest $R^2 = .056$ associated with the S-type curvilinear transformation. Linear and curvilinear regressions where the dependent variable was UniqueQuery did not produce statistically significant results, with the largest effect size (R^2) of 1.5% for the cubic curvilinear transformation. Linear and

curvilinear regressions where Pre-PA and Pre-NA were predicting ReviewedHits resulted in not statistically significant models with the highest R^2 = .045 associated with the growth, exponential and ligisti curvilinear transformations. Linear and curvilinear regressions where Pre-PA and Pre-NA were predicting GooglePages resulted in not statistically significant models with the highest R^2 = .047 for the cubic curvilinear transformation.

5.2.2.2   *Effect of search performance on mood*

We conducted a linear regression test to examine the effect of performance variables on PA scores collected after the search task completion. The statistical analysis yielded a not statistically significant model with a very modest 11% of post-PA variance explained by TaskTime, AllURLs, ReviewedHits, GooglePages, UniqueQueries, QueryLength, TviewResults, TreadHits and Quality variables (R^2 = .108, $F(9, 59)$ = .670, p = .632 at 95% confidence interval). None of the independent variables were statistically significant at 95%, 90% and 80% confidence intervals.

We conducted linear regression test to predict post-task NA scores with performance variables (TaskTime, AllURLs, ReviewedHits, GooglePages, UniqueQueries, QueryLength, TviewResults, TreadHits and Quality). The statistical analysis yielded a not statistically significant model with a modest 20% of post-NA variance explained (R^2 = .198, $F(9, 59)$ =1.372, p = .226 at 95% confidence interval). None of the independent variables were statistically significant at 95%, 90% and 80% confidence intervals. The findings suggested that the search performance did not affect participants' moods.

5.2.3 Additional findings related to mood

In addition to addressing relationships stated in the research question, we investigated whether mood was related to the type of search task.

We used multiple regression analysis to examine effects of task-related variables and the mood prior to the search on the mood reported during the search. Independent variables included NA and PA scores reported prior to the start of the search; task type (an identifier based on task sequence and topic); interest in a task; and perceived task difficulty. These independent variables were used to predict PA and NA scores collected after search tasks. Results of the statistical models were not statistically significant, with $R^2 = .12$, $F(5, 59) = 1.440$, $p = .225$ for the model predicting PA scores; and $R^2 = .06$, $F(5, 59) = .632$, $p = .676$ for the model predicting NA scores. The results of the statistical model indicate that task-related variables explained 12% of the variance of the PA scores, and 6% of the NA scores variance. Interest in a search task was the strongest predictor of PA scores after search tasks, $\beta = .25$, $t = 1.800$, $p = .078$. NA prior to the search was the strongest predictor of NA scores after search tasks, with $\beta = .190$, $t = 1.335$, $p = 187$.

We also examined whether searchers' mood can be used to distinguish between their performance; in other words whether searchers who predominantly felt negative, neutral or positive affect behaved differently from another group. In order to perform descriptive discriminant analysis that would allow us to examine this issue, we created a single mood score for each participant. We came up with the procedure for creating an individual mood scores that accounted for the ratios of positive and negative moods in each

participant and helped to classify participants into three groups depending on the

dominance of positive or negative affect. The procedure consisted of the following steps:

1) based on the individual PA and NA scores collected before the search, after task one

and task two, we calculated an average PA and NA score for each participant; 2) we then

calculated a single mood score for each participant by deducting an average NA score

from an average PA score (resulting in a single mood score ranging between 1 and 30); 3)

we split the total of mood scores into 3 groups, where 1=scores between 1-10

(representing group of participants that experienced mostly negative affect), 2=scores

between 10-20 (group that reported neutral affect), and 3=scores between 20-30 (group

that reported positive affect). Group 2 was the most populated group since most of the

participants' NA scores were balanced by their PA scores suggesting that they didn't feel

extreme negative or positive affect. Group 1 included searchers who felt mostly negative

affect, that group had fewer cases than Group 2; and Group 3, that included searchers

who felt mostly positive affect, had the least number of searchers. We then performed

descriptive discriminant analysis where we used mood category (1 for negative, 2 for

neutral, and 3 for positive) to discriminate between search behaviors. Because we did not

have an equal number of participants in each mood category, the descriptive discriminant

test was not statistically significant, *Chi square* = 23.534, *p* = .171 at the .05 level.

However, the model effect size (eta²) was a respectable 56%, and the analysis of the two

yielded functions indicated that participants belonging to different mood categories, also

varied in their search behavior.

Standardized discriminant function coefficients show that the first function is primarily based on the number of all the URLs and Google pages visited, number of reviewed hits and unique queries, since these variables were the primary contributors to the dependent synthetic variable. We therefore called this function Search Activity. The structure coefficients indicated that the number of all the URLs, reviewed hits and query length were highly correlated with the discriminant function.

For the second function, standardized discriminant function coefficients show that it is primarily a time viewing results construct. We called this function a Time Reading Results function. The structure coefficients indicated that the time viewing results, time on task and total number of Google pages visited were highly correlated with the discriminant function.

Table 5.18 *Standardized Discriminant Function Coefficients, Structure Coefficients and Group*

Centroids for Function 1 and 2.

Functions/ Variables	Function coefficient (coef)*	Structure coefficient (r_s)*	Communalities $(r_s^2(\%))$
Function 1 – Search activity			
TaskTime	.460	.056	
TotalURLs	**-11.253**	**-.348**	
ReviewedHits	**5.215**	**-.378**	
GooglePages	**5.362**	-.234	
UniqueQueries	**1.394**	-.161	
QuerLength-ave	.723	**.442**	
TviewingResults-ave	.526	.279	
TreadingHit-ave	-.476	.197	
Total qualityT1	.496	.268	
Group 1			-.689
Group 2			.457
Group 3			.868
Function 2 – Time Viewing Results			
TaskTime	.125	**.438**	
TotalURLs	-.452	.338	
ReviewedHits	.005	.233	
GooglePages	.681	**.360**	
UniqueQueries	.558	.237	
QuerLength-ave	-.110	.014	
TviewingResults-ave	**1.037**	**.611**	
TreadingHit-ave	-.120	.197	
Total qualityT1	-.488	-.229	
Group 1			-.065
Group 2			.192
Group 3			-1.509

* interpreted coefficients appear in bold font

Figure 5.12 examines groups' centroids in order to determine between which groups the

functions discriminate. Figure 5.12 makes it clear that function 1 separates between

groups 1 and 2, and 1 and 3; there is not much difference between groups 2 and 3 on

function 1 (Search Activity). Function 2 (Time Viewing Results) separates between

groups 1 and 3, and 2 and 3. The findings related to Function 1 indicate that group 1

(searchers that reported mostly negative affect) performed less search activities (less

URLs and Google pages visited, number of reviewed hits and unique queries) than group

2 and 3 (groups that reported neutral and primarily positive affect). Interpretation of

Function 2 suggests that group 1 and 2 (negative and neutral affect) spent more time

viewing results than group 3. Two reservations we have about interpreting the

discriminant functions is lack of statistical significance and relatively small sample

size/variable ratio (3.3 to 1).

Canonical Discriminant Functions
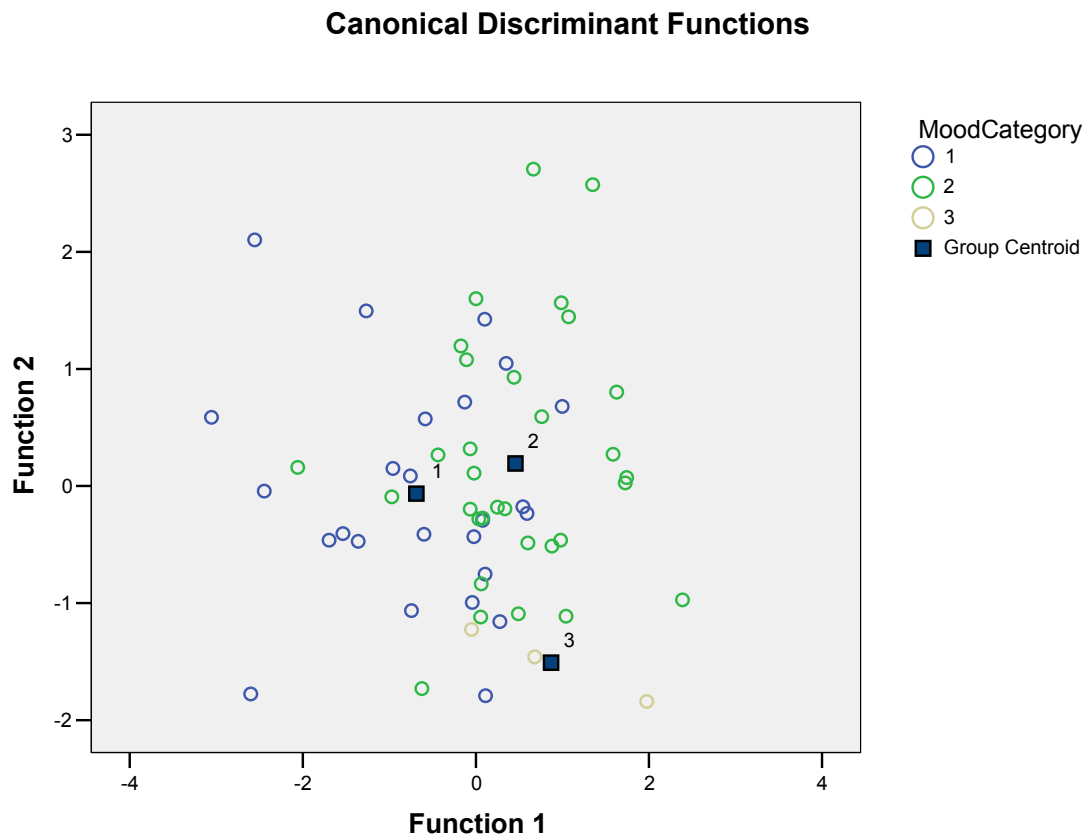
Figure 5.12 **Canonical discriminant functions**

5.3 Research Question 3: relationships between emotions and searchers' individual characteristics

Analysis of the data to address Research Question 3 tries to answer the following question:

> What are the relationships between users' individual characteristics (frequency of searching the internet, pleasantness of the search experience, interest in the search task, familiarity with similar searches, clarity about the search goal, and satisfaction with search results) and their emotional expressions during the search?

We performed canonical correlation analysis to examine relationships between seven emotional expressions and searchers' individual characteristics, including frequency of searching the internet (Frequency), pleasantness of the search experience (Experience), interest in the search task (Interest), familiarity with similar searches (Familiarity), clarity about the search goal (Clarity), satisfaction with search results (Satisfaction). The resulting model was not statistically significant; however, the effect size was relatively large at about 61% of variance explained. The analysis yielded six functions, none of which were statistically significant with squared canonical correlation (R_c^2) of .340 for the first function, squared canonical correlation (R_c^2) of .268 for the second function, (R_c^2) of .123 for the third function, and squared canonical correlation below .10 for the remaining functions. The full model across all functions was not statistically significant using the Wilk's $\lambda = .39$ criterion, $F(42, 223.90) = 1.188$, $p = .215$. However, the full

model r^2 type effect size was .61 which indicated that the six canonical functions

explained a large 61% of the variance shared between the variable sets.

We did not investigate the frequency of searching variable further as there was too little

variability in the reported scores (i.e. the subjects were really all alike on this variable).

We chose to interpret the first two functions that explained the largest amount of

variance. Table 5.19 below presents the standardized canonical function coefficients

(*Coef*), structure coefficients (r_s) and squared structure coefficients, or communalities (r_s

^{2}) for the interpreted function.

