TESTING THE RELIABILITY OF PREDICTIVE MODELS ON THREE DIFFERENT DEVICES

by

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Abstract

Nowadays, the first sources of information are websites on the Internet with its categories. Some users find certain websites' layout and design not always user friendly. This may lead to poor performance, ambiguity and loss of potential customers. Websites designs' use the principles of user interface (UI) laws and usability guidelines to be consistent and convenient to users. Due to the evolution of technology, society now uses various devices with a wide range of features like screen size, in order to obtain their information. Examples include personal computers (PC), smartphones (SP,) and tablets (TB). Since user interface laws were founded in the 20th century and most were applicable for the PC's websites, this thesis tests and investigates the reliability of predictive models on three devices: PC, SP and TB. User interfaces were designed with five tasks, and each task represented one of the user interface laws. Human-Computer Interaction (HCI) techniques, user interface design and evaluation methods were followed to test the reliability of predictive models on different devices.

Keywords

Predictive models, Fitts' law, Hick-Hyman law, Keystroke-level model, Weber's law, Serial Position Effect law, HCI.

Lovingly dedicated to my family, especially my mother: Salihah Alsalmi, for all the unconditional love, guidance, and support that they have always given me.

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1. Introduction

The component of an interactive computer system that interacts and communicates with the user is the user interface. Any aspect of the system that the user can see and deal with is considered a design of the user interface. In computer systems, the user interface is the component that is becoming a more focused part of the software. As more users utilize computers, the user interface is becoming the most important part of the process. The user interface is the crucial bottleneck in applying a computer-based system to resolve the problems [71], as computers become more robust and powerful.

Since the design of the user interface comprises all the components that are visible to the user, the design of the interface stretches deep into the entire interactive system design. After the system is built, a proper user interface cannot be simply added to it. The interface needs to be a part of the design process from the beginning [71]. There are numerous advantages of having a proper user interface and can make a fundamental difference in user's performance speed, error rates and training time. Poor designs, however, can prevent the user from continuing to use the interface. To guide the designers and evaluators, theories and predictive models of performance are developed.

In the past, users only used the personal computer (PC) to access the Internet. Nowadays, there are many devices used to access the Internet, such as smartphones (SP) and tablets (TB). In December of 2013 [39], 6% of the global population owned a tablet, 20% owned PCs and 22% owned smartphones, according to historical data by BI Intelligence, Business Insider's subscription research service. It also reported that the universal smartphones exploded from 5%

of global population in 2009 to 22%. Therefore, in four years there was an increase of approximately 1.3 billion smartphones, which means that for every nine people there were two smartphones. Tablets showed quicker adoption rates than smartphones and achieved in two years what smartphones achieved in four years. This indicates that one in every 17 people owns a tablet [39]. These findings show that people use smartphones and tablets more nowadays to interact and access the Internet.

The motivation of this thesis is to determine the relevance of the user interface laws and models to the interfaces that users encounter today. Many user interface laws were founded a long time ago, in the 20th century, and they were applicable for PCs. So, their reliabilities need to be tested on other devices that users are using these days for both leisure and work purposes. In response to, that we intended to test and investigate the reliability of predictive models and user interface laws on three different devices: PC, SP, and TB. The predictive models predict the time taken to achieve a task on a device without users' intervention. Since this was the main purpose of this thesis, we designed several user interfaces that needed to be tested by the participants in order to obtain and analyze the findings to achieve our final aim.

The remainder of the thesis is structured as follows. Chapter 2 presents the related work on user interface laws, such as: Fitts' law, Hick-Hyman law, Keystroke-Level Model, Weber's law, and Serial Position Effect law. Chapter 3 explains in detail the process of designing the interfaces of the experiment, and the programming languages used. It then illustrates how to collect the data and the evaluation methods that were used. Furthermore, it gives details of how our subjects participated in the experiment and what task they were asked to accomplish. Chapter 4 expresses the findings that were gained from the participants' performance in the experiment.

In Chapter 5, the findings that were shown in Chapter 4 are discussed in details in order to understand the results. In Chapter 6, the conclusions of our work are presented. In the appendices, we provided the code that was used to design the experiment's user interface (see appendix A). Also, we provided the ethics approval, consent form, HCI Lab questionnaire and some interfaces from the experiment's user interface.

2. Literature Review

In this chapter, user interface laws and predictive models will be presented. Moreover, we will present the different mediums that were used in the study. We will start with presenting the mediums.

2.1 Mediums

In our study, we used three types of mediums. Personal computer, smartphone and tablet were utilized throughout our experiment. All of the mentioned devices will be particularly presented.

2.1.1 The History of the Computer

The computer has its origins in 19th Century England, with Professor Charles Babbage [62]. His design of the Analytical Engine formed the foundation for computers as they are in the present age. The development of computers can be divided into three main generations. Each generation either represents a time frame, a new computer, or an enhancement of the existing machine.

The first generation may be defined by the period from 1937 to 1946 [62] [63]. Dr. John V. Atanasoff and Clifford Berry developed the first electronic and digital computer. It was referred to as an Atanasoff-Berry Computer (ABC). Afterwards, in 1943 [64], the Colossus was developed for military use. It was not until 1946 that the first general purpose machine emerged, referred to as the Electronic Numerical Integrator and Computer (ENIAC). It reportedly weighed 30 tons and had 18,000 vacuum tubes for the processor. It is also reported that when the ENIAC was turned on for the first time some sections of Philadelphia witnessed dim lights [62]. These types of computers could only accomplish a single task. Moreover, they had no OS.

1947 to 1962 represents the second generation. Computers in this era replaced vacuum tubes with transistors, which were more reliable. The Universal Automatic Computer (UNIVAC 1)

was the first computer to be introduced to the public [64], in 1951. Shortly after, in 1953, the International Business Machine (IBM) 650 and 700 series computers defined the computer world. In the second generation, more than 100 computer programming languages were created. In addition, computers had operating systems and memory, Tape and disk were also used as storage media and even printers served as output devices.

