Mouse Tracking for Web Marketing: Enhancing User Experience in Web Application Software by Measuring Self-Efficacy and Hesitation Levels.

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Abstract: Mouse tracking allows web developers to view the behaviour of actual users in their natural browsing environment. By tracking the mouse movements and clicks, designers can evaluate the usefulness and ease of use of their web applications in order to enhance user experience. In today’s highly competitive web marketplace, mouse tracking can reveal significant benefits for web marketing issues, since it can be used to analyze user behavior, so as we developers can design web environments to attract and win over the user (web consumer). However, simple mouse tracking is not enough since user behavior in web is multifold and influenced by human factors such as gender, age, expectations, experience etc. Hence, mouse tracking should be used in compliance to human factor analysis and user behavioral attributes: self-efficacy and risk perception, and we analyze their influence on the user experience and user performance (i.e. the achievement of the desired task) while interacting with web software applications. We present the mouse tracking patterns that have been realized so far to measure these two attributes, and we conduct our own experiment by designing a prototype mouse tracking tool to measure user hesitation. Finally we discuss the contribution of this approach in the enhancement of user experience and in the broader web marketing area.

Keywords: Mouse tracking, web interaction, user mouse activity, user mouse behavior, mouse movements 

1. Introduction 

Humans are by nature trained to assess the body language and facial expressions of other humans and read their motivational state (among other traits). For a computer application, this diagnosis is not so easy. Traditional diagnosis of personal, emotional or motivational states is commonly done using psychometric instruments like questionnaires and self reports. However, the reliability of a questionnaire increases by its length, which in turn
increases the time consumption for a user and causes the diagnosis to become an obstruction to the primary task of development [1].

The default communication channels in a normal computer application setup are limited to keyboard and mouse input and on-screen output. Some researchers try to overcome these limitations by incorporating additional communication channels in the form of special sensors to measure the physiological responses of a user [2; 3; 4]. However, it would be more beneficiary to diagnose the motivational state of a user using only the default computer input channels: keyboard and mouse input.

Mouse tracking applications promise the ability to estimate the relevance of search results in the presence or absence of clicks [5; 6] for improving search relevance estimation, to study web usability design (Arroyo et al, 2006) and to determine preferred reading regions that help in inferring which portions of long documents receive more user attention [7; 8].

In this paper, we attempt to go beyond measurement of user behavior to generating predictions about user experience of web page content from mouse movement patterns alone. We are going to examine to what extent levels of two significant behavioral attributes, self-efficacy and risk-perception, can be diagnosed using mouse input in order to improve a user's software experience.

Self-efficacy and Risk-perception have been shown to influence end-user behavior. Self-efficacy can determine the user’s choice of whether to engage in a task, the effort expended in performing it, and the persistence shown in accomplishing it [9]. The greater people perceived their self-efficacy to be, the more active and longer they persist in their effort [10].

It is expected that mouse input of end-users with a high level of self-efficacy is be different from their input when they have a low level of self-efficacy.

Risk-Perception is explained in by Blackwell’s Attention Investment Model theory [11] to strongly influence the end user’s behavior through his/her cost/benefit evaluation. Risk perception can be reflected in mouse movements through hesitation. In finance and other research fields hesitation comes from perceived risk. Hesitation reveals uncertainty and fear to make an action or a choice. This uncertainty and/or fear are derived by the level of risk the end-users perceive about their actions and choices in computer environments.

In this paper we examine to what extent can levels of self-efficacy and hesitation be diagnosed using mouse input in order to improve a user’s software experience. Based on our survey of the literature review, we conducted an experiment on 32 end-users to understand and revalidate mouse behavior. In our study we measured many behavioral attributes (e.g. perceived ease of use, perceived playfulness, tinkering etc) including risk-perception and self-efficacy. We conducted our study in the context of a web based End-User Development tool environment, which includes a number of features assisting the end-users build their own web application. Then, we conducted a questionnaire-based survey to collect the users’ perceived behavioral attitude during the web tool interaction, so that we could compared these explicitly provided data to the implicitly provided (via mouse tracking) ones.

This paper is organized as follows: In the second section we provide a basic literature background regarding the impact of the understudy behavioral attributes (self-efficacy and
risk-perception) to user experience. Moreover, we provide with a basic literature background regarding the mouse inputs related to these attributes that have been studied and used so far in previous research works and mouse tracking implementations. In the third section we present our experimental evaluation where we describe our methodology, the prototype tool's design approach and we present and discuss the experimental results. Finally, in section four we discuss our conclusions and discuss our future work.