Table 5.19 *CCA of performance and emotion variables*

Functions/ Variables	Function coefficient (coef)*	Structure coefficient (r_s))*	Communalities (r_s^2(%))
Function 1			
Dependent synthetic variable			
Neutral	**.583**	**.538**	.29
Happy	**1.136**	.216	.05
Surprise	.192	-.167	.03
Anger	.019	-.175	.03
Disgust	**-.617**	-.163	.03
Fear	**-.842**	**-.432**	.19
Sad	-.225	-.056	.00
Independent synthetic variable			
Frequency	.297	.500	.25
Experience	.177	.445	.20
Interest	.308	.476	.23
Familiarity	**.747**	**.844**	.71
Clarity	-.208	-.008	.00
Satisfaction	-.067	.090	.01
Function II			
Dependent synthetic variable			

Neutral	-.243	-.068	.00
Happy	.046	-.206	.04
Surprise	**-.647**	**-.834**	.70
Anger	.472	.451	.20
Disgust	.080	.112	.01
Fear	-.211	-.468	.22
Sad	-.300	-.443	.20
Independent synthetic variable			
Frequency	. -.051	-.006	.00
Experience	.014	.013	.00
Interest	**-.815**	**-.527**	.28
Familiarity	.442	.413	.17
Clarity	.425	.608	.37
Satisfaction	.423	.306	.09

* interpreted coefficients appear in bold font

In interpreting Function 1, the strongest contributor to the dependent synthetic variable

was Happy, followed by Fear, Disgust, and Neutral. This was partially supported by the

strong structure coefficients. Judging by the function coefficients, the strongest

contributors to the independent synthetic variable was Familiarity. This conclusion was

supported by the strong structure coefficients. Our interpretation of the signs of the

structure coefficients of the dependent and independent variables indicated that frequent

happy and neutral expressions and infrequent fear and disgust expressions coincided with

familiarity of the searchers with similar searches in the past.

In Function 2, the strongest contributor to the dependent synthetic variable was Surprise.

This was supported by the structure coefficient. Judging by the function coefficients, the

strongest contributor to the independent synthetic variable was Interest. This conclusion

was supported by the structure coefficient. Our interpretation of the function coefficients

and the signs of the structure coefficients of the dependent and independent variables

indicated that less frequent surprise expressions correlated with less interest in the search task, and visa versa, more interest in the task corresponded to more surprise expressions.

Because the CCA model was not statistically significant, we ran several multiple regressions to verify the relationships between individual variables. Linear and curvilinear regressions between individual characteristics variables and emotional expressions variables (disgust, fear, sadness, anger, surprise and happy) did not produce statistically significant models. The highest effect size (R^2) of the model predicting 1) happy with individual characteristics variables was 6.5% for the cubic transformation; 2) sad with individual characteristics variables was 7.1% for the cubic transformation.

6   Discussion

6.1 Discussion on Research Question 1: emotional expressions around search behaviors

By answering Research Question 1, we were trying to understand

> What patterns of emotional expressions of seven basic universal emotions (neutral, fear, anger, disgust, happiness, sadness, and surprise) can be observed immediately before and immediately after three types of search decisions (selection, text manipulation and (re-) examination) represented by seven search behaviors: left button single, left button double, right button single, middle button mouse clicks, mouse up and down scroll and Google and non-Google page changes?

Analysis of emotion expression distribution indicated that the most frequently expressed

emotion was surprise followed by neutral. Surprise expressions were also the most

frequent expressions around the analyzed search behaviors. The high frequency of

surprise might represent the reality of the search experience, characterized by the high

uncertainly levels, high levels of surprise about the (non)findings, retrieved results, and

reviewed information. It might also point to the inexactness of the measurement

instrument, in our case, the eMotion software. Because the software is does not

adequately interpret the context in which the facial expressions occur, it is possible that

the software misinterprets other expressions as surprise. For example, during a

concentrated reading a mouth might be opened, the eyes can be opened wide, which can

be misinterpreted not as a concentrated reading, but as a surprise. Further research and

fine-tuning of the instrument are necessary.

Our analysis of the patterns of emotional expressions around search events resulted in a

few general findings:

1. Certain analyzed search events were more frequent than other events. Wheel

   down mouse scroll was the most frequent event, followed by the Left button down

   click. This finding suggests that most of the interactions with the system during

   the search are routine clicks for the purpose of selecting a document or a

   command like search, or scrolling down the page to read more. The distribution of

   the Google (N=508) and non-Google sites (N=658) points to the ratio of roughly

   1.22 non-Google, or target, pages opened for every Google results page viewed.

While on average participants reviewed more non-Google pages than Google

results pages, the low ratio suggests that searchers made quick judgments about

the quality of the retrieved results from Google pages and either re-formulated

their queries, or clicked on the target link that appeared relevant. This conclusion

is supported by manual examination of the search screen video recordings. The

recordings show that participants rarely even went as far as the bottom of the first

Google results page. If they did not see and click on a promising target link after

examining a few top search results, they usually re-typed their query. This finding

is consistent with the results of the previous studies that show that the probability

of clicking on a search result decreases dramatically with the rank order of results

(Joachims, Granka, Gay, Hembrooke, & Pan, 2005.)

2. Every analyzed search behavior was characterized by a unique pattern of

   emotional expression changes (see summary Table 5.14, Section 5.1.3). This

   finding suggests that search events can be characterized, recognized and classified

   based on the unique pattern of emotional expressions around them; emotion-

   recognizing machines can potentially be programmed to recognize, anticipate and

   properly react to the search moves.

We will now discuss individual patterns of emotional expressions around the analyzed

search behaviors. In this discussion, we assume that emotional expressions at least to

some degree represent emotions experienced by the searchers before and after they

interact with the retrieval system.

Left Button mouse click represented a decision to change the current view by clicking on a Search button, URL or another application, changing the page focus, and was the most frequent search behavior across all participants. While surprise was the most frequently expressed emotion around that decision, other emotional expressions were also found to vary significantly. The analysis showed that neutral expressions decreased while surprise and sad expressions increased after the click. This finding suggests that searchers are relatively calm before deciding to change the current screen view, but the change usually leads to immediate surprise or sadness, which in turn might indicate that searchers see something unexpected or disappointing.

Left Button Double click is similar to the single Left Button click, and might represent personal style, preference or impatience. The distribution of emotional expressions around this click is similar to the distribution of emotions around Left Button click. Expressions of disgust and sadness increased after the click. The latter expression peaked right after the click (within 0-3 second interval after the click). The increase of disgust and sad expressions might indicate that searchers did not see what they were expecting to see, which in turn might suggest presence of wrong expectations before the decision to change the status quo, for example, an expectation to immediately solve the problem and find the answer, etc.

Middle Button Double click was a rare behavior which might represent a selection or a scrolling technique. Similar to the previously discussed clicks, neutral expressions decreased while surprise expressions increased after the click, indicating that perhaps

searchers saw something they did not expect to see after the click. Disgust expression varied around the click, it did not consistently increased or decreased after the change on the screen. We saw a significant variation of happy expressions around this click: they peaked around 9-12 seconds after the click, indicating that after brief initial examination of the changed screen, searchers were happy with what they saw.

We did not find any significant variations of emotional expressions around the Right Button Down click that represented decision to manipulate screen text (copy, paste, etc.). This finding might suggest that this type of click is different from others. It is made when the judgment about the text quality is made, and the decision to use it is also made, resulting in no specific expectations that lead to emotion variations around other clicks.

Wheel Down scroll, representing the decision to review additional information on the page, was the most frequent search behavior. Analysis of total distribution of wheel down clicks indicated that surprise peaked right after the click; anger increased after the click but subsided by the 13-15 seconds after the click. Around 9-12 seconds after the click, neutral expressions increased. Happy expressions decreased after the click, sad expressions decreased right before the click and continued decreasing after the click. Disgust expressions increased right before (3-0 seconds) and right after (1-3 seconds) the click, fear expressions increases right before the click and remain frequent after the click. In other words, right before scrolling down, searchers felt happy with the viewed information and wanted to continue reading. However, their immediate reaction on the changed view is surprise and anger, possibly disappointment, decreased happiness and

increased fear. However, these initial negative reactions stabilized by the 13-15 after the click, when the neutral expressions increased and sad expressions continued to decrease. This pattern might indicate general optimism before the decision to change the status quo, than quick disappointment possibly due to the unexpected text or lack of immediate answer, followed by the continuing examination of a document.

We analyzed emotional patterns around the Wheel Down scrolls performed on the Google search results pages. As searchers scrolled down the Google page, they felt sadder, possibly more disappointed in not seeing relevant results. Presence of this emotion during the viewing of the Google page helps to explain why most of the participants examined top results and either clicked on one of the top links or chose to re-formulate their query.

The large number of Wheel Down clicks on non-Google pages indicates active examination of the target pages, the pages where participants were expecting to find the answer based on the information given by the Google result page. The pattern of emotions around wheel down scroll on non-Google pages resembles the pattern of this type of click around all wheel down click. More specifically, surprise increased right after the click, while angry expressions peaked in the 3-6 second interval after the click; disgust expressions peaked around the click (between 3 sec before and 3 sec after the click). Fear and neutral expressions increased after the click, while happiness and sadness decreased. This pattern suggests that before deciding to scroll down the page, searchers felt happy and/or sad, and were interested in further examining the page. After the click

they were surprised, fearful and angry, perhaps because they did not immediately see what they expected to see. Their happiness and sadness levels dropped, but their neutral expressions also increased, possibly indicating return to the search routine mode.

Wheel Up scrolls, indicating searchers desire to re-examine the information on the page or return to the navigation features, were significantly less frequent than the Wheel down scrolls. Analysis of the emotional pattern indicates that fear and disgust decreased after that type of click, but so did happiness. Angry expressions peaked 0-3 seconds after the click and sad expressions generally increased after the click. Relatively high happiness before the click might point to the searchers positive evaluation of the examined page. Increase disgust, anger and sadness after the click might suggest that participants were upset about the examined information and/or amount of effort it takes to find the answer.

A similar pattern of emotional expressions was observed around Wheel up scroll on Google results pages. Analysis indicated that the probability of angry expressions peaked right after the click, disgust peaked between 6 to 12 seconds after the click, fear expressions decreased and sad expressions increased after the click. As with the previous click, the immediate reaction to the change was generally negative, except for the decreased fear, suggesting that searchers were generally upset while scrolling up the Google page to re-visit the results or reformulate query.

The pattern of the Wheel up scrolls on non-Google pages was one of the few patterns where we can actually talk about improvement of emotions after the click. Specifically,

happy expressions varied around the click, but peaked in the interval between 3 seconds before and 3 seconds after the click and than between 12-15 seconds after the click; disgust and fear expressions decreased after the click. The emotional pattern around the Wheel up scroll on the target, non-Google page points to the improved feelings associated with the re-examination of the information on the previously selected page, possible confirmation of relevance judgments made during selection of the page.

We performed two types of analysis of the emotion expression patterns around Google page changes using different time intervals around the event. In one analysis we used five 3 second intervals before and after the page change, resulting in the total of 30 seconds around the page change. In another analysis we extended the intervals to 6 seconds and analyzed the total of 60 seconds around the event. Both analyses revealed no significant variations in the expressed emotions.

Analysis of the emotion patterns around the non-Google page indicated higher levels of happiness before the page change, especially in the interval of 18-24 seconds before the page change. This finding suggests that the searchers were happier about the previous page they examined.

Overall, though all emotional patterns around various clicks were unique, there were some similarities. For example, surprise, and sometimes sadness, tended to increase immediately after the search behavior. This finding suggests that the change resulting from the search behavior is not what participants expected, and in turn suggests that

participants surprise is either 1) a natural reaction on any change during the search, or, 2) searchers set the wrong expectations for the change. It is interesting that despite negative emotions that immediately follow the click, searchers continue clicking. Wheel up on non-Google page was the only behavior characterized by emotional pattern where these was an obvious improvement in emotions, so it was the only emotionally 'rewarding' behavior made during the search.