1963 to the present age represents the third generation. It ushered in the integrated circuit computers. Thanks to the integrated circuit, smaller computers could be built. In addition, they could be more powerful, more reliable, and perform numerous tasks simultaneously. Microsoft Disk Operating System (MS-Dos) was introduced in 1980, and in 1981 IBM ushered in the personal computer for both office and home use. Afterwards, three years later, Apple unveiled the Macintosh, with an interface driven by icons. The 90s, however, witnessed the entry and growth of Windows. In addition, most of the changes that have taken place since the 90s have not been drastic but have been progressive advances on existing systems.

The third generation witnessed gains in parallel computing [63], both in hardware and enhanced knowledge of how to come up with algorithms that take advantage of parallel architecture. Furthermore, workstations progressively improved, with processor designs making use of a combination of pipelining, RISC, and parallel processing. In addition, Wide Area Networks, bandwidth, networking, and operation speeds have recorded increased capabilities.

Presently, PCs operate with Gigabit per second processors hundreds of Mbytes of RAM, multi-Gigabyte disks, high resolution graphic monitors, color printers, stereo sound cards, in addition to graphic user interfaces. Up to thousands of software, including operating systems and applications, are available today, with Microsoft Inc. being a leader. The third generation has also introduced micro controller technology. Micro controllers are devices that are integrated into other devices, which are often consumer products. Through micro-controllers, the features of control devices can be controlled as well as other activities. They are essentially small computers within devices and are currently critical components of most machines. The personal computer that we utilized in our study can be found in section 3.1.

2.1.2 The History of Smartphones

Smartphones have been around for the last eight years. It began with the unveiling of the first IPhone to the public. In fact, the Smartphone has been in existence since 1993 [66].The major difference between the early smartphones and the ones in circulation presently is that the earlier handsets targeted corporate users and were generally out reach of the public consumer due to their prohibitive costs. The smartphone era can be divided into up to three main phases [65]. The first phase is represented by the age when smartphones were the preserve of corporate clients. In the above era, smartphones featured functions customized to suit corporate needs. Simon from IBM represents the first smartphone, launched in 1993. In addition, Blackberry is regarded a major player in this phase, who introduced a wide range of capabilities in the form of Email, Fax, Internet, Web Browsing, and the camera.

The IPhone ushered in the second phase of the smartphone revolution in 2007 [65]. This represents the first time smartphones were released to general public customers. Furthermore, at the end of 2007, Google released its wildly popular Android platform. In the second era,

proponents were focusing on offering smartphones with tools that the mass public would find useful in the course of their daily lives or activities. In addition, the manufacturers and software developers were attempting to keep the costs of acquiring a handset low so as to attract users. A phone hosted applications that facilitated sending of emails, messages, audio and video playback, social networking, and chatting, among other features.

The third phase of smartphone development concentrated on reconciling the entrepreneurial goals of developers and satisfying customers in terms of the smartphone experience. Consequently, manufacturers sought to improve displays, make the Operating Systems stable, while integrating many more features. The fourth phase began [66] in 2008, and it involved upgrades to the mobile operating systems. In addition, more powerful batteries were adopted and the user interfaces radically improved. The last seven years have witnessed several upgrades to the iOS platform, Android, as well as Blackberry. The most successful Operating Systems, including Android, iOS, Windows Mobile, and Blackberry, and the leading vendors, represented by Samsung, Apple, HTC, Nokia, LG and Motorola, have been working to offer more exciting features. Android has been very influential over this growth period, offering a critical opportunity for all vendors to create devices that run on a brilliant open source technology. The smartphone that we used in the study can be seen in section 3.1.

2.1.3 The History of the Tablet

The idea of the tablet computer is not as novel as it seems. As early as 1968, Alan Kay, a computer scientist, predicted [67] [68] that with advances in user interfaces, flat-panel technology, miniaturization, and experiments with Wi-Fi technology, one could come up with an all-encompassing computing device. He further advanced the idea, proposing that a device of

that nature would serve as a perfect educational tool for school going children. Alan Kay published a paper on the envisioned device and he referred to it as the Dynabook.

Sketches depicting the Dynabook present a device resembling present day's tablet computers save for a few deviations. In the Dynabook, there was a keyboard and a screen on the same plane. Kay went as far as predicting that if the appropriate touch-screen technology would be available, the physical keyboard could be discarded [67] and a virtual keyboard employed on the screen in any configuration.

Alan Kay was certainly ahead of his time, as it would take nearly half a century for a tablet similar to the one he envisioned to grace our stores, homes, and offices. This does not imply, however, that no tablets existed in between the Dynabook and the first IPad.

The GRiDPad [69] [70] represents one of the early tablets, introduced in 1989. It consisted of a monochromatic capacitance touchscreen connected to a stylus. It weighed nearly 5 pounds (2.26 Kg). When compared with the tablets of today, the GRiDPad was a bulky and heavy device, and with a very short battery life lasting only three hours. Jeff Hawkins is the man associated with the GRiDPad, and he later introduced Palm.

More pen based tablet devices were released following the GRiDPad and Palm, although none generated much interest from the public. Apple's own entry into the tablet fray was announced by the release of the Newton [67]. The Newton has been loved and ridiculed in equal measure over time. The criticism directed at the Newton concentrated on its handwriting-recognition software.

Tablet computers were finally recognised as viable consumer products when Steve Jobs revealed the first IPad to an eager audience. Presently, corporations such as Apple, Microsoft, HP and Google are attempting to anticipate consumer needs while designing the tablets that will usher in the next generation of computing. Although it might have taken quite a long time to come up

with tablets that satisfy consumer needs, all signs indicate that tablets will be major players in our homes and offices for the foreseeable future. The tablet that we utilized in our study can be seen in section 3.1.

2.2 User interface laws

In the following sections, we will define predictive models and present various user interface laws that we used in our study. These laws are essential to design suitable user interfaces.

2.2.1 Predictive Models

Predictive models are also referred to as engineering models or performance [48] [61] and are incorporated within a myriad of fields. In human-computer interaction, predictive models influence the determination of metrics of human performance through the integration of an analytical process in an efficient and effective manner. A design scenario are allowed to be explored hypothetically by predictions [74] without implementing a real system and collecting the performance metrics on real users through direct observation. The benefits of using predictive models are obvious.