2. Background

In this section we present a basic background literature regarding the impact of the understudy behavioral attributes (self-efficacy and risk-perception) to user experience. Moreover, we provide with a basic literature background regarding the mouse inputs related to these attributes that have been studied and used so far in previous research works and mouse tracking implementations.

2.1. The Impact of Computer Self-Efficacy and Risk Perception on User Experience

Several studies have demonstrated the effect of and computer self-efficacy and risk perception on computer related behavior and user computer related performance. Following we present a basic overview of self-efficacy and risk-perception concepts, underling their importance in the human computer interaction research area.

Self-efficacy is an important psychological construct that conveys an individual’s level of confidence to execute courses of action in a given situation. This topic has been studied in depth by Bandura (1977), [12] who found that self-efficacy is influenced by environmental situations, cognitive and personal factors as well as demographic characteristics. Computer self-efficacy is an extension of self-efficacy that is specifically related to computer usage. Pajares (2002), [13] argues that self-efficacy can affect task effort, persistence, expressed interest, and the level of difficulty of goals users will strive to attain.

Research has linked it closely with performance accomplishments, level of effort, and the persistence a person is willing to expend on a task [12]. Because software development is a challenging task, a person with low self-efficacy may be less likely to persist when a task becomes challenging or may calculate attention investment tradeoffs differently [14].

Thus, when end-user developers have high computer Self-Efficacy, they are also likely to successfully face the challenges involved in development tasks. Computer self-efficacy has been also shown to be positively related to performance during computer training and computer related tasks [15]. A user’s confidence about computer skills may affect the willingness to learn about computer skills.

According to Lowenstein’s information gap theory, a user needs to have a certain level of confidence in order to reach a useful level of curiosity. This curiosity will leverage the levels of their exploratory behavior and willingness to learn, enhancing at last their performance [16].

Risk-Perception is explained in by Blackwell’s Attention Investment Model theory [11] to strongly influence the end user's behavior through his/her cost/benefit evaluation.
According to Blackwell (2002), terminology, Risk is the Probability that no pay-off will result, or even that additional future costs will be incurred from the way the user has chosen to spend attention.

Blackwell’s Attention Investment model [17; 11] provides a cognitive model of these insights, describing individuals' allocations of attention as cognitive “investments.” Perception of risk plays an important role in a user’s decision making about whether to use particular application features [18].

The Attention Investment model is related to other descriptions of end-user strategy such as Carroll and Rosson’s Paradox of the Active User (1987) which describes the way that users are reluctant to suspend productive use of already-learned (but perhaps inefficient) methods, and tend not to engage in learning further skills, even though this might bring longer-term benefits.

Just as the Attention Investment Model predicts, higher perception of risk can lead to differences in actual behavior. Risk-Perception can strongly influence computer related behavior (e.g. Willingness to learn) since it determines the whole ‘confidence and security’ the end-user feels while interacting with the computer environment.

Low Risk Perception has been shown to be positively related to performance during computer related tasks. High Risk-Perception renders users less likely to make use of unfamiliar features [19] eliminating their 'high performance' possibilities and the successful task completion. High perceived risk results in avoidance behavior (not using features that might help them in their task), then the result could be lower task performance, or a higher cost (in time) to accomplish the desired computer task [18].

For instance, a user might notice an unfamiliar but potentially useful feature in the software environment, but he/she may not try the feature if he/she perceives a substantial risk, such as the significant loss of time trying to learn the feature without ultimately succeeding. [16].

Risk actually can be defined in a variety of ways. However we define risk (uncountable) as a characteristic of reality or risks as threatening agents, the essential feature here is uncertainty. Without uncertainty there is no risk. And uncertainty leads to hesitation. Hesitation to make an action or/and hesitation to make a choice among two or more options. In this work we will use the term of ‘hesitation’ to specifically describe the users’ perceived risk in computer application usage, and it is their hesitation levels that we can capture via mouse tracking to measure their levels of risk perception.