Based on the nature of emotional patterns around Google and non-Google page changes and Right Button down clicks, these are different types of search behaviors then other clicks. We hypothesize that Right Button click is not a typical searching behavior since it does not involve set expectations before the click or evaluative judgments after the click, but rather a technical solution to modifying the text. The reason for not seeing patters of emotional expressions around URL changes could be related to the time intervals we chose to observe. It is possible that our window of observation is skewed by the time it takes for the page to load, so in the future we need to find out not when the page registered in the URL address bar, but when the page actually loads in a browser.

Use of qualitative methods, such as detailed interviews with participants or use of a think-aloud technique, is needed for the future studies to validate the findings and find out what exactly did searchers' feel and why. While the post-search interview was intended to collect such data, we found that an average 40 min recording of a search session was too long for participants to describe in great detail and to recall their emotions and specific actions during this time interval. In the future, the use of shorter

short sessions is needed to solicit detailed post-search self-reports of search events and experienced emotions. Some of the data that was collected during the interview will be analyzed in the future.

6.2 Discussion on Research Question 2

6.2.1 Emotions and search performance

Our analysis indicated that more frequent happiness expressions coincided with longer time spent on task, more time spent reading non-Google target pages and reviewing results as well as entering more unique queries. Less frequent happiness and fear and more frequent sad expressions correlated with more Google pages reviewed, less unique queries and less time spent reading hits. The possible explanations for these correlations between emotional expressions and search performance variables might include the following:

- The longer the time one spends searching, the more chances the searcher has to experience and express happiness

- The more thorough the searcher (e.g. more unique queries entered, more time spent reading results), the more "rewarding" results the searcher gets, and the more happy s/he feels. The less thorough searchers have fewer opportunities to feel happy and not sad because they might not get to the best results, the most interesting sites, etc.

- The sadder and less happy one feels, the sooner s/he will end the search because there is no positive reinforcement to continue. This finding might be linked to

earlier studies that linked motivation to continue search with self-efficacy (Nahl, 2004). If a searcher feels like s/he is making a good progress and feels good about his/her searching abilities, it is more likely that s/he will continue searching. We do not know how to explain the association of fear expressions with the number of Google pages reviewed, unique queries and time spent reading hits.

6.2.2 Mood and search performance

Our multivariate analysis of the relationship between mood and search performance variables indicated that positive and negative affect during the search had no effect on the quality of the search results and moderate effect on search behaviors, such as number of sites visited and time spent reviewing the results. Some explanation lies in the nature of mood, which is a relatively long lasting feeling that, unlike emotion, is not felt "about" anything (Morris, 1999). A theory of mood that helps to explain effects of mood on search behaviors is the view that the mood is responsible for monitoring resources needed for meeting current demands and, in case of negative mood, corresponds with assessments of resources inadequacy (Morris, 1999). In light of this theory, fewer visited sites and reformulated queries can signal searchers' assessments of resources adequacy (e.g. feeling good about status quo) and correlate with the positive mood, while more visited sites and reformulated queries might signal the opposite, the assessment of resources inadequacy (e.g. feeling bad about status quo, so keep changing tactics), and correspond with the negative mood.

Previous studies of the effect of mood on behavior suggested that people experiencing

negative mood prefer risky options, while people experiencing positive moods are risk-

averse and are afraid that the loss would spoil their mood (Isen, 1993; Mano, 1994). In

the information search environment, this might suggest that searchers who experience

positive mood are reluctant to review many websites and reformulate a lot of queries not

to spoil their mood, while searchers whose mood is lower search more 'actively' to

improve the situation.

Lack of a link between mood and the quality of search results might suggest that

influencing mood before and during the search, for example, by designing 'pleasurable'

retrieval systems, might not result in improved search results, but changed search

behaviors and experiences. This opens a broader question: whether affective computing

should focus on improving human computer interactions or the end-results of this

interaction.

We ran an additional test to see if search outcomes are impacted by the search

performance variables, such as time spent on search task, number of unique queries, etc.

The performed regression was not statistically significant, pointing to the lack of

connection between search performance and search outcomes. In other words, the quality

of search results did not depend on the time participants spent searching or examining

search results, number of unique queries, etc. In light of this finding, if neither mood nor

search performance variables impact end-results, good mood is better than the bad mood,

because it correlates with fewer activities and shorter search, while bad mood

corresponds to more activities and longer searchers. To put it another way, searchers in a positive mood and in a negative mood will reach the search results, but searchers who experience positive mood will do it with less effort and in shorter time.

6.2.3 Mood and search task

Our statistical analysis indicated lack of statistically significant relationships between mood prior to the search, topic of the search, sequence of task, task difficulty level, searcher's interest in a task and positive and negative affects. Effect sizes (R^2) of the tested models were also relatively small. These findings were also confirmed by the post-search interviews with participants. When asked to recall the most emotional moments experienced during their searches, most of the participants could not recall anything. For example, when information was hard to find, participants did not report high frustration levels; when participants found results, they did not indicate extreme happiness, etc. We also asked participants if performing the search in a laboratory setting impacted the way they searched and behaved. For most of the participants, the lab setting was not at all problematic and did not differ from the way they usually use computers in a library or another public place. So why did task properties and mood reported prior to the search have such a minimal effect on moods experienced during the online searching?

One possible explanation is well supported by the human information behavior literature: searching is a complex experience involving many variables of potential consequence to the mood (Nahl & Bilal, 2007). We only investigated some of them. Other search-related factors, such as participants' performance, searching skills, motivation to obtain the best

possible results can contribute to affect experienced during the search. There might also be factors outside the scope of an online search experience influencing search moods. For example, most of our participants reported feeling tired and worried about their mid-term exams. It is possible that while students participated in our experiment and searched the web for the two given tasks, they were thinking and worrying about their exams and other issues.

Another possible explanation for the relatively stable mood throughout the search lies in the nature of the mood construct, which is a relatively long lasting feeling that, unlike emotion, is not felt "about" anything (Morris, 1999).

The nature of the study findings can also be attributed to the study and instruments' design. One can argue that participants did not have a personal stake in the quality of the search outcomes and did not experience extreme positive and negative reactions to the search stimuli. From the beginning of their search, participants knew that they would be awarded research credits for participation, regardless of the outcome quality. It is possible that in a naturalistic setting where participants had to find information to satisfy their personal information needs, their behavior and affective profile would be different. The topics of the two tasks might have contributed to the results as well. It would be interesting to observe if the relationships between search task variables and mood change when people are searching for information that has important consequences in the lives of their loved ones (e.g., health issue). Our results can also be attributed to the measurement instrument error (e.g., participants' fatigue while filling out PANAS questionnaire).

Further inquiries into the role of affect in information search can help to address some of these issues.

While the study did not find statistically significant correlation between the mood reported prior to the search, search task characteristics and the mood reported after the completion of search tasks, the findings suggest that online searching is a complex and rich experience and is part of a larger life context. The study used an affect measurement instrument, PANAS that was not previously applied in the library and information science research, and can be used in the future. The future studies of subjective experiences during an information search can benefit from the study findings and methods.

6.3 Discussion on Research Question 3: emotional expressions and individual characteristics

Our analysis of the correlations between emotional expressions and searchers' individual characteristics showed that searchers' familiarity with similar searches correlated with frequent happy and neutral expressions and infrequent fear and disgust expressions. Familiarity with the retrieval system or a search task was linked to positive feelings in previous studies (Meghabghab, 1995; Bilal & Kirby, 2002; Nahl, 2004). The more familiar we are with something, the more positive feelings (e.g., happiness, confidence, self-efficacy) we experience.

Another individual characteristic variable that showed strong connection with certain emotional expressions was interest. Low interest in the search task was linked to less frequent surprise expressions while high interest in the task corresponded to more frequent surprise expressions. While we did not find any support of this finding in the previous LIS literature, mostly because we did not find studies that focused on the surprise emotion, intuitively, the finding makes sense: the more interested we are in the task, the more critically we examine the information that might be new and surprising.

6.4 Summary

This section summarizes the findings for each research question based on the conceptual models proposed at the beginning of the study.

Research Question 1 examined patterns of emotional expressions around the search decision points that manifested themselves in several search behaviors. The analysis of the patterns indicated the existence of the unique emotional patterns around the decision points. Table 6.1 maps emotional patterns onto the decision making points examined in the study.

Table 6.1 *Search behaviors, decision points and emotional patterns around them*

Search behavior	Decision point	Preceding emotions	Following emotions
Mouse clicks: Left button down	Decision to change the current view by clicking on a Search button, URL or another application, changing the page focus (scrolling up/down the page, bringing one page on top of the other), etc.	neutral	surprise sad
Left button double	Same as Left button down, might also represent the personal preference in clicking and/or impatience to get to the action results		sad disgust
Right button down	Decision to manipulate found text (copy, paste, save, etc.)	no significant emotion changes	
Middle button down	Scrolling technique, see Wheel up/down	neutral	happy surprise
Wheel scroll down (total)	Decision to review additional sources/information	happy sad	neutral surprise anger disgust fear
Wheel scroll down on Google result pages	Decision to scroll down the results page in search of links that appear relevant		sad
Wheel scroll down on non-Google, target pages	Decision to scroll down the target page in search of an answer	happy sad disgust (right before the click)	neutral surprise angry fear disgust (right after the click)
Wheel scroll up (total)	Decision to return to the previously seen information, might be indicative of a thorough examination of result(s)	happy disgust (12-9 sec before the click) fear	angry sad
Wheel scroll up on Google result pages	Decision to scroll up the results page to re-examine results or query	fear	angry disgust sad
Wheel scroll up on non-Google, target pages	Decision to re-examine information on the target page for careful examination or search for navigation features	happy (right before the click) disgust (12-9 sec before the click)	happy (right after the click)

		fear	
URL changes: Google page change	Submission of a query and review of Google search results immediately after the submission	no significant emotion changes	
Non-Google page change	Selection of one of the Google retrieved results and review of a document immediately after the selection	happy	

Research questions two and three examined relationships between emotional expressions, mood, individual characteristics and search performance and outcomes. Figure 6.1 summarizes the findings based on the initially proposed conceptual model between the variables. Only the variables that were found to have meaningful relationships with other variables were included in the final model. Most of the relationships between variables that were hypothesized earlier in the study (see Figure 3.3) were confirmed. We confirmed relationships between the following constructs:

- searchers' individual characteristics and emotional expressions during the search;

- the mood before and during the search and search performance;

- and search performance and emotions.

However, several differences were identified. The final model illustrates the differences between the initial and final conceptual models:

- Relationships between mood and search outcomes were not confirmed; therefore on the model the line between these variables is crossed.

- Relationships between task type and mood were not confirmed.

- Query length as one of the search performance variables was not found to be affected by or affect other examined variables.

- The only individual characteristics that were found to impact searchers' emotions

  were level of familiarity with similar searches and interest in the search task.

During search   **After search**

| **Individual characteristics** interest in the search task familiarity with similar searches | **Search performance** search duration time examining search results number of queries number of viewed hits number of result pages requested per session | **Search outcomes** quality of search results |

Before search

| **Mood** (Positive Negative) | **Mood** (Positive Negative) | **Mood** (Positive Negative) |

| **Task type** | **Emotions** neutral fear anger disgust happiness sadness surprise | |

Note: Arrows represent one-way or reciprocal relationships between constructs.