2.2.2 Fitts' law

The integration of information theory to human performance modeling has been in place since the 1950s. This was influenced by the adoption of the majority of work by several information theorists [20] such as the work of Shannon, Wiener, and other information theorists within experimental psychologists. The information has been utilized in the development of an effective framework, which influences the development of a better understanding pertaining to human perceptual, cognition and motor processes. This has influenced the development of several

models within the field including the Hick-Hyman law pertaining to choice reaction time [8] [16] together with Fitts' law for movement time [21] [22].

Fitts espouses that a movement tasks' difficulty (*ID*, the "index of difficulty") may be enumerated through the utilization of the information theory through the utilization of "bits" as the measurement unit. This is as illustrated below:

$$ID = \log_2(2A/W) \quad (1)$$

Where: A = distance or amplitude to move

W = width or tolerance of the region that terminates the movement

A and W provide measurements pertaining to distance, which limits the provision of units to the term within the parentheses in Equation 1, which influences the development of the unit "bits" from the provided random option of base 2 for the logarithm. From Equation 1, the duration necessary in the completion of the movement task is computed through the utilization of a linear equation, where movement time (*MT*) identifies a linear function of *ID*.

Figure 2.1 provides an illustration of the serial tapping task utilized by Fitts [22]. Within the study, the subjects efficiently identified two targets of width W at a distance A. However, as the targets drew further or smaller, the task was rendered more complex and required additional time to be completed. Through the integration of Fitts' experiment A and W each incorporated variances, which were categorized into four main levels. The least complex task had:

A = 1 inch

W = 1 inch for $ID = \log_2(2A/W) = \log_2(2) = 1$ bit.

The most complex task had:

A = 16 inches and W = 0.25 inches for $ID = \log_2(128) = 7$ bits

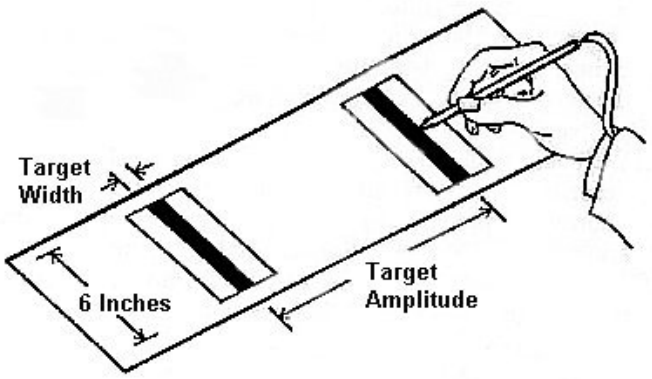

Figure 2.1 The serial tapping task used by Fitts (1954)

The activity illustrated through Figure 2.1 may be integrated within interactive graphics systems through the utilization of targets, which are demonstrated on a CRT, which involves the influencing of a cursor through the utilization of an input device. This influences the identification of a familiar variation; the discrete task that integrates a single movement toward a target from the home position (see Figure 2.2). The target is realized through the activation of a button push when the cursor is identified over the target.

Fitts' law utilization within HCI research was realized through a study conducted by Card, English, and Burr [23]. The study integrated the model on data collected within a text selection task through the utilization of a joystick and a mouse. The participants within the study were subjected the task of shifting the cursor from the original position to the target through the selection of a specific word and consequent selection through the push of a button. This influenced the integration of Fitts' law within numerous HCI research studies including Boritz, Booth, and Cowan [24]; Gillan, Holden, Adam, Rudisill, and Magee [25]; Card, Mackinlay, and Robertson [26]; Epps [27]; MacKenzie, Sellen, and Buxton [28]; Walker and Smelcer [29]; and Ware and Mikaelian [30].

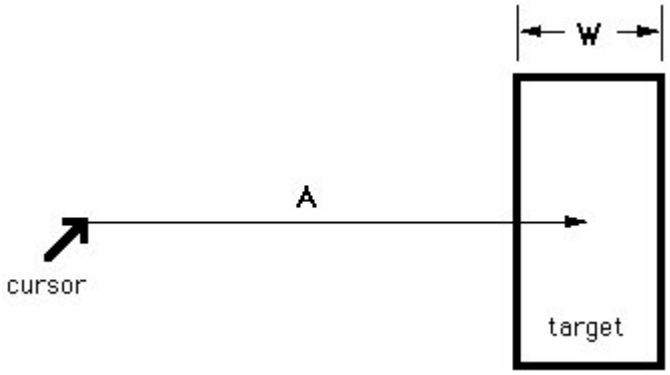

Figure 2.2 A discrete task using a cursor and a target displayed on a CRT

This influenced the development of a movement model, which developed its basis upon Fitts' law through the integration of an equation that enhanced the prediction of movement time (*MT*) through the utilization of a task's index of difficulty (*ID*). This is illustrated through Figure 2.3.

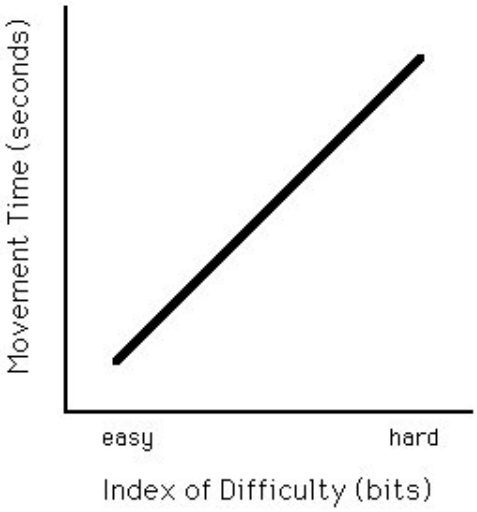

Figure 2.3 Movement time prediction

As projected, the movement time pertaining to hard tasks is recorded as higher than the one required for easy tasks. This influences the development of the prediction illustrated next page:

$$MT = b \times ID \qquad (2)$$

or

$$MT = a + b \times ID \quad (3)$$

The selection of either of the above equations remains dependent upon the possibility of the line going through the origin. In both equations, *b* is identified as the slope of the line.

Refinements to Fitts' Law

Fitts' law has been successfully integrated within empirical tests. However, it has received numerous critical reviews as provided [31] [32]. This is influenced by the development of an array of shortcomings upon close examination through the development of a comparison with other studies. This has influenced the integration of numerous corrections or refinements pertaining to the model. This section incorporates an analysis of these and other proposals aimed at providing a conclusive guide pertaining to the application of the law.