2.2. Self-Efficacy Reflected in Mouse Movements

In the Human Computer Interaction (HCI) research area, researchers have been trying to quantify the movement of humans who perform pointing tasks on computers and other devices. Mouse cursor movement is a vital part in this field and used in many studies. Since the HCI research field mainly focuses on the improvement of the interaction between humans and computers, most research that involves mouse movements is done to increase the pointing performance of humans. A good example is Gajos et al. (2012) [20], to obtain lab-quality mouse movement measurements from a normal computer setup. They did this to be able to differentiate between deliberate and accidental mouse movement for people with motor disabilities in order to compensate for their accidental
mouse movements during their computer interactions. Although this is a form of user modeling using mouse movements, it does not reveal anything about the motivational state of the user. The same can be said about the research of Pusara and Brodley (2004), [21], who used mouse movements characteristics (distance, angle, and speed) and mouse events (single and double clicks of either a left, right or a middle mouse button, and the mouse wheel movements) to re-authenticate a known user for security purposes. This differentiates between different users through their use of the mouse, but again does not provide any knowledge about the motivational state of that user or their level of expertise in a subject. Of the research that does describe something similar to the diagnosis of self-efficacy or any other part of the motivational state of a student using his or her mouse input, the first is the research of Khan et al. (2008), [1], who correlated mouse and keyboard usage to the outcome of personality tests. Their measurement of mouse usage was the number of clicks in a given window (during a given mood rating) and the average and standard deviation times between all the events (keyboard and mouse input and window switching) and they did not record any positional or movement data for the mouse. The second article is a rationale of Zimmerman et al. (2003), [22], who indicate they intent to research mood through mouse and keyboard input and will record the mouse coordinates, not just the mouse clicks.

In (Navalpakam and Churchill, 2012), [23] they demonstrate that mouse movement patterns can predict whether the experience of a user is perceived as pleasant or not.

Although these studies do not indicate characteristics of motivation or self-efficacy within mouse input, they do supply general characteristics of mouse input which can be tested for correlations with self-efficacy.

Kinzie, Delcourt, and Powers (1994) defined self-efficacy as an individual’s confidence in his or her ability, which may impact the performance of tasks: “Self-efficacy reflects an individual’s confidence in his/her ability to perform the behavior required to produce specific outcome and it’s thought to directly impact the choice to engage in a task, as well as the effort that will be expended and the persistence that will be exhibited.”

Except from time, many researchers have concluded that the ‘direct mouse movements’ (contradictory to the random ones) can determine self-efficacy levels. Defined as “straight pattern” [24] the users’ ‘confident movements’ are characterized by a pause before a direct movement towards a target, since ”once traced the desired feature (or link) users move the mouse straight to it” [24] On presence of these pattern researchers’ infer there is an earlier decision and the user feels certain about his/her movement. This use of the mouse (Rodden et al, 2008) defines direct movements that occur once the user has decided which action to take. And this undoubtedly reveals task-oriented self-efficacy. In the context of interaction with web applications, direct movement is characterized by ”a direct movement with no big pauses” [25].

Hence, drawing from the related literature review, pause time (big or small) and mouse trajectory (direct or not) can measure the end-user’s self-efficacy level when interacting with computer applications.
2.3. Risk Perception Reflected in Mouse Movements

Risk perception can be reflected in mouse movements through hesitation. In finance and other research fields hesitation comes from perceived risk. Hesitation reveals uncertainty and fear to make an action or a choice. This uncertainty and/or fear are derived by the level of risk the end-users perceive about their actions and choices in computer environments. Across several studies regarding patterns of mouse movements, hesitation pattern is among the most common and recognizable patterns of mouse behavior.

The project Cheese (Mueller and Lockerd, 2001), [26], mentions a Hesitation pattern that is repeated in most studies of patterns. "Hesitation on links or text could potentially provide information about what else interests the user on the page" [26] its application as a variable to detect second choices of users is evident.

Other studies focused on the analysis of movements of the cursor in web forms, refer to the pattern of hesitation as movements between "two or more answers while trying to decide which one to choose [25]. Have also been identified hesitation pattern during interaction with navigation menus [7]. In both cases reflect a doubt about the answer or option to choose. In the case of the forms the greater the degree of difficulty in the questions, the more hesitation patterns are observed [25]. In commercial applications of mouse tracking, as ClickTale (2010), [27], the pattern of hesitation is defined as "the average time from the beginning of a mouse hover to the moment of the mouse click". There is a clear distinction between those who believe that the hesitation may occur on a single target, as a pause before the click [27] and among those studies that consider the hesitation as a pattern of doubt among at least two possible targets [25].

3. Measuring Self-Efficacy and Risk-Perception via Mouse Input

In this section we aggregate most of the variables for mouse input found in the relative literature that can measure self-efficacy and risk-perception levels. Table 1 presents a list of the most common mouse inputs for self-efficacy and risk-perception, in the field literature.