Figure 6.1 **Refined conceptual model investigated by Research Questions 2 and 3.**

7 Conclusion

Affect is a growing area of interest in many disciplines, including psychology, engineering, and LIS. Recent research suggests that emotions are a ubiquitous element of any human computer interaction (Brave and Nass, 2002) and should be considered in the design of "usable" systems (Karat, 2002). If we want to consider affect in the design of information retrieval systems that are attuned to users' emotional needs, we need to understand searchers' emotional experiences, their manifestations and their effects on searching behaviors.

We conducted a study that investigated emotional patterns associated with online search decisions and examined the role of the mood and emotions in the search process. The most significant results of the study include classification of emotions and search behaviors and understanding of the relationships between moods, emotions and search performance and outcomes that leads to the development of conceptual model of the affective information retrieval. We found that all search behaviors (clicks) were characterized by the unique patterns of emotional expressions, and almost all (except one) type of click lead to immediate improvement of searchers' emotions. We also discovered that mood and emotions were related to search performance: better moods were found to be correlated with the shorter searches, while, at the same time, the longer (and more thoroughly) participants searched the web, the more frequently they expressed happiness. Our analysis showed that familiarity with similar searches and the interest in the search task were correlated with the increased happy and surprise expressions. The

study did not find any relationships between the mood and the quality of the search

outcomes.

Another contribution of the study includes the use of the methods and instruments not

previously used in LIS research. For the first time in the LIS research of affect, we

operationalized definitions of emotion and mood, and developed a method for examining

and measuring affect during searching. All the developed definitions, methods and

techniques can be used in the future studies of affect in the information retrieval context.

For example, the study used Positive Affect Negative Affect Scale (PANAS) to measure

participants' moods. While this instrument is used in psychology and other disciplines, it

was not previously used in the LIS and can be used in the future LIS studies of emotions

and affect. Our study introduced and relied on the universal facial expression theory of

emotions and the automated facial recognition software. While the current software's

recognition accuracy rate is not very high (approximately 60%), conceptually, automated

recognition process is still the most efficient way to recognize emotions from facial

expressions. In the future, the software will improve and it will be possible to incorporate

them into IR systems.

Our study was conducted in an experimental setting, where participants were asked to

perform online searches to find the answers to the two questions coming from a

hypothetical friend. During the course of the search, participants' moods were measured,

their facial emotional expressions were captured by video cameras and later analyzed by

the emotion classification software, and their search actions were logged. The collected

data was analyzed using a number of statistical techniques. While the study was primarily

exploratory in nature, we hypothesized about the existence of certain relationships

between the variables. For example, we hypothesized that emotions are linked to search

performance, mood, and searchers' individual characteristics are related to search

performance and outcomes. Some of our preliminary assumptions were confirmed and

clarified, while others were not.

We confirmed the relationships between emotional expressions, search actions and

decisions. One of our most interesting and important findings related to the emotional

patterns around the search behaviors. That was the fact that each behavior, that in turn

represented a decision to change the search screen, was associated with a unique pattern

of emotional expressions. If behaviors are characterized by the unique set of emotions

and vice-versa, it can lead to the development of classification of search behaviors and

corresponding emotional expressions. Such a classification can inform the development

of affective IR systems that can recognize emotions, anticipate and, if necessary,

influence searchers' behaviors. For example, if the system can read an emotional pattern

that usually precedes a certain type of click, it can anticipate what a user wants to do and

do it for him/her (e.g., a system might suggest a certain search move that might be useful

for the searcher in his/her current situation). Affective IR systems can mitigate negative

emotions by being 'intelligent', making judgments and providing additional information

about the search to the searchers. For example, our analysis of the emotional patterns

indicated that most of the decisions to change the status quo lead to immediate negative

reactions to the change. Increase of the negative emotions might be explained by the

inaccurate predictions about the effects of the change. Perhaps, systems can be programmed to adjust searchers' expectations. A system, for example, can evaluate a query and immediately inform the searcher about its difficulty level. If the query has a ready answer, the system might offer it, if the preliminary results indicate that there is no immediate answer, the system can be programmed to warn the searcher about estimated search time and effort needed to find the answer. Presentation of the search results and documents can be altered to save searcher's efforts and disappointments associated with certain types of clicks. For example, information can be presented on a split screen view that can present more text, highlight relevant parts of the text, etc.

It was somewhat surprising to find that most of the clicks were immediately followed by the increase in negative emotions. One would think that any click is a result of a decision to change the status quo for the better. Why, then, did the change not result in an immediate improvement of the searcher's emotional state? One possible explanation might be the fact that we did not examine long enough episodes when the positive change occurs after the click. Extending analyzed periods after the click might show eventual improvements of emotional states of the searcher after the clicks. It is also possible that immediate negative reactions to the change is quite natural and does not need to be mitigated since it leads to learning better search strategies. Another possibility is that searchers have high expectations about the results of their actions, they might expect to find relevant information sooner, and therefore are disappointed when their action does not always or immediately leads them to the answer.

It is worth highlighting that the only type of the search behavior that lead to the improvement of emotional state was wheel up scroll, or a decision to re-examine an already selected page or document more thoroughly. This observation can be used to emphasize that thoroughness in examining documents pays off by increasing positive feelings.

The study found reciprocal relationships between emotions and search performance. More frequent expressions of happiness was found to be associated with longer and more thorough searches; sadder feelings were found to be associated with shorter searches and less thorough searches. We could say that the thoroughness of the searchers pays off and this type of searchers tend to experience more happiness during the course of the search. However, another finding suggests that the search thoroughness does not impact the quality of search results (rated by independent judges), and it would probably be counterintuitive, though not unique[9], to suggest that a longer search does not to improve the search outcomes but does impact the interim emotional experiences. In the future, we also consider examining relationships between search performance and searchers' subjective evaluations of search results (e.g., while 'objectively' the searchers might not produce the best possible answer to the search question, 'subjectively' they might be quite happy with the results.)

The fact that longer searches were correlated with more frequent happy expressions somewhat contradicts another finding related to the searchers' mood and search

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[9] The studies of colonoscopy procedures (Kahneman et al., 1993) suggested that it might be worth extending the duration of the generally unpleasant procedure to improve the overall subjective evaluation of the experience

performance. Positive mood was found to be associated with fewer search activities (such as fewer visited sites and reformulated queries), while negative mood was associated with increased search activities. In light of the two findings, on one hand, searchers who spent more time searching experience more happiness, but at the same time, searchers who search longer (and more thorough) also find themselves in a worse mood. Therefore, on one hand, a more thorough searching is linked to the increased happy occurrences, on the other hand, a shorter search is related to better mood. The two findings might point to the differences in the nature of mood and emotions. Mood might be a long-lasting 'background' state during which emotions, including emotions inconsistent with the general state, can occur (e.g. happy emotions during generally sad mood). This inconsistency in the findings warrants further investigations into the nature and role of mood and emotions in the online searching process.

Since we found that neither mood nor search performance impacted the end-results, we believe that positive mood generally benefits the searchers. Searchers in a positive mood invest less effort into search, but get comparable results and maintain their positive mood. Perhaps, affective IR systems can attempt to improve searchers' moods before they start interacting with the system. Some websites might already attempt to improve searchers' states by innovative graphics, such as the changing designs of the Google search engine main page.

Searchers' mood generally did not change significantly during the course of the search, indicating that it would be difficult to manipulate the mood if that was one of the

objectives of affective IR systems. The fact that neither affective states nor search performance variables affected the quality of the search outcomes suggests that the focus of affective systems should be improvement of the searchers' emotional states during the search (and possibly their memories of the search experiences), and not necessarily improvement of the search outcomes.

The relationships, or more accurately lack thereof between search task and mood, are somewhat puzzling. On the one hand, mood is a relatively long-term affective construct that might not be easily changed over the course of one's online search. On the other hand, it is logical to expect some changes in the mood influenced by the difficulty or other parameters of the search task. If the task difficulty does not influence mood, perhaps future studies can vary not the task difficulty, but the degree to which a searcher cares about the end-results (e.g., information needed to satisfy curiosity, for a school project, for a decision on a medical procedure, for a friend versus self, etc.) We hypothesize that search tasks that have direct impact on a searcher's well-being will have greater influence on searcher's moods and emotions.

The study found that the only individual characteristics that effected searchers' emotions were the level of familiarity with similar searches and the interest in the search task. The study linked familiarity to the increased expressions of happiness and neutral emotions, and interest in the search task was linked to the increased expressions of surprise. This finding is in line with the previous work that found positive correlation between topic familiarity and positive emotions, such as efficacy (Kelly & Cool, 2002). Perhaps if the

system could predict searchers' familiarity through some evidence (e.g., records of previous searches) or if searchers could indicate to the system their level of familiarity with similar search tasks, the system can adjust its output to mitigate negative feelings, give 'unfamiliar' searchers more search recommendations, thematically group the results, etc. The effect of interest on emotions requires further investigation. It would be interesting to know whether increased surprise associated with interest in the search task represents "more emotionally involved" searchers, or searchers who are more 'passionate' about the information they are seeking. Perhaps affective IR systems could manipulate the outputs to increase searchers' interest, and therefore involvement in the search (e.g., by presenting interesting, controversial, attention grabbing information first).

The study had a number of limitations related to the study design, sample, data analysis methods and investigated variables. The study was designed as an experiment because we needed to control for the variables that would impact searchers' emotions and moods and because we needed to use recording methods that would be difficult, if not impossible, to use in the naturalistic settings. The main negative side effect of the experimental setting was the fact that the participants performed pre-determined search tasks, did not have a personal stake in the search outcomes, and could have been indifferent to the quality of the search outcomes. We tried mitigating this effect by designing tasks that would appear interesting and relevant to the studied sample (e.g., music piracy and college enrollment), but future research should consider studying searchers in their natural environments where they care about search outcomes and look for the information that solves their real life problems. While most of the participants indicated that they were not aware of the

laboratory equipment and that searching in the lab felt similar to searching in a public

space (e.g. library), the lab setting might have affected searchers' performance and

subjective states.

The study used a convenience sample of undergraduate students most of whom used

search engines very frequently. Such a sample makes the study findings generalizable to

a relatively small group. However, if emotional expressions are universal, that should at

least in theory mean that other groups of searchers with the similar searching skills and

experience would exhibit similar emotion patters. Future work is needed to examine

emotions and moods of searchers with different searching skills, representing different

demographics, etc. The sample size created issues with some of the statistical analyses

used in the study. While the sample size was adequate for examining emotion patterns, it

was relatively small for some of the multivariate statistical methods used to examine the

role of mood in the search process. A larger sample size would be beneficial for the

future studies.

The study was, to a large extent, exploratory because it is still a relatively new area of

research. Because we did not have a lot of theories or prior findings to ground our

decisions, we made some judgments based on the preliminary data analysis. A priori, we

did not know what intervals before and after search behaviors to review for the presence

of emotions. We had to determine the intervals, a posteriori, by examining the data and

detecting variations in the data. We also did not examine all possible search behaviors,

but made a decision to examine behaviors that are easiest for the system to detect (e.g.,

different type of clicks). In the future, we can include other search behaviors, for example

a query typing event, and examine emotional patterns during and around this process.

One of the major assumptions we made in the study, the assumption that facial

expressions represent emotions, also needs verification. While our assumption is based

on the well-supported theory, there is disagreement about the nature of emotions and their

expressions in the psychology research, which limits our findings to a particular view on

emotions. To better know what emotions participants experienced during the search,

future studies would need to ask participants to describe their emotional states using a

talk-aloud, interview or other self-report methods.

Massive amounts of data about searchers' emotions, moods and search behaviors were

collected during the study. Only a portion of these data was analyzed to address the

research questions. Our future plans include analyzing data that would help to understand

emotional patterns that occur between search actions (clicks), emotional patterns

associated with query typing, and other search processes.