Formulation for Index of Difficulty

Earlier analysis incorporated pertaining to the law identified the existence of regular departure of data points above the regression line pertaining to the integration of less complex tasks ($ID < 3$ bits). This influenced the integration of a new formulation for *ID* [33] to eliminate the disparity:

$$ID = \log_2(A/W + 0.5) \quad (4)$$

The majority of researchers including Fitts identified the existence of an enhanced fit through the utilization of Equation 4. The Welford formulation was utilized by Card [34] [35]. This has influenced the adoption of the Welford formulation by the majority of HCI researchers [24] [25].

Several researchers espouse that in the development of the model by Fitts, the theory incorporated immense differences from Shannon's original work pertaining to the information theory [36] [37]. This influenced the development of a theoretical sound formulation for the index of task as illustrated below:

$$ID = \log_2 (A/W + 1) \quad (5)$$

In relation to the terms of *MT*, the prediction model is as illustrated below:

$$T = RT + MT = a + b \log_2 (A/W + 1) \quad (6)$$

The time T is equal to the reaction time RT plus the movement time MT. Equation 6, which is also referred to as Shannon formulation provides several benefits including:

- The provision of an enhanced fit pertaining to observations
- Incorporates the policies stipulated by the information theorem pertaining to Fitts' law
- Influences the provision of positive results regarding the index of task difficulty

Extension to Two Dimensions

It is vital to keep in mind that the experiments incorporated by Fitts together with the majority of experimental psychologists integrated several tests relating to one-dimensional movements. This is illustrated within Figures 2.1 and 2.2 as they incorporate the measurements of both target amplitude and target width along similar axis, which illustrates that the model is one-dimensional.

HCI researchers integrating Fitts' law utilize target selection tasks through a two-dimensional CRT display. This necessitates the integration of a conclusive review pertaining to the shape of the target and the angle of approach upon the application of the model. In the event that the targets are circles or squares, one-dimensional constraints remain in existence. However, in the event that the targets are rectangles such as words, the situation is considered more complex.

This study views the amplitude as the distance to the center of the target, which provides a vague definition of target width. This is demonstrated in Figure 2.4.

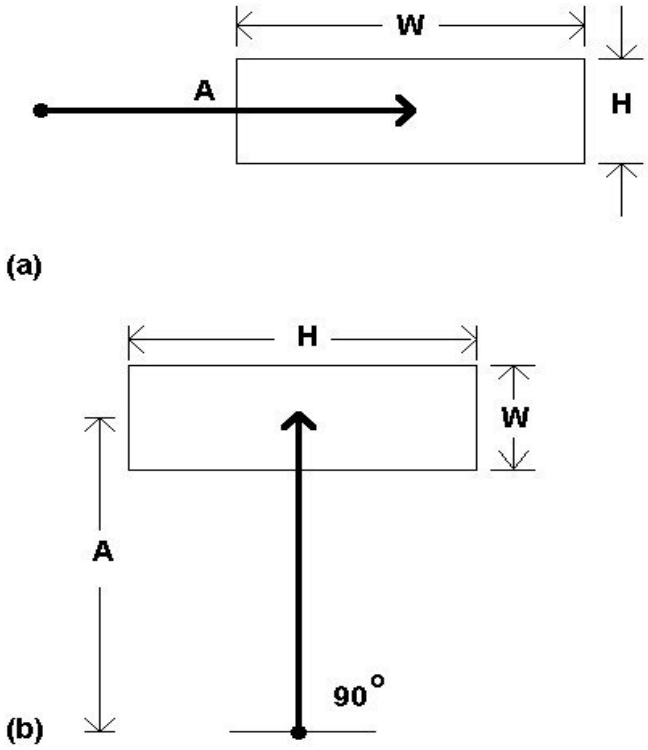

Figure 2.4 Fitts' law in two dimensions. The roles of width and height reverse as the approach angle changes from 0° to 90°

The integration of the model within 2D tasks raises questions pertaining to the identification of the target width. This is catered to through the utilization of the horizontal extent of the target, which is referred to as the "STATUS QUO" model for target width. However, this model provides low and at times negative estimates pertaining to task difficulty. This is identified in the case of a short and wide target for instance a word or series of words, which is analyzed through the review of the above or below at close range. Gillan [25] utilized Fitts' law within a target selection task through the integration of a variety of characters as targets while incorporating varied approaches pertaining to the approach angle and approach distance. This was illustrated

by a 26-character (6 cm) target was approached diagonally from a distance of 2 cm. The process integrated the Welford's formulation, which identified the index of task difficulty at $ID = \log_2 (A / W + 0.5) = \log_2 (2 / 6 + 0.5) = -2.6$ bits. This was also illustrated by Card [34].

One consequence of the task difficulty extending to the left of $ID = 0$ bits is that it is rendered a positive as it enlarges, which develops under linear regression. This is influenced by the corresponding of conditions with $ID = 0$ bits or less to occurring conditions within the experiment. These tasks incorporate a positive effect the majority of time. However, this may be altered through the integration of two approaches. The first approach involves the utilization of the Shannon formulation for *ID*, which influences the identification of an increase within the rating to $\log_2 (2 / 6 + 1) = +0.42$ bits. The second approach involves the substitution for *W* a measure with one that is in-line with the 2D nature required by the task. Through an analysis of Figure 2.5, the existent 1D challenge identified pertaining to the constraint with the model is enhanced through the integration of a measurement of *W* along the approach axis.