<table>
<thead>
<tr>
<th>Variables for mouse input</th>
<th>Self-Efficacy</th>
<th>Risk-Perception</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>distance difference</td>
<td>X</td>
<td></td>
<td>Maarten Dijkstra, 2013; Rodden et al, 2008</td>
</tr>
<tr>
<td>number of pauses</td>
<td>X</td>
<td></td>
<td>Maarten Dijkstra, 2013</td>
</tr>
<tr>
<td>time difference</td>
<td>X</td>
<td></td>
<td>Maarten Dijkstra, 2013; ClickTale, 2010</td>
</tr>
<tr>
<td>pause time</td>
<td>X</td>
<td>X</td>
<td>Maarten Dijkstra, 2013</td>
</tr>
</tbody>
</table>
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### 3.1. Experimental Evaluation

To evaluate our approach we conducted an experiment on 32 end-users, 14 males and 18 females, all students age 20-25. The experiment was conducted in an introductory informatics course, in the Department of Accounting and Finance of a Greek University.

The participants were asked to interact with a web-based tool in order to develop their own application. All their actions were being captured by our mouse tracking tool and were stored in a database. In the end of the task the participants were asked to answer on a number of questions regarding their perceived risk-perception and self efficacy levels during the usage of the tool. The questionnaire was provided to the users as an online survey form and was embedded in the last page of the web application, so as the users’ system code (users’ session id) could be retrieved in the questionnaire form and we could associate each user’s recorded data to their responses.

### 3.2. Methodology

In order to implement and evaluate our behavioral mouse tracking approach, we designed a prototype web tool that captures and analyses most of the users’ actions. Then we conducted an experiment on 32 end-users. We asked them to use a web-based tool (it was a user-friendly End-User Development Tool) and then we asked them answer on a questionnaire regarding their perceived risk and self-efficacy during the system interaction. We chose to use a EUD tool environment for our experiment due to the fact that such a tool is more cognitively demanding for the user, compared to a simple web site. Hence the participants would better express via mouse inputs their behavioral states.

After the end of the EUD task, each student had to answer the online survey which consisted of 36 questions.

The end-users’s actions were monitored by our mouse tracking – monitoring tool (presented in the next subsection) and stored in a database. Their resulting records were compared to the mouse-tracking actions and they were measured in a scale from one to five. Doing this, we could evaluate our monitoring model and confirm the mouse input – user behavior correlation.

Following we present the approach of our prototype tool and the evaluation experiment we conducted. The experiment was conducted only to measure risk-perception (hesitation)

<table>
<thead>
<tr>
<th>Movement Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement between items</td>
<td>Ferreira et al., 2010</td>
</tr>
<tr>
<td>Average time from the beginning of a mouse hover</td>
<td>ClickTale, 2010</td>
</tr>
<tr>
<td>Movement inclination towards the item</td>
<td>Lee and Chen, 2007; Rodden et al., 2008; Ferreira et al., 2010</td>
</tr>
</tbody>
</table>
levels, while self-efficacy measurements will be implemented and presented in our future works.

3.3. Participants and Procedure

The participants were 32 end-users, 14 male and 18 female undergraduates all of whom were familiar with web applications (since they had been taught some web tools in the context of the 'e-commerce e-business' course). All the participants were finance and accounting students with poor ICT background.

After the end of the software task, each student had to answer the survey which consisted of a number of questions (items) which measure end-user related behavioral variables, including the self-efficacy and risk perception. Table 2 depicts the items we used to measure self-efficacy and risk perception.

A five point Likert-type scale with 1 = “strongly disagree” to 5 = “strongly agree” or 1 = “never” to 5 = “many times” was used to measure the items. Our questionnaire structure was based on previous research behavioral computer related questionnaires (e.g. Davis, 1989; Venkatesh et al., 2003; Moon and Kim, 2001; Wang et al. 2009). The original questionnaire was in a Linker scale form consisted of a prompt, “during the usage of the web tool I felt that . . . I was totally confused, or I was bored, or I was confident” etc.

In order to capture and analyze the end-user behavior while interacting with web software, we designed a prototype mouse tracking tool that monitors the users’ actions and estimates the users’ hesitation levels (risk perception).

Table 2. Self-Efficacy and Risk-Perception Questionnaire-Survey Items

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Efficacy</td>
<td>S1 I felt confident while I was using the system</td>
</tr>
<tr>
<td></td>
<td>S2 I believed that I could perform well</td>
</tr>
<tr>
<td></td>
<td>S3 I felt I had the control of the task</td>
</tr>
<tr>
<td></td>
<td>S4 I felt that everyone else knew what to do but me</td>
</tr>
<tr>
<td></td>
<td>S5 I felt confused while using the system</td>
</tr>
<tr>
<td>Risk-Perception</td>
<td>R1 It was taking me time to decide how to move while using the system</td>
</tr>
<tr>
<td></td>
<td>R2 I felt nervous every time I took an action (e.g. pressed a button)</td>
</tr>
<tr>
<td></td>
<td>R3 I checked well my actions before moving to the next steps</td>
</tr>
<tr>
<td></td>
<td>R4 I had difficulty to decide on which action to take</td>
</tr>
<tr>
<td></td>
<td>R5 I had difficulty to decide on which feature (among other) to use</td>
</tr>
</tbody>
</table>
3.4. The Prototype Behavioral Mouse Tracking Tool

The main purpose of this work is to create a monitoring tool that can be integrated in web systems, contributing in the analysis of user behavior in order providing them with appropriate aids to facilitate the usability of the system.