The study was exploratory and investigated some of the emotion and mood variables in

the LIS context. We hope that our findings related to the role of emotions and moods in

online searching will advance the science of designing and optimizing IR systems.

Emotion detection is the first step in building interactive affective systems. Once it

becomes possible to build systems that are capable of recognizing ever-changing

emotions and relating them to specific search behaviors, we can focus on developing a set

of appropriate system reactions to specific recognizable emotions (e.g., humorous

message to cheer up an upset user from studies of Klein et al., 2002 and Tzeng, 2004).

References

Arapakis, I., Jose, J., M., Gray, P., D., 2008. Affective feedback: an investigation into the role of emotions in the information seeking process. *SIGIR '08: Proceedings of the 31st annual international ACM SIGIR conference on Research and development in information retrieval, New York, NY, USA,* 395–402.

Bamidis, P. D., Papadelis, C., Kourtidou-Papadeli, C., Pappas, C. & Vivas, A. B. (2004). Affective computing in the era of contemporary neurophysiology and health informatics. *Interacting with Computers, 16*(4) 715-721.

Barrett, L. F. & Russell, J. A. (1999). Structure of current affect. *Current Directions in Psychological Science*, *8*, 10-14.

Bell, D. J. & Ruthven, I. (2004). Searchers' assessments of task complexity for web searching. In S. McDonald and J. Tait, J. (Eds.). *Advances in Information Retrieval, 26th European Conference on Information Retrieval. Lecture Notes in Computer Science 2997*, pp. 57–71. Sunderland, UK: Springer.

Bilal, D. (2000). Children's use of the Yahooligans! web search engine: I. cognitive, physical, and affective behavior on fact-based search tasks. *Journal of the American Society for Information Science, 51*(7), 646–665.

Bilal, D. (2002). Children's use of the Yahooligans! web search engine: III. Cognitive and physical, and affective behavior fully self-generated search tasks. *Journal of the American Society for Information Science, 53*(73), 1170–1183.

Bilal, D. & Bachir, I. (2007a). Children's interaction with cross-cultural and multilingual digital libraries. I. Understanding interface design representations. *Information Processing and Management, 43*(1)*, 47*-64.

Bilal, D. & Bachir, I. (2007b). Children's interaction with cross-cultural and multilingual digital libraries. II. Information seeking, success, and affective experience. *Information Processing and Management, 43*(1)*, 65*-80.

Bilal, D. & Kirby, J. (2002). Differences and similarities in information seeking: children and adults as web users. *Information Processing and Management, 38,* 6495-670.

Blom, J. O & Monk, A. F. (2003). Theory of personalization of appearance: why users personalize their PCs and mobile phones. *Human-Computer Interaction, 18*(3), 193-228.

Bower, G. H. (1992). How might emotions affect learning? In S. A. Christianson (Ed.). *The handbook of emotion and memory research and theory,* pp. 3-31. Hillsdale, NJ: Lawrence Erlbaum.

Brave, S., Hutchinson, K. & Nass, C. (2005). Computers that care: investigating the effects of orientation of *emotion* exhibited by an embodied computer agent. *International Journal of Human-Computer Studies, 62*(2), 161-178.

Butler, D. L., & Cartier, S. C. (2005). Multiple complementary methods for understanding self-regulated learning as situated in context. Presented at the *Annual Meeting of the American Educational Research Association*. Montreal, QC, April 2005.

Chen, H-M. & Cooper, M. D. (2001). Using clustering techniques to detect usage patterns in. a web-based information system. *Journal of the American Society for Information Science and Technology, 52*(11), 888-904.

Cohn, J. F. & Kanade, T. (2007). Automated facial image analysis for measurement of emotion expression. In J. A. Coan & J. B. Allen (Eds.), *The handbook of emotion elicitation and assessment. Oxford University Press Series in Affective Science.* pp. 222-238. New York: Oxford.

Crawford, J. R., & Henry, J. D. (2004). The positive and negative affect schedule (PANAS): construct validity, measurement properties and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 43*, 245-265.

Dervin, B. & Reinhard, C. D. (2007). How emotional dimensions of situated information seeking relate to user evaluations of help from sources: an exemplar study informed by sense-making methodology. In D. Nahl and D. Bilal (Eds.) *Information and Emotion: The emergent paradigm in information behavior research and theory,* pp. 51-84. Medford, NJ: Information Today.

Eich, E., Brodkin, I. A., & Reeves, J. L., (1999). Questions concerning pain. In D. Kahneman, E. Diener, and N. Schwarz (Eds.), *Well-being: The foundations of hedonic psychology.* New York: Russell Sage Foundation, pp. 155-168.

Ekman, P. (1984). Expression and the nature of emotion. In K.R. Scherer and P. Ekman, (Eds.), *Approaches to Emotion*, Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 319-345.

Ekman, P. (1992). An argument for basic emotions. Cognition and emotion, 6, 169-200.

Ekman, P. (2003). *Emotions revealed: recognizing faces and feelings to improve communication and emotional life.* New York, NY: Times Books.

Ekman, P. & Friesen, W. V. (2003). *Unmasking the face.* Cambridge, MA: Malor books.

Essa, I., A., (1995). *Analysis, interpretation and synthesis of facial expressions.* Unpublished Doctoral Dissertation, Massachusetts Institute of Technology, Cambridge, MA, USA.

Essa, I., A. & Pentland, A., P., (1997). Coding, analysis, interpretation, and recognition of facial expressions. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 19*(7), 757–763.

Fasel, B. & Luettin, J. (2003). Automatic facial expression analysis: A survey. *Pattern Recognition, 36*(1), 259–275.

Fredriekson, B. L., & Kahneman, D. (1993). Duration neglect in retrospective evaluations of affective episodes. *Journal of Personality and Social Psychology, 65,* 44-55.

Frijda, N. (1999). Emotions and hedonic experience. In D. Kahneman, E. Diener, and N. Schwarz (Eds.), *Well-being: The foundations of hedonic psychology.* New York: Russell Sage Foundation, pp. 190 - 210.

Frijda, N. H. (1986). *The emotions.* Cambridge, England: Cambridge University Press.

Frijda, N. H. (1994). Emotions are functional, most of the time. In P. Ekman & R. J. Davidson (Eds.), *The nature of emotion: Fundamental questions*, pp. 112-122. Oxford, UK: Oxford U. Press.

Gwizdka, J**.** (2008). Cognitive Load on Web Search Tasks. *Proceedings of Workshop on Cognition and the Web, Granada.* 83-86.

Gwizdka, J., & Lopatovska, I. (in press). The role of subjective factors in the information search process, *Journal of the American Society for Information Science and Technology*.

Hans-Rüdiger P. & Gisela B. (2008). The multiplicity of emotions: A framework of emotional functions in decision making. *Judgment and Decision, 3*, 5-17.

Henson, R. K. (2000). Demystifying parametric analyses: Illustrating canonical correlation as the multivariate general linear model. *Multiple Linear Regression Viewpoints, 26*(1), 11-19.

Henson, R. K. (2006). Effect size measures and meta-analytic thinking in counseling psychology research. *The Counseling Psychologist, 34*, 601-629.

Hong, H., Neven, H., von der Malsburg, C., 1998. Online facial expression recognition based on personalized galleries. *Proceedings of the 3rd. International Conference on Face & Gesture Recognition. IEEE Computer Society*, *Washington, DC, USA,* 354.

Huang, C., Shen, Y., Chiang, I., & Lin, C. (2007). Characterizing Web users' online information behavior. *Journal of the American Society for Information Science and Technology, 58*(13), 1988-1997.

Jaimes, A. & Sebe, N. (2007). Multimodal human-computer interaction: A survey. Computer. *Vision and Image Understanding, 108*(1-2), 116–134.

Jansen, B. J. (2006). Search log analysis: What is it; what's been done; how to do it. *Library and Information Science Research, 28(3), 407-432.*

Jansen, B. J. & Spink, A. (2003). An analysis of Web information seeking and use: Documents retrieved versus documents viewed. *Proceedings of the 4th International Conference on Internet Computing 2003, Las Vegas, NV*, 65-69.

Jansen, B. J., Spink, A., & Saracevic, T. (2000). Real life, real users and real needs: A study and analysis of users' queries on the Web. *Information Processing and Management, 36*(2), 207-227.

James, L. & Nahl, D. (1996) Achieving Focus, Engagement, and Acceptance: Three Phases of Adapting to Internet Use. *Electronic Journal on Virtual Culture, 4*(1). Retrieved May 10, 2009, from http://www2.hawaii.edu/~nahl/articles/ejvc.html.

Joachims, T., Granka, L., Gay, G., Hembrooke, H., & Pan, B. (2005). Accurately Interpreting Click-through Data as Implicit Feedback. *Proceedings of the Conference on Research and Development in Information Retrieval (SIGIR), 2005, Salvador, Brazil, 154-161.*

Johnson-Laird, P. N. & Oatley, K. (1989). The language of emotions: an analysis of a semantic field. *Cognition and Emotion, 3*, 81-124.

Julien, H. (2007). Experiencing information literacy affectively. In D. Nahl and D. Bilal (Eds.) *Information and Emotion: The emergent paradigm in information behavior research and theory,* pp. 243-254. Medford, NJ: Information Today.

Julien, H., McKechnie, L. E. F., & Hart, S. (2005). A Content Analysis of Affective Issues in Library and Information Science Systems Work." *Library & Information Science Research, 27*(4), 453-466.

Ingwersen, P. (1992). *Information Retrieval Interaction*, London: Taylor Graham.

Isen, A. M. (1993). Positive Affect and Decision Making. *Handbook of Emotions*. Lewis, M. & Haviland, J. (Eds.). The Guilford Press: New York, pp. 261-277.

Kahneman, D. (2000). Experienced utility and objective happiness: A moment-based approach. In D. Kahneman & A. Tversky (Eds.) *Choices, Values, and Frames*. New York: Cambridge University Press, pp. 673-692.

Kahneman, D., Fredrickson, B. L., Schreiber, C. A. & Redelmeier, D. A. (1993), When more pain is preferred to less: Adding a better end. *Psychological Science, 4*, 401-405.

Kahneman, D., Krueger, A. B., Schkade, D., Schwarz, N., Stone, A. A. (2004). A Survey Method for Characterizing Daily Life Experience: The Day Reconstruction Method. *Science, 306*(5702), 1776-1780.

Kalbach, J. (2006). "I'm feeling lucky": the role of emotions in seeking information on the web. *Journal of the American Society for Information Science, 57*(6), 813–818.

Kelly, D. & Cool, C. (2002). The effects of topic familiarity on information search behavior. *Proceedings of the Second ACM/IEEE Joint Conference on Digital Libraries (JCDL '02), Portland, OR*, 74-75.

Kim, K.-S. (2008). Effects of users' emotion control and search task on navigation behavior and search performance. *Information Processing & Management, 44*(1), 375-385.

Kimura, S. & Yachida, M., (1997). Facial expression recognition and its degree estimation. *Proceedings of the 1997 IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, 295–300.

Klein, J., Moon, Y., & Picard, R. W. (2002). This computer responds to user frustration: theory, design, and results. *Interacting with Computers, 14*(2), 119-40.

Kleinginna, P., Jr., & Kleinginna A. (1981). A categorized list of motivation definitions, with suggestions for a consensual definition. *Motivation and Emotion, 5*, 263-291.

Kleinsmith, A., De Silva, R., & Bianchi-Berthouze, N. (2006). Cross-Cultural Differences in Recognizing Affect from Body Posture. *Interacting with Computers, 18* (6), 1371-1389.

Kowalski, G. & Maybury, M. T. (2000). I*nformation Storage and Retrieval Systems: Theory and Implementation, 2nd ed.* Boston, MA: Kluwer Academic Publishers.