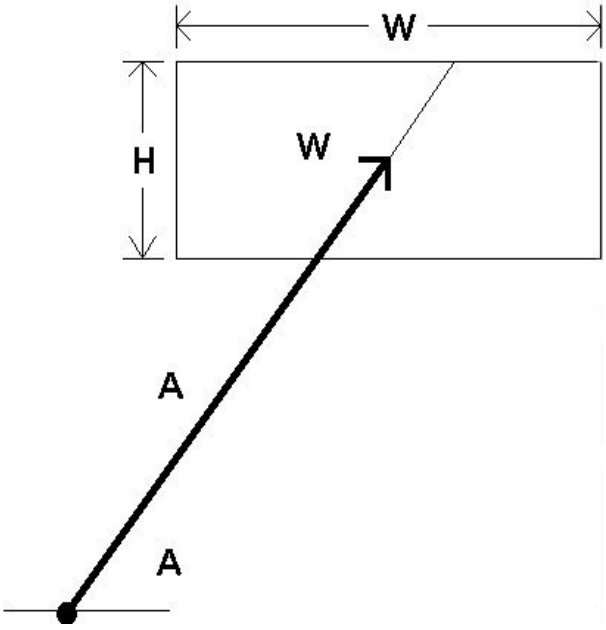

Figure 2.5 The smaller of W or H

In addition the target width may also be substituted with the small capacity of W or H. This identifies that the smaller of the two dimensions identifies the existence of high levels of accuracy required by the task. This is referred to as the "SMALLER-OF" model, which is identified less complex as it may be incorporated within *A*, *W*, and *H.* The SMALLER-OF model influences rectangular targets. The SMALLER-OF model is more effective than the STATUS QUO model [38]. This influences the recommendation of Fitts' law within two-dimensional tasks [40]. The experimental design incorporates Fitts' law can be found in section 3.7.1 and the results in section 4.1.

2.2.3 Hick-Hyman law

Hick's law states that the time it takes to make a decision by a person is a function of the number of possible choices [4]. This law is utilized to measure how long it takes for users when they are presented with multiple options to make a decision [8][16]. The decision time will logarithmically increase when the number of multiple options increases. When a pilot, for instance, needs in response of some special event to press a specific button, such as an alarm, the law of Hick-Hyman estimates that the longer it takes to make the decision and choose the perfect one, the greater the number of multiple and alternative buttons the pilot has. The implications of Hick-Hyman law for designing any system or process needs simple decisions to be made on alternative options.

This can be described in mathematical terms as follows:

The average of reaction time T required by giving N equally possible options to choose among them [8] [6] is approximately:

$RT = a + b \log_2 (n)$

This is the Hick-Hyman law, where RT = response and reaction time, a = the total amount of time that is not comprised while the user makes a decision, b = an empirically derived constant based on the cognitive processing time for each option (in this case ≈ 0.155 seconds for humans) [4], n = the number of equally possible alternatives. In this form Hick's Law predicts reaction time in which a high level of accuracy is maintained [6]. There are four basic steps for all tasks to be consisted of:

- Determine a problem or goal
- Estimate the possible choices to solve the problem or accomplish the goal.
- Make a decision on a choice
- Apply the choice

Hick-Hyman law interferes in the third step: decide on a choice. Nevertheless, when decisions involve considerable levels of searching, reading, or sophisticated problems that need to be solved, the Hick-Hyman law does not apply to those decisions [4]. A sophisticated task that requires reading sentences and a lot of focusing with three options can readily take much time longer than an easy stimulus-response task with six choices. Subsequently, where there is a unique response for each choice, Hick-Hyman law is most applicable for simple decision-making.

The designers can improve the efficiency of a design when they understand the implications of Hick-Hyman law. The law, for example, applies to the design of software [4] menus, wayfinding design and signage, control displays, and emergency response training as long as the provided decisions are simple. The applicability of Hick-Hyman law decreases when the hardness of the

tasks increases. For instance, when we have complex menus or hierarchies of choices, Hick-Hyman law does not apply. Menu selection of this type is not considered an easy decision-making since it absolutely involves reading sentences, searching and scanning for choices, and some level of problem solving.

When designing systems that involve decisions based on multiple options, Hick-Hyman law should be considered. When designers design for time-critical tasks, reduce the number of choices that are involved in a decision to reduce times and errors. The required time for a user to press the correct button among alternatives (R, G, or B) depending on the color of the light (red, green, or blue) will increase with the number of probable colors (see Figure 2.6).

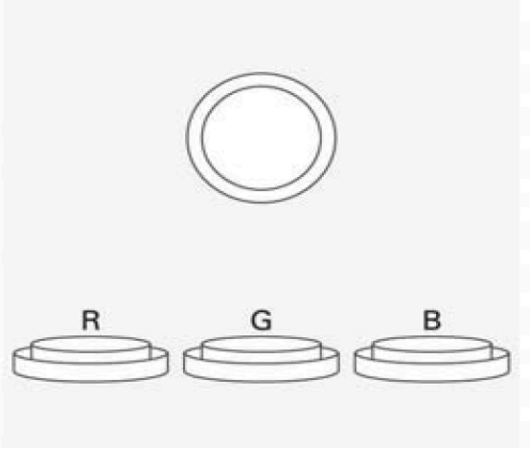

Figure 2.6 Three colored buttons

The required time for a person to choose an item from a simple software menu will increase with the number of items available (see Figure 2.7). However, this may not be the case for more sophisticated menus that need a lot of test or submenu. The experimental design incorporates Hicks' law can be found in section 3.7.2 and the results in section 4.2.

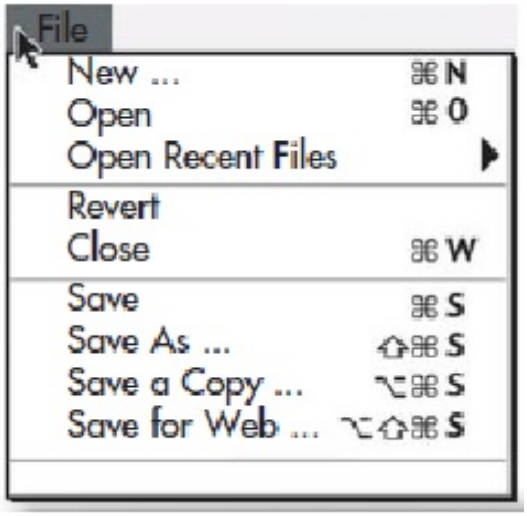

Figure 2.7 A simple software menu

2.2.4 Keystroke-Level Model

The full form of GOMS is Goals, Operators, Methods and Selectors [11]. The main emphasis of GOMS is on the perfect use of the interface by an accomplished user. The user who is an expert is defined as a person who has a good understanding of the tasks involved and has the capability to complete the given work satisfactorily. This particular person should be so knowledgeable that he would not have any queries or need any help during the task. It is presumed that he will do his job well and commit no mistakes so there is no inbuilt provision in GOMS to deal with human error. When described in detail GOMS consists of specific objectives (user's goals) that the user has defined like a user might want to use the term "Britain "in place of "England" in a text and wants appropriate editing to be done, it also encompasses the operators and methods that will be used to reach the goals along with the selection rules which decide on the type of the method to be used if there are many options available. The time period taken by the user to utilize the interface provides the result of the GOMS model. As time has elapsed modifications in the original model have created new versions like CMN-GOMS, which stands for Card, Moran, and Newell. Natural GOMS language (NGOMSL) was devised by Kieras in 1998 [10] and is in fact

the formal code that can explain GOMS models. CPM GOMS or Cognitive Perceptual Motor Version of GOMS also known as Critical Path Method was developed by Gary [5]. This version can deal with many scenarios at the same time.