Hence we have designed a prototype monitoring tool that base on the reviewed literature mouse patterns, captures user mouse behavior and conducts some basic behavioral analysis. We have designed our tool in a way to capture all the user mouse movements and keyboard actions, which graphically present in an admin interface both in real time and afterwards since we also store them all in a database. An important feature is that the tool displays graphs and statistics in real-time at any website connected via javascript file in the central server.

Expect from capturing mouse movements, clicks, double clicks etc., the monitoring tool also analyses these inputs and provides with behavioral results. In particular it detects horizontal and vertical reading (which is out of the current paper’s scope) and hesitation, based on the relative literature mouse patterns. In our implementation hesitancy recognized with the passage of the indices an array of options (items) and characterized as weak or strong.

For example, our tool detects weak hesitation in case the user mouse hovers between two items (buttons, links etc) from one to two times. If the user keeps moving the mouse over these items this could reveal a strong hesitation since it means that the user cannot decide and thinks of the ‘risk’ of his/her final choice.
In this way we captured and measured risk-perception for the entire experiment sample. Since we stored these data in a database we could then compare them to the ones provided through the questionnaire survey.
3.5. **Experimental Results and Discussion**

The results of the implementation showed that the tool satisfies our target, to capture and analyze user behavior while interacting with a web-based environment.

The records regarding hesitation detection were all stored in a database table along with the user session id. The questionnaire results regarding hesitation were also stored in a database table along with the same user id. Then, the two ‘kinds’ of results (source based) were compared to each other in order to validate that mouse tracking detected hesitation levels were close to the ones detected by the users questionnaire answers (which were measured in a scale from 1 to 5).

Indeed, users who stated a low hesitation level were also proved to be of low hesitation reflected in their mouse movements. Correspondingly users who stated in the questionnaire a high hesitation level were showed by the monitoring tool to have small or zero hesitation while interacting with the web environment.

The following diagram depicts questionnaire-based hesitation flow to the mouse-based one and shows their close correlation.

![Graphical Results – Questionnaire versus Mouse detected Hesitation](image)

As already mentioned self-efficacy questionnaire-based results were not compared to the mouse inputs, since this is a separate work that will be implemented in our future plans.

4. **Conclusions and Future Work**

Mouse tracking allows web developers to view the behavior of actual users in their natural browsing environment. By tracking the mouse movements and clicks, designers can evaluate the usefulness and ease of use of their web applications in order to enhance user experience. Mouse tracking techniques combined with user behavioral analysis can significantly contribute to web marketing area by provided tools and approaches to detect and analyze user behavior in order to enhance web software products and services. In his
work we have outlined this necessity and provided with a basic background literature review regarding mouse tracking implementation on particular behavioral attributes, self-efficacy and risk-perception (or hesitation). These two attributes have been shown to significantly influence end-user experience while interacting with web environments. Hence their monitoring in real time, measurement and analysis can assist in the developing of user-centered web products. The existing online communities which allow for experiences to be created and shared by the users, may also contribute to users’ examination and social media offer ground for such exploration in real time with the use of innovative tools [41, 42].

In this work we have designed and implemented a prototype mouse tracking-monitoring tool that can capture all the mouse user actions while interacting with a web application. It stores these data in a database and visually presents them in an admin panel. It also provides with some basic behavioral results such as user detected hesitation levels. In this context, we conducted an experiment where we compared mouse to questionnaire user inputs and confirmed that users detected by the tool hesitation levels were similar to the ones resulted from the questionnaire answers.

In our future work we plan to measure also self-efficacy levels and conduct similar experiments to evaluate mouse tracking self-efficacy detection. We also plan to evolve our tool, enhancing its graphical interface presentation and also providing it with more analyzing-decision making mechanisms in order to provide with user behavioral analysis for more behavioral attributes influencing user experience. To refer some of these we plan to measure also perceived ease of use, willingness to learn new features, exploratory behavior (tinkering), overconfidence, playfulness and curiosity.

We hope our work is the first step to a complete behavioral mouse tracking work, and we hope to contribute in the research field by encouraging more mouse-behavioral contributions.

References