Kracker, J. (2002). Research anxiety and students' perceptions of research: an experiment. Part I. Effect of teaching Kuhlthau's ISP model. *Journal of the American Society for Information Science, 53*(4), 282–294.

Kracker, J. & Wang, P. (2002). Research anxiety and students' perceptions of research: an experiment. Part II. Content analysis of their writings on two experiences. *Journal of the American Society for Information Science, 53*(4), 295–307.

Kuhlthau, C. C. (1991). Inside the search process: Information seeking from the user's perspective. *Journal of the American Society for Information Science, 42*(5), 361–371.

Kuhlthau, C. C. (1993). A Principle of Uncertainty for Information Seeking. *Journal of Documentation*, *49*(4), 339-355.

Lanitis, A., Taylor, C., J., & Cootes, T., F., (1997). Automatic interpretation and coding of face images using flexible models. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 19*(7), 743–756.

Larsen, R. J., & Fredrickson, B. L. (1999). Measurement issues in emotion research. In D. Kahneman, E. Diener, and N. Schwarz (Eds.), *Well-being: The foundations of hedonic psychology.* New York: Russell Sage Foundation, pp. 40-60.

Lazar, J., Jones, A., Hackley, M. & Shneiderman, B. (2006). Severity and impact of computer user frustration: a comparison of student and workplace users, *Interacting with Computers*, 18(2), 187-207.

Lazarus, R. S. (1984). Thoughts on the relations between emotion and cognition. In K.R. Scherer and P. Ekman, (Eds.), *Approaches to Emotion*, Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 247-259.

Light, A. (2004). Designing to persuade: the use of emotion in networked media. *Interacting with Computers, 16*(4): 729-738.

Lopatovska, I. & Cool, C. (2008). Online Search: Uncovering Affective Characteristics of Information Retrieval Experience. Presented at the *2008 ALISE Annual Conference*, Philadelphia, PA, Jan. 8, 2008.

Lopatovska, I. & Mokros, H. (2007). Willingness to pay and experienced utility as measures of affective value in the information retrieval objects: users' accounts. *Information Processing and Management, 44*(1), 92-104.

Mackinnon, A., Jorm, A. F., Christensen, H., Korten, A. E., Jacomb, P.A., & Rodgers, B. (1999). A short form of the positive and negative affect schedule: evaluation of factorial validity and invariance across demographic variables in a community sample. *Personality and Individual Differences, 27*, 405-416.

Mano, H. (1994). Risk-taking, framing effects, and affect. *Organizational Behavior and Human Decision Processes*, *57*(1), 38-58.

Meghabghab, D. B. (1995). CD-ROM vs. online vs. Internet: search strategies and evaluation from the user's perspective. In E. Williams (Ed.), *Proceedings of the 16th national online meeting,* (pp. 295-307). Medford, NJ: Information Today.

Mellon, C. A. (1988). Attitudes: the forgotten dimension in library instruction. *Library Journal 113*(14), 137-139.

Mentis, H. M. (2007). Memory of frustrating experiences. In D. Nahl and D. Bilal (Eds.) *Information and Emotion: The emergent paradigm in information behavior research and theory,* pp. 197-210. Medford, NJ: Information Today.

Mooney, C., Scully, M., Jones, G., J., & Smeaton, A., F., (2006). Investigating biometric response for information retrieval applications. *Lecture Notes in Computer Science, 3936*, 570–574.

Morris, W. N. (1999). Mood system. In D. Kahneman, E. Diener, and N. Schwarz (Eds.), *Well-being: The foundations of hedonic psychology.* New York: Russell Sage Foundation, pp. 169-189.

Muller, M. (2004) Multiple paradigms in affective computing. *Interacting with Computers, 16*(4), 759-768.

Nahl, D. (1998). Learning the Internet and the structure of information behavior. *Journal of the American Society for Information Science, 49*(11), 1017-1023.

Nahl, D. (2004). Measuring the affective information environment of web searchers. *Proceedings of the 67th Annual Meeting of the American Society for Information Science & Technology, (41)*, 191-197.

Nahl, D. (2005). Affective and Cognitive Information Behavior: Interaction Effects in Internet Use. In A. Grove, (Ed.), *Proceedings 68th Annual Meeting of the American Society for Information Science and Technology* (42). Medford, NJ: Information Today.

Nahl, D. (2007). The centrality of the affective in information behavior. In D. Nahl and D. Bilal (Eds.) *Information and Emotion: The emergent paradigm in information behavior research and theory,* pp. 3-38. Medford, NJ: Information Today.

Nahl, D., & Bilal, D. (eds.) (2007) Information and Emotion. *Medford, NJ: Information Today, Inc.*

Nahl, D. & Meer, M. P. (1997) User-Centered Assessment of Two Web Browsers: Errors, Perceived Self-Efficacy, and Success. *Proceedings of the Annual Meeting of the American Society for Information Science, (34),* 89-97.

Nahl, D., & Tenopir, C. (1996). Affective and cognitive searching behavior of novice end-users of a full-text database. *Journal of the American Society for Information Science, 47*(4), 276–286.

Norman, D., A. (2004). *Emotional design: Why We Love (Or Hate) Everyday Things.* New York: Basic Books.

Onwuegbuzie, A. J. & Jiao, Q. G. (2004). Information search performance and research achievement: an empirical test of the Anxiety-Expectation Mediation model of library anxiety. *Journal of the American Society for Information Science, 55*(1), 41–54.

Ortony, A., Clore, G., & Collins, A. (1988). *The cognitive structure of emotions.* Cambridge: Cambridge University Press.

Parker, N. & Berryman, J. (2007). The role of affect in judging 'what is enough?'. In D. Nahl and D. Bilal (Eds.) *Information and Emotion: The emergent paradigm in information behavior research and theory,* pp. 243-254. Medford, NJ: Information Today.

Partala, T. & Surakka, V. (2003). Pupil size variation as an indication of affective processing. *International Journal of Human-Computer Studies, 59*(1-2), 185-198.

Partala, T., Surakka, V. & Vanhala, T. (2006). Real-time estimation of emotional experiences from facial expressions. *Interacting with Computers, 1*(2), 208-226.

Peter, C. & Herbon, A. (2006). Emotion representation and physiology assignments in digital systems. *Interacting with Computers, 18*(2), 139-170.

Peters, T. (1993). The history and development of transaction log analysis. *Library Hi Tech, 42*(11), 41-66.

Picard, R. W. (1997). *Affective Computing.* Cambridge, MA: The MIT Press.

Picard, R. W. (2003). Affective computing: challenges. *International Journal of Human-Computer Studies, 59*(1-2), 55-64.

Picard, R. W., Vyzas, E., & Healey, J. (2001). Toward machine emotional intelligence: analysis of affective physiological state. *IEEE transactions on pattern analysis and machine intelligence, 23*(10), 1175-1191.

Plutchik, R. (1980). A general psychoevolutionary theory of emotion. In R. Plutchik & H. Kellerman (Eds.), *Emotion: Theory, research, and experience: Vol. 1. Theories of emotion*. New York: Academic. pp. 3-33

Redelmeier, D. & Kahneman, D. (1996). Patients' memories of painful medical treatments: real-time and retrospective evaluations of two minimally invasive procedures. *Pain, 66*, 3-8.

Redelmeier, D., A., Katz, J. & Kahneman, D. (2003). Memories of colonoscopy: a randomized trial. *Pain, 104*, 187–194.

Rieh, S. Y. (2002). Judgment of Information Quality and Cognitive Authority, in the Web. *Journal of the American Society for Information Science and Technology*, 53(2), 145-161.

Rieh, S. Y. & Xie, H. (2006). Analysis of Multiple Query Reformulations on the Web: The Interactive Information Retrieval Context. *Information Processing and Management, 42*, 751-768.

Schachter, S. & Singer, J. (1962). Cognitive, social and physiological determinants of emotional state. *Psychological Review, 63,* 379-399.

Scheirer, J., Fernandez, R., Klein, J., & Picard, R. W. (2002). Frustrating the user on purpose: a step toward building an affective computer. *Interacting with Computers, 14*(2), 93-118.

Schreiber, C. A., & Kahneman, D. (2000). Determinants of the remembered utility of aversive sounds. *Journal of Experimental Psychology: General*, 129, 27-42.

Scherer, K. R. (Ed.) (1988). *Facets of emotion: Recent research.*Hillsdale, NJ: Erlbaum.

Sebe, N., Lew, M. S., Sun, Y., Cohen, I., Gevers, T., & Huang, T. S. (2007). Authentic facial expression analysis. *Image and Vision Computing, 25*(12), 1856-1863.

Sherry, A., & Henson, R. K. (2005). Conducting and interpreting canonical correlation analysis in personality research: A user-friendly primer. *Journal of Personality Assessment, 84*, 37-48.

Sonnemans, J. & Nico Frijda, N. (1994). The Structure Of Subjective Emotional Intensity. *Cognition & Emotion* 8, 329-350.

Stenmark, D. (2008). Identifying clusters of user behaviour in intranet search engine log files. *Journal of the American Society for Information Science and Technology*, *59*(14), 2232-2243.

Stone, A. A., Shiffman, S. S., & DeVries, M. W. (1999). Ecological momentary assessment. In D. Kahneman, E. Diener, and N. Schwarz (Eds.), *Well-being: The foundations of hedonic psychology*. New York: Russell Sage Foundation, pp. 26-39.

Tenopir, C., Wang, P., Zhang, Y., Simmons, B. & Pollard, R. (2008). Academic users' interactions with ScienceDirect in search tasks: affective and cognitive behaviors. *Journal of the American Society for Information Science, 44*(1), 105-21.

Thompson, E. R. (2007). Development and validation of an internationally reliable short-form of the positive and negative affect schedule (PANAS), *Journal of Cross-Cultural Psychology, 38*(2), 227-242.

Tomkins, S. S. (1984). Affect theory. In K.R. Scherer and P. Ekman, (Eds.), *Approaches to Emotion*, Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 163-197.

Tractinsky, N. (2004). Tools over solutions? Comments on Interacting with Computers special issue on affective computing. *Interacting with Computers, 16*(4), 751-757.

Tzeng, J.-Y. (2004). Toward a more civilized design: studying the effects of computers that apologize. *International Journal of Human-Computer Studies, 61*(3), 319-345.

Valenti, R., Sebe, N., & Gevers, T. (2007). Facial expression recognition: a fully integrated approach. 14th *International Conference on Image Analysis and Processing Workshops. ICIAPW 2007*, 125-130.

van Goozen, Stephanie H. M., Van de Poll, Nanne E. & Sergeant, Joseph A. (1994). *Emotions: Essays on Emotion Theory*. Hillsdale, NJ: Erlbaum. – insert in text

VandenBos, G. (2006). *APA Dictionary of Psychology*. Washington, DC: American Psychological Association.

Wang, P., & Soergel, D. (1998). A cognitive model of document use during a research project. Study I. Document selection. *Journal of the American Society for Information Science, 49*(2), 115–133.

Wang, P., Hawk, W. B., & Tenopir, C. (2000). Users' interaction with World Wide Web resources: an exploratory study using a holistic approach. *Information Processing and Management, 36*, 229-251.

Ward, R. D. & Marsden, P. H. (2004). Affective computing: problems, reactions and intentions. *Interacting with Computers, 16*(4), 707-713.

Watson, D., Clark, L. A., & Tellegen, A. 1988. Development and validation of brief measures of positive and negative affect: The PANAS scale. *Journal of Personality and Social Psychology, 54*(6), 1063-1070.

White, R.W. (2004). *Implicit feedback for interactive information retrieval*. Unpublished Doctoral Dissertation, University of Glasgow, Glasgow, United Kingdom.

White, R.W., Ruthven, I., Jose, J.M. (2005). A study of factors affecting the utility of implicit relevance feedback. *Proceedings of the 28th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval 2005, Salvador, Brazil,* 35–41.