GOMS model is actually used to estimate a time frame in which a task can be done or a command can be executed. The in built assumption of this model is that the use of computer is done to achieve a goal by using a particular method, which encompasses a series of well-defined operators. The given task is broken down into smaller and smaller goals and the designer can thus predict the user's actions while performing the task.

Keystroke-Level Model

In 1983, one of the earliest versions was developed by Card [11] and is known as keystroke level model. It is also denoted by KLM-GOMS or only as KLM and is a simplified GOMS model. In this the goals and selectors are not taken into account and importance is given only to keystrokes and mouse presses of the expert. It is not only a simple model but its simplicity also makes it quite effective and thus it can be used in a variety of sectors like text editing to analyzing a database of outer space operations [7].

There are a number of operators in KLM [15]. The five most important parameters in modern technology (see Figure 2.2.4.1) are: P,K,H,B and M. P denotes the use of a pointing device to point out a position on the screen; this does not include button presses. K operator stands for the button press and release of a pointing device or the press of a single key on the keyboard. The value of K depends on the typing speed of the user. If a person types 55 words per minute then the value of K will be around .20 seconds. The H operator represents the points of movements of

the user's hands from the keyboard to the pointing device and is around .40 seconds [3] when calculated for a process involving the keyboard and the mouse.

The amount of time taken to give a command, make preparations to complete a given task, ending an operation or deciding which operation to choose represents the M operator. Card [11] proposed that the thinking time was approximately 1.35 seconds but according to Olson and Nilsen [17][14] this seems to be the upper limit with their time calculation coming out to be around 1.20 seconds. While performing a task, there may be situations when the computer does not respond to given commands as it is performing some other task so the user cannot perform any action during this time period.

The B operator denotes the mouse press or release. Generally, the parameters are dependent on the user's physical movements except the M operator. The model can predict the amount of time that will be needed to finish simple data entry tasks on a computer using a mouse. The user can analyze all the steps of the sequence and remove or move around the unnecessary steps using the KLM- GOMS model thus finding a bettor method to complete the task. This can be seen in Table 2.1 below.

Table 2.1 Operators times table for KLM

Code	Operation		Time
K	Key press and release (keyboard)	Best Typist (135 wpm)	0.08 seconds
		Good Typist (90 wpm)	0.12 seconds
		Poor Typist (40 wpm)	0.28 seconds
		Average Skilled Typist (55 wpm)	0.20 seconds
		Average Non-secretary Typist (40 wpm)	0.28 seconds
		Typing Random Letters	0.50 seconds
		Typing Complex Codes	0.75 seconds
		Worst Typist (unfamiliar with keyboard)	1.20 seconds
P	Point the mouse to an object on screen		1.10 seconds
B	Button press or release (mouse)		0.10 seconds
H	Hand from keyboard to mouse or vice versa		0.40 seconds
M	Mental preparation		1.20 seconds
T(n)	Type string of characters		n × K seconds

KLM-GOMS is much easier to use than other GOMS methods. Its best use is in scenarios that involve minimum interaction with a computer or a software program. All the permutations involved and the number of steps needed to predict the total time for task completion increases rapidly when the number of tasks increases. The design of KLM-GOMS is quite simple as the whole process is divided into a well-defined sequence of small operations. Each operation is to be completed within a time frame, which is a reflection on the time an expert user would need to complete that particular task. The experimental design incorporates KLM model can be seen in section 3.7.3 and the results in section 4.3.

Muscle memory

The technique of improving and learning motor skills is called muscle memory. That technique occurs through practice and repetition. The whole process occurs in the brain not in the muscle, as it seems, which is also called motor learning. When a person practice or iterate a movement,

his/her body learns how to conduct the movement readily and rapidly. Riding a bicycle, typing on a keyboard and typing in a PIN are examples of muscle memory, which are found in various everyday activities.

2.2.5 Weber's law

There are several things that can help graphic designers in designing perfect interfaces and interactions is to understand the ability of human of noticing slight differences in shapes, colors, heights etc. The cognition and the interaction efficiency are affected by perceptual ability to make out differences in objects, colors, shapes, texts etc.

The difference threshold or Just Noticeable Difference (JND) [13] is the least amount by which stimulus intensity must be altered in order to provide a noticeable variation in sensory experience. A 19th century experimental psychologist [9], Ernst Weber, noticed that there was a relationship between the size of the difference threshold and the initial stimulus magnitude. This is known as Weber's Law. This relationship can be illustrated as:

$$\frac{\Delta I}{I} = k$$

where ΔI (delta I) represents the difference threshold,
I represents the initial stimulus intensity and k signifies
that the proportion on the left side of the equation remains
constant despite variations in the I term

What Weber's Law states in simple way that that the size of the just noticeable difference *(*ΔI*)* is a constant proportion of the original stimulus value. In other words, Weber's Law [12] states that the ratio of $\Delta I/I$ is constant for a specific measure. So when a person is in a noisy environment the person must shout to be heard from others whereas a whisper works in a quiet

environment. In addition to that, when you measure increment thresholds on various intensity backgrounds, the thresholds increase in proportion to the background.

Suppose, for example, a subject was presented two spots of light by an experimenter. Each one of the two spots was with an intensity of 100 units [9]. The subject was asked to increase the intensity of one of the spots by the experimenter. The subject kept increasing the intensity until the intended spot was just noticeably brighter than the other. If the subject noticed the increment of the brightness with the intensity of 110 units, the subject's difference threshold would be 10 units ($\Delta I = 110 - 100 = 10$).

The equivalent Weber fraction [9] for the above difference threshold would be 0.1 ($\Delta I/I = 10/100 = 0.1$). The size of the subject's difference threshold for a spot of any other intensity value could be estimated when using Weber's law. That is, the size of the just noticeable difference for a spot with an intensity of 1000 units would be 100 ($\Delta I = 0.1 * 1000 = 100$) if the Weber fraction for differentiating changes in stimulus brightness is a constant proportion equal to 0.1.

If the equation is rewritten to $\Delta I = IK$, it is apparent that Weber's Law predicts a linear relationship between the difference threshold and the initial intensity of stimulus. This is shown in Figure 2.8, which is a plot of some hypothetical [12] data showing Weber's Law. The slope of the line is the Weber fraction.

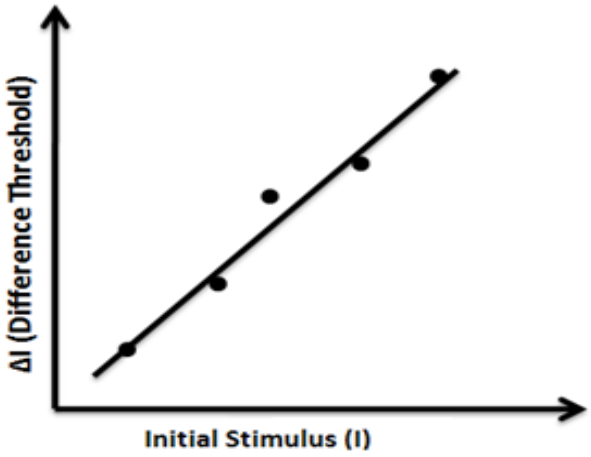

Figure 2.8 The relationship between difference threshold and initial stimulus

Weber's Law can be applied to different sensory modalities in GUIs such as brightness, loudness, line length, visual weight of fonts in typography, color matching etc. Many times a lot of information in needed to be shown on a limited size computer screen. Information can be showed in different forms such as: text, pictures, drawings, maps, graphs, videos etc. The ability of discriminating between two close enough visual stimuli is needed when poor visual design of user interface is applied. Two lines, for instance, with various thicknesses in a map (for both narrow lanes and wide road). The experimental design incorporates Weber's law can be seen in section 3.7.4 and the results in section 4.4.

2.2.6 Serial Position Effect

Memory works in different ways. One of these ways is Serial Position Effect whereby one tends to remember the items in a series of good items first and last while those, which are worst, tends to be remembered in the middle [41]. The origin of this term is Herman Ebbunghaus. After conducting studies on self, he found that recall exactness depended on the location of that item on a list that he had studied earlier. Practically, when people are requested to remember a given

of items without necessarily putting them in order or free recall, they incline on remembering the items that appear at the end of a list more than those at the middle. This is known as the recency effect. Those items in the middle of the list tend to be forgotten more than those at the beginning of the list. This is known as primacy effect.

The primacy effect works more since the items that appear at the beginning of the list are kept in the long-term memory since the mind tends to put greater effort in processing their remembrance. For instance, the items that appear at the beginning of a list can be recalled independently while those in the middle must be recalled in combination with those at the beginning etc. If the items to be remembered are presented quickly, the primacy effect is lowered and vice versa. The primacy effect is also inversely proportional to the length of the list being presented.

One theory used to explain the recency effect argues that those items last in the list are remembered faster since they are still in the working memory while the remembrance is initiated. To this effect, items in the middle of the list tend to lose out from the two. The temporariness of the context can act as the retrieval sequence in case one starts remembering directly after memorizing. In this case, the items at the end of list are likely to be remembered more than those, which appeared prior in the memorizing sequence. Nevertheless, engagement in interfering task can lower the recency effect. As the distractor action, intervening tasks comprise working memory and can cancel out the recency outcome if more than 15 to 30 seconds in time. Moreover, the recency effect is steady irrespective of studied list's length or performance rate as a result of recall coming soon after test.

In sequencing things in a control panel of an interface of a product or GUI's menu we can utilize the primary effect and recency. In the end or beginning of the list is where the more regularly or

more essential used controls or items should be sited. At the center of the list should be items less often used. It is easier to recall a list of inscribed words as opposed to a set of symbols or colors.

The Serial Position Effect might not be directly seen in event of a list with colors. Here, brightness, saturation and hue too are the various color properties that remembrance depends on. Therefore, it is more possible to remember a brighter color despite of its position in the list. Whenever the context demands, this may be used to over-rule the Serial Position Effect. Thus in aiding remember color can be applied as a strategy. For instance, a significant command which cannot be billeted at the ending or starting of the list, can be located in the central part with a faintly brighter color, so that it continues to receive the user's attention and the user inclines to remember it simply and for a lengthier duration when designing a tool bar.

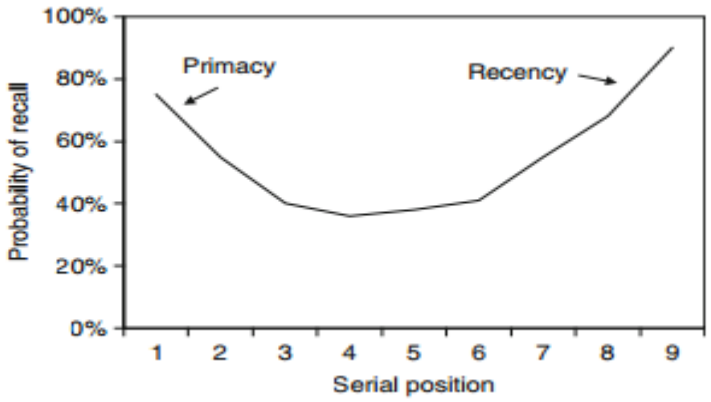

Figure 2.9 Serial position curve

A nine-item word list were remembered freely (see the Figure 2.9). The possibility of recalling the word depended on the position of that word in the list. Both words presented at the beginning (70%) or at the end (60%) of the list were more likely to be recalled than the ones in the middle of the list (40%). The experimental design incorporates Weber's law can be found in section 3.7.5 and the results in section 4.5.