Wilhelm, F. H., Pfaltz, M. C. & Grossman, P. (2006). Continuous electronic data capture of physiology, behavior and experience in real life: towards ecological momentary assessment of emotion. *Interacting with Computers, 18*(2), 171-186.

Wilson, T. D., Ford, N., Foster, D., Ellis, D., & Spink. (2002). Information seeking and mediated searching. Part 2: Uncertainty. J*ournal of the American Society for Information Science and Technology, 53*(9), 704-715.

Zajonc, R. B. (1984). The interaction of affect and cognition. In K. R. Scherer and P. Ekman, (Eds.), *Approaches to Emotion*, Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 239-246.

Appendix A – Positive Affect Negative Affect Scale

PANAS

Directions

This scale consists of a number of words that describe different feelings and emotions.

Read each item and then circle the appropriate answer next to that word. Indicate to what

extent you have felt this way during the past week.

Use the following scale to record your answers.

(1) = Very slightly   (2) = A little   (3) = Moderately   (4) = Quite a bit   (5) = Extremely
     or not at all

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
1. Interested	1	2	3	4	5
2. Distressed	1	2	3	4	5
3. Excited	1	2	3	4	5
4. Upset	1	2	3	4	5
5. Strong	1	2	3	4	5
6. Guilty	1	2	3	4	5
7. Scared	1	2	3	4	5
8. Hostile	1	2	3	4	5
9. Enthusiastic	1	2	3	4	5
10. Proud	1	2	3	4	5
11. Irritable	1	2	3	4	5
12. Alert	1	2	3	4	5
13. Ashamed	1	2	3	4	5
14. Inspired	1	2	3	4	5
15. Nervous	1	2	3	4	5
16. Determined	1	2	3	4	5

17. Attentive	1	2	3	4	5
18. Jittery	1	2	3	4	5
19. Active	1	2	3	4	5
20. Afraid	1	2	3	4	5

Appendix B – Online Pre- and Post-Search Questionnaire and Search Tasks

Page 1

Please, answer a few questions before starting the first search

1. **Age***

2. **Gender***

    ☐ male

    ☐ female

3. **Major** (main area of study)*

4. What is your **ethnicity** (such as Hispanic, Latino, Black, African American, Asian, White American, Irish American, Native American, etc)?*

5. What is your **nationality** (such as American, Canadian, Chinese, Korean, etc)?*

6. How often do you **search the internet** *

    ☐ Several times a day

    ☐ Once a day

    ☐ Several times a week

    ☐ Once a week

    ☐ Several times a month

☐ Once or twice a month

☐ Less than once a month

7. What **internet browser(s)** (such as Firefox, Internet Explorer, etc.) do you usually use?*

[   ]

8. What **operating system** do you usually use?*

○ Mac

○ PC

This scale consists of a number of words that describe different **feelings and emotions**. Read each item and then circle the appropriate answer next to that word. Indicate to what extent you have **felt this way during the past week**.

9. **Interested***

○ Very slightly or not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

10. **Distressed***

○ Very slightly or not at all ○ A little ○ Moderately ○ Quite a bit
○ Extremely

11. **Excited***

○ Very slightly or not at all ○ A little ○ Moderately ○ Quite a bit
○ Extremely

12. **Upset***

○ Very slightly or not at all ○ A little ○ Moderately ○ Quite a bit
○ Extremely

13. **Strong***

○ Very slightly or not at all ○ A little ○ Moderately ○ Quite a bit
○ Extremely

14. **Guilty***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

15. **Scared***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

16. **Hostile***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

17. **Enthusiastic***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

18. **Proud***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

19. **Irritable***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

20. **Alert***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

21. **Ashamed***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

22. **Inspired***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

◻ Extremely

23. **Nervous***

◻ Very slightly or not at all ◻ A little ◻ Moderately ◻ Quite a bit
◻ Extremely

24. **Determined***

◻ Very slightly or not at all ◻ A little ◻ Moderately ◻ Quite a bit
◻ Extremely

25. **Attentive***

◻ Very slightly or not at all ◻ A little ◻ Moderately ◻ Quite a bit
◻ Extremely

26. **Jittery***

◻ Very slightly or not at all ◻ A little ◻ Moderately ◻ Quite a bit
◻ Extremely

27. **Active***

◻ Very slightly or not at all ◻ A little ◻ Moderately ◻ Quite a bit
◻ Extremely

28. **Afraid***

◻ Very slightly or not at all ◻ A little ◻ Moderately ◻ Quite a bit
◻ Extremely

Please, go to the next page to read your **first search scenario**

Next

Page 2

Your friend has just finished reading a copy of a national newspaper in which there is an article about Internet music piracy. The article stresses how this is a global problem and affects compact disc sales worldwide. Unaware of the major effects you decide to find out **how and why music piracy influences the global music market**.

Please, open an internet browser in a separate window, go to www.google.com and start your search. Once you gather enough information to answer your friend's question, come back to this window and write your answer in a form of an email message to your friend. Your answer may include links to the websites that you found particularly helpful.

27. Type your **answer** here:*

Please, go to the next page to answer a few questions about your search experience

Page 3

This scale consists of a number of words that describe different **feelings and emotions**. Read each item and then circle the appropriate answer next to that word. Indicate to what extent you have **felt this way during the search**.

28. **Interested***

    Very slightly or not at all   A little   Moderately   Quite a bit

    Extremely

29. **Distressed***

    Very slightly or not at all   A little   Moderately   Quite a bit

    Extremely

30. **Excited***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

31. **Upset***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

32. **Strong***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

33. **Guilty***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

34. **Scared***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

35. **Hostile***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

36. **Enthusiastic***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

37. **Proud***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

38. **Irritable***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

39. **Alert***

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit
☐ Extremely

40. **Ashamed***

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit
☐ Extremely

41. **Inspired***

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit
☐ Extremely

42. **Nervous***

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit
☐ Extremely

43. **Determined***

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit
☐ Extremely

44. **Attentive***

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit
☐ Extremely

45. **Jittery***

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit
☐ Extremely

46. **Active***

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit
☐ Extremely

47. **Afraid***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

Please, answer a few questions **about your search experience**.

48. How would you **evaluate your search experience in general:***

☐ pleasant ☐ unpleasant

49. Was the search task **interesting**?*

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

50. Were you **familiar with similar searches**?*

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

51. Did you have an **exact idea about the type of information needed** to answer the search question?*

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

52. Are you **satisfied** with the answers you found?*

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

53. How **intense were the feelings** you experienced during the search?*

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

54. To what extent did you try to **control your feelings** by reducing their intensity and shortening their duration?*

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

55. To what extent did you try to **control the expressions** of your feelings?*

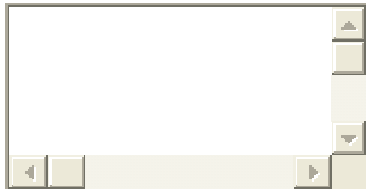☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit

☐ Extremely

Please, go to the next page to read your **second search scenario**

Page 4

A friend has recently been applying to various universities and courses but has been complaining that he finds it difficult to get accepted due to the rising numbers of students. You were unsure if his assessment was correct so you have decided to find out **how the size of the student enrollment changed over the last 5 years and how it is expected to change in the coming 5 years**.

Please, open an internet browser in a separate window, go to www.google.com and start your search. Once you gather enough information to answer your friend's question, come back to this window and write your answer in a form of an email message to your friend. Your answer may include links to the websites that you found particularly helpful.

56. Type your **answer** here:*

[text box]

Please, go to the next page to answer a few questions about your search experience

Page 5

This scale consists of a number of words that describe different **feelings and emotions**. Read each item and then circle the appropriate answer next to that word.

Indicate to what extent you have **felt this way during the search**.

57. **Interested***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

58. **Distressed***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

59. **Excited***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

60. **Upset***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

61. **Strong***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

62. **Guilty***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

63. **Scared***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

64. **Hostile***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

65. **Enthusiastic***

   ☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
   ☐ Extremely

66. **Proud***

   ☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
   ☐ Extremely

67. **Irritable***

   ☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
   ☐ Extremely

68. **Alert***

   ☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
   ☐ Extremely

69. **Ashamed***

   ☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
   ☐ Extremely

70. **Inspired***

   ☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
   ☐ Extremely

71. **Nervous***

   ☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
   ☐ Extremely

72. **Determined***

   ☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
   ☐ Extremely

73. **Attentive***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

74. **Jittery***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

75. **Active***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

76. **Afraid***

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

Please, answer a few questions **about your search experience**.

77. How would you **evaluate your search experience in general:***

☐ pleasant ☐ unpleasant

78. Was the search task **interesting**?*

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

79. Were you **familiar with similar searches**?*

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

80. Did you have an **exact idea about the type of information needed** to answer the search question?*

☐ Very slightly or not at all ☐ A little ☐ Moderately ☐ Quite a bit
☐ Extremely

81. Are you **satisfied** with the answers you found?*

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit

☐ Extremely

82. How **intense were the feelings** you experienced during the search?*

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit

☐ Extremely

83. To what extent did you try to **control your feelings** by reducing their intensity and shortening their duration?*

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit

☐ Extremely

84. To what extent did you try to **control the expressions** of your feelings?*

☐ Very slightly or not at all   ☐ A little   ☐ Moderately   ☐ Quite a bit

☐ Extremely

You have completed your searches and questionnaires, you will now be debriefed by the experimenter

Appendix C – Post-search interview

Experimenter: I will now show you a video recording of your search session. As you view the recording, please make comments about your search actions, thoughts and feelings. I will pause the recording if you want to discuss a particular search episode in greater detail.

The following questions prompted participants to share information about their emotional states and search experiences:

- And what did you do next?

- What did you feel when you did this?

- Why did you do/felt this?

- What is your general mood today?

- How distracted were you by the lab setting/equipment?

- What was your primary motivation to participate in the study?

- Did you find any of the tasks/questionnaires confusing or difficult?

- Did you keep track of the time during the search?

Appendix D – Informed Consent Form

You are invited to participate in a research study that is being conducted by Irene Lopatovska, who is a Ph.D. candidate in the Program in Communication, Library and Information Science, and Media Studies at Rutgers University. The purpose of this study is to learn more about information search behavior. The results will help to better understand searchers and, ultimately, to design information systems that are better attuned to searchers needs.

Procedure: Approximately 30 subjects will participate in this study. The study will be conducted at SCILS. You will perform search tasks in an individually held study session. An experimenter will give you a description of information that you need to find. The entire session will last from one to three hours.

At the beginning of the session, you will fill out a background questionnaire. You will then be given a set of instructions and introduced to the information retrieval system you will be using. You will be given two search scenarios and asked to solve posed tasks. You will perform several searches until you find the answers. You will be alone in the room during the searches. The total time for both searches will be limited to two hours. After completing each search, you will be asked to fill out a questionnaire about your search experience. After each search, an automatic message will be generated to the experimenter about your progress. At this point, the experimenter will return to the room to interview you about your search experience.

Your interaction with a computer during the search tasks will be recorded. Logging software will capture mouse clicks, keystrokes, and computer screen shots.

The search sessions will also be audio and/or video recorded. Please, acknowledge your understanding of the recording procedures by signing below

 [participant's signature]_   .

You will be asked for demographic data such as age, gender, cultural identity and native

language, and for information related to your internet search experience and current mood before

you begin searching. Your responses to questions will be recorded. Upon your request, the

overall research results will be provided to you after the study is completed.

Confidentiality: This research is anonymous. No information about you will be recorded that

could identify you. This means that we will not record your name, address, phone number, date of

birth, etc. If you agree to take part in the study, you will be assigned a random code number that

will be used on each task and the questionnaire. Your name will appear only on a list of subjects,

and will not be linked to the code number that is assigned to you. There will be no way to link your

responses back to you. Therefore, data collection is anonymous. All data, including results, notes,

computer interaction logs and tapes will be used only for research purposes. Any report on this

study will refer to results only by using the assigned random code.

Risks or Discomforts: There are no foreseeable risks associated with participation in this study.

Benefits: Your participation in this study will advance the cause of science and give you a

genuine research experience. While your information search skills are not likely to improve from

participation in this research, the study is expected to produce valuable data about information

search process.

Participation is voluntary. Your refusal to participate will involve no penalty. You may

discontinue participation at any time without penalty. At the completion of the study session,

you will receive certification of fulfillment of the 04:192:300 course requirement. At the end of the

study you will have an option to obtain a copy of your search profile and learn about your search behavior.

For more information: If you have any concerns or require any further information, please contact Irene Lopatovska (irenelo@scils.rutgers.edu or xxx-xxx-xxxx). If you have any questions about your rights as a research subject, you may contact the Sponsored Programs Administrator at Rutgers University at 732-932-0150, ext. 2104; humansubjects@orsp.rutgers.edu; Rutgers University Institutional Review Board for the Protection of Human Subjects, Office of Research and Sponsored Programs, 3 Rutgers Plaza, New Brunswick, NJ 08901-8559

You will be given a copy of this consent form for your records.

I, [print name] _____ agree to the conditions set forth above.

Participant signature   _____   Date _____

Investigator signature: _____   Date _____

This informed consent form was approved by the Rutgers University Institutional Review Board for the Protection of Human Subjects on 8/28/2008.

Appendix E – Examples of the original eMotion recognition

classification output and the file prepared for analysis

First two numbers are the frame number, and elapsed time in Milliseconds.

The next 7 numbers are the classification results, corresponding to Neutral, Happy,

Surprised, Angry, Disgust, Fear and Sad respectively.

```
0     0 0.999 0.000 0.000 0.000 0.000 0.000 0.000
1 187 0.999 0.000 0.000 0.000 0.000 0.000 0.000
2 375 0.999 0.000 0.000 0.001 0.000 0.000 0.001
3 578 0.998 0.000 0.000 0.001 0.000 0.000 0.001
4 765 0.998 0.000 0.000 0.001 0.000 0.000 0.001
5 968 0.990 0.000 0.000 0.004 0.000 0.000 0.006
6 1172 0.850 0.000 0.001 0.033 0.000 0.003 0.112
7 1312 0.715 0.000 0.002 0.033 0.000 0.004 0.244
8 1500 0.755 0.000 0.002 0.050 0.000 0.005 0.188
9 1687 0.711 0.000 0.002 0.044 0.000 0.005 0.238
10 1890 0.651 0.000 0.003 0.057 0.000 0.007 0.281
11 2078 0.648 0.000 0.003 0.048 0.000 0.006 0.295
12 2281 0.652 0.000 0.002 0.051 0.000 0.006 0.288
13 2422 0.712 0.000 0.002 0.037 0.000 0.005 0.244
14 2562 0.761 0.000 0.001 0.038 0.000 0.004 0.195
15 2703 0.718 0.000 0.002 0.046 0.000 0.005 0.229
16 2890 0.690 0.000 0.002 0.042 0.000 0.006 0.260
17 3093 0.787 0.000 0.001 0.030 0.000 0.005 0.176
18 3281 0.889 0.000 0.000 0.024 0.000 0.002 0.083
19 3422 0.862 0.000 0.001 0.021 0.000 0.003 0.113
20 3562 0.892 0.000 0.000 0.022 0.000 0.003 0.083
21 3750 0.865 0.000 0.001 0.023 0.000 0.003 0.108
22 3953 0.875 0.000 0.000 0.026 0.000 0.003 0.096
23 4140 0.666 0.000 0.009 0.006 0.000 0.009 0.309
24 4343 0.964 0.000 0.000 0.001 0.000 0.001 0.032
25 4484 0.015 0.000 0.044 0.009 0.000 0.009 0.923
26 4625 0.017 0.000 0.053 0.048 0.000 0.034 0.849
27 4812 0.022 0.000 0.014 0.189 0.001 0.050 0.725
28 5000 0.030 0.000 0.019 0.097 0.000 0.040 0.814
29 5203 0.058 0.082 0.000 0.562 0.029 0.007 0.261
30 5390 0.000 0.084 0.000 0.764 0.046 0.025 0.080
31 5578 0.000 0.571 0.000 0.395 0.008 0.017 0.010
32 5781 0.000 0.240 0.000 0.713 0.013 0.014 0.020
33 5968 0.000 0.986 0.000 0.011 0.000 0.002 0.001
34 6109 0.000 0.980 0.000 0.015 0.000 0.004 0.001
```

35 6328 0.000 0.973 0.000 0.014 0.000 0.013 0.000
36 6515 0.000 0.884 0.000 0.084 0.007 0.022 0.004
37 6875 0.000 0.903 0.000 0.041 0.003 0.051 0.003

Example of an Emotion dump:

		Neutral,	Happy,	Surprised,	Angry,	Disgust,	Fear	Sad
0	0	0.999	0	0	0	0	0	0
1	235	0.999	0	0	0	0	0	0
2	1000	0.991	0	0	0.007	0	0	0.002
3	1203	0.998	0	0	0.001	0	0	0
4	1406	0.998	0	0	0.001	0	0	0
5	1719	0.996	0	0	0.002	0	0	0.002
6	1922	0.972	0	0	0.011	0	0	0.017
7	2125	0.97	0	0	0.013	0	0	0.016
8	2328	0.012	0	0.007	0.028	0	0.081	0.872
9	2547	0.145	0.001	0.002	0.087	0.001	0.012	0.751
10	2766	0	0.002	0.007	0.048	0	0.15	0.793
11	2969	0	0.01	0.011	0.067	0	0.156	0.755
12	3172	0	0.099	0.013	0.023	0	0.723	0.142
13	3391	0	0.01	0.016	0.038	0	0.406	0.53
14	3610	0	0.028	0.001	0	0	0.971	0
15	3813	0	0.067	0.001	0.001	0	0.931	0
16	4031	0	0.001	0	0	0	0.999	0
17	4235	0	0.001	0.006	0	0	0.991	0.001
18	4438	0	0	0.001	0	0	0.998	0
19	4703	0	0.001	0	0.001	0	0.996	0.002
20	4906	0	0.001	0.001	0.008	0	0.982	0.009

Same lines processed for analysis

Neutral,	Happy,	Surprised,	Angry,	Disgust,	Fear	Sad
1	0	0	0	0	0	0
1	0	0	0	0	0	0
1	0	0	0	0	0	0
1	0	0	0	0	0	0
1	0	0	0	0	0	0
1	0	0	0	0	0	0
1	0	0	0	0	0	0
1	0	0	0	0	0	0
0	0	0	0	0	0	1
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	1	0

0	0	0	0	0	1	0
0	0	0	0	0	1	0
0	0	0	0	0	1	0
0	0	0	0	0	1	0
0	0	0	0	0	1	0

Original sums							Frames
14179	487	5448	2830	199	1954	6816	38202

Normalized sums						
0.371159	0.012748	0.14261	0.07408	0.005209	0.051149	0.17842

Appendix E – Example of Search Results Grading Instructions

Search Instructions/Task given to participants:

Your friend has just finished reading a copy of a national newspaper in which there is an article about Internet music piracy. The article stresses how this is a global problem and affects compact disc sales worldwide. Unaware of the major effects you decide to find out how and why music piracy influences the global music market.

Please, open an internet browser in a separate window, go to www.google.com and start your search. Once you gather enough information to answer your friend's question, come back to this window and write your answer in a form of an email message to your friend. Your answer may include links to the websites that you found particularly helpful.

Judge participant answer using the following criteria:

1. **Completeness** (Answered the question?):

   0=no/didn't answer the question; .5=partially (some information is provided, but not all aspects of the question were covered, For example, specific college data is provided, but not nationwide data; no data to support the argument is provided; only personal opinions are included, etc.; 1=yes/answered all aspects of question;

2. **Trustworthiness** (Enough details):

   0=poor (no details/links, just personal opinion);.5=average (some details/links provided); 1=good (enough details/links provided to support the argument)

3. **General quality of the answer:**

   0=poor (poor grammar/sources/information); .5=average (enough information but not well written or well written but not informative); 1=good (nicely written and addresses all aspects of the question

4. **Notes**: (if you need to explain your rating)

Curriculum Vitae
Irene Lopatovska

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EDUCATION

- Ph.D., Information, Communication and Library Studies, Rutgers, New Jersey
- M.S., 1999, Information Sciences, University of North Texas
- BS, 1996, Russian Language and Literature, Kiev State University

EXPERIENCE

Assistant Professor (Visiting Professor since 2006), School of Information and Library Science, Pratt Institute, New York, NY. **Sept. 2008 – present.**

Research assistant, School of Information, Communication and Library Studies, Rutgers, New Brunswick, NJ. **March 2007 – June 2007.**

Consultant, Shared Integrated Library Systems (ILS) Cost Study for the State of Wisconsin project, **Sept. 2005 – Jan. 2006.**

Teaching/Research Assistant, University of North Texas, Denton, TX, **Jan. 2004 – Aug. 2005.**

Project Coordinator, University of North Texas, Denton, TX, **2002 – Sept. 2003.**

Applications Engineer, Information Research Department, AMX, Inc., Richardson, TX, **2000 - 2002.**

Web Designer/Librarian, University of North Texas, Denton, TX, **1999.**

Information Specialist, U.S. I. S., U.S. Embassy, Kiev, Ukraine, **1994 - 1997**

PUBLICATIONS

Lopatovska, I. & Arapakis, I. (submitted for publication). Theories, Methods and Current Research on Emotions in Library and Information Science, Information Retrieval and Human-Computer Interaction.

Lopatovska, I. (2009). Does the mood matter? *Proceedings of the 2009 International Conference on Affective Computing & Intelligent Interaction ACII 2009, Amsterdam, The Netherlands,* 237-240.

Lopatovska, I. (in press). Searching for good mood: examining relationships between search task and mood. *Proceedings of the 72th Annual Meeting of the American Society for Information Science and Technology.*

Gwizdka, J. & Lopatovska, I. (in press). The role of subjective factors in the information search process. *Journal of the American Society for Information Science and Technology.*

Lopatovska, I. (2007). Decision making framework for thinking about information seeking behavior. *Proceedings of the 70th Annual Meeting of the American Society for Information Science and Technology, 44,* n/a.

Lopatovska, I. & Mokros, H. (2007). Willingness to pay and experienced utility as measures of affective value in the information retrieval objects: users' accounts. *Information Processing and Management, 44*(1), 92-104.

Lopatovska, I. (2006). Measuring affective reactions on information objects: quantitative vs. qualitative analysis. *Proceedings of the 69th Annual Meeting of the American Society for Information Science and Technology, 43*(1), 240.

Lopatovska, I. (2005). Measuring Experienced Utility of Information Retrieval Systems: Experimental Approach *Proceedings of the 68th Annual Meeting of the American Society for Information Science and Technology, 42*(1), n/a.

Moen, W. E., Murray, K. R., & Lopatovska, I. (2004). Optimizing resource discovery service interface: the Library of Texas challenge. In P. Brophy, S. Fisher, & J. Craven (Eds.), *Libraries Without Walls 5: The Distributed Delivery of Library and Information Services* (pp. 161-173). London: Facet Publishing.

Lopatovska, I. V., Oguz, F., & Moen, W. E. (2004). Design, development, and implementation of a Texas library directory database: A multipurpose database for the Library of Texas. *Proceedings of the 67th Annual Meeting of the American Society for Information Science and Technology 41*(1), 93-101.

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