After taking an overview on some of the different devices we have today and the user interface laws, we are now familiar with both devices and laws that we will use in the study. Since these user interface laws were applicable to PC, we intended to check whether these user interface laws were applicable to SP and TB as well.

3. Methodology

In this chapter, we will discuss the equipment that was used in our study as well as the participants that were recruited. The objectives of the study and the hypotheses will also be discussed in this chapter. We will also illustrate the methodology that was utilized for the experiment and the design of user interfaces.

3.1 Equipment

It was essential that the equipment used for both conducting an experiment and gathering the data needed to be completely provided. The equipment included a laboratory room, computer, smartphone and tablet.

Laboratory room

The laboratory room was reserved to conduct the experiment. It can be seen below in Figure 3.1. The lab contained a table with a computer, smartphone, and tablet. The lab room was provided with an Ethernet for the computer. There was also wireless Internet with full signal used for both smartphone and tablet. The laboratory room facilitated to conduct the experiment without disturbance and interruption. Moreover, it gave the same environments and conditions for all participants. Also, Laurentian University server was utilized to host the experiment's user interfaces. By typing the experiment's domain into the browser's address bar:, labofhci.cs.laurentian.ca, the first interface appeared to us to select the intended platform.

Figure 3.1 Typical experiment lab room with computer, tablet and chair

Computer

A computer with 2 GB of RAM was used to conduct the experiment. The computer had 2 GB of free hard disk space and the screen size of the monitor was 19 inches. A regular keyboard and a regular laser mouse were used in the experiment.

Smartphone

The Samsung Galaxy Note 3 was used in the experiment, which was equipped with a 5.7 inch FHD S-AMOLED display. The resolution of the screen was 1080 x 1920 pixels. It had a suitable processor in regard to mobile devices with a quad-core 2.3 GHz. It came with internal memory of 32 GB and 3 GB of RAM. The 4.3 Jelly Bean Android operating system was used with Touch Wiz user interface and software. The picture of the Samsung Galaxy Note 3 can be seen in Figure 3.2.

Figure 3.2 Samsung Galaxy Note 3

Tablet

The Samsung Galaxy Tab 2 10.1 was used in the experiment. It came with a 10.1 inch PLS TFT capacitive touchscreen display. The resolution of the screen was 800 x 1280 pixels. The processor used was a dual-core that operated at 1 GHz. Samsung has customized the interface with its Touch Wiz UX software. It came with an internal memory of 32 GB and 1 GB of RAM. The operating system was Android 4.0.3 (Ice Cream Sandwich) operating system. The picture of the Samsung Galaxy Tab 2 10.1 can be seen in Figure 3.3.

Figure 3.3 Samsung Galaxy Tab 2 10.1

It is noteworthy that the screen sizes that we dealt with were completely different from each other. It can be said that the PC screen size is approximately double the TB screen size. Also, the size of the TB screen is almost twice the SP screen size. This is shown in Figure 3.4 next page.

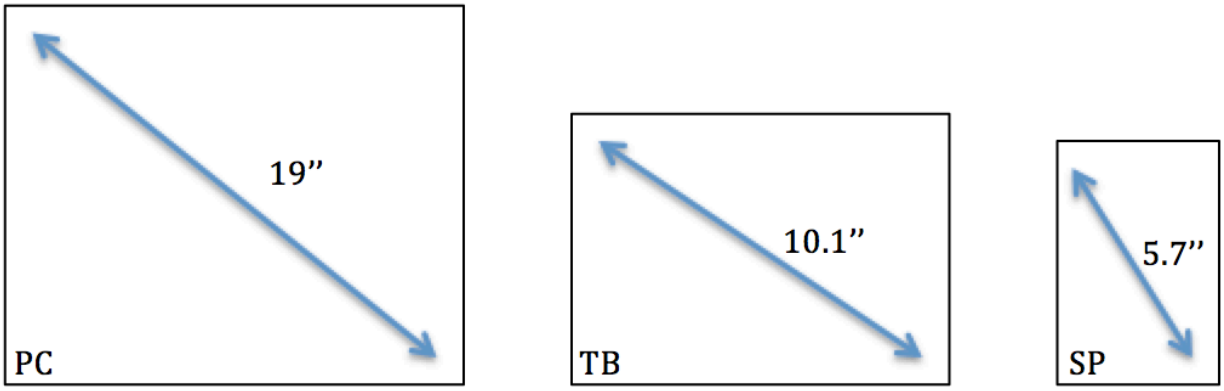

Figure 3.4 Display sizes for the three devices

Stopwatch

The Oslo Silver 2.0 twin chronograph and countdown timer was used in the experiment, and only in this experiment. As mentioned earlier, this stopwatch was used to achieve certain roles in certain tasks that the users have completed, such as timing, the reaction time, and the time that was not involved in measuring some tasks. Figure 3.5 depicts the utilized stopwatch.

Figure 3.5 Stopwatch was used in the experiment

3.2 Collection of Data

The process of preparing and gathering data is called data collection. Data collection is one of the major principles of any type of research study. The results of a study can be influenced by collecting inaccurate data and finally lead to invalid results. In order to obtain accurate results, this study used multiple methods.

Windows 7 operating system was used during the experiment. Also, the Laurentian University server was used to host the experiment's user interfaces. The language used to write the code to collect data during the experiment were HTML, CSS, JavaScript, JQuery and PHP. By using the JavaScript programing language, we were able to measure accurately the time taken in each task. PHP was chosen as the language to access the data in the database. Although JavaScript was responsible for measuring the time in the experiment, a stopwatch was used to do the similar function. The stopwatch measured the reaction time before moving the mouse in Task 1 and the time that not involved in Task 2 after making the decision by participants (time in milliseconds).

Another method used to collect the data was a questionnaire. The questionnaire was provided and handed out to the participant before the experiment. It contained various questions, such as the age range of the participant, any color impairment, and level of their degree (undergraduate or graduate student). See Appendix D for the questionnaire.

3.3 Pilot Study

The approach of our study was to conduct the experiment for the predictive models on three different devices: PC, SP, and TB. We started the study after designing the user interfaces. A pilot study was conducted before starting the actual experiment to seek participants' interest. The pilot study consisted of five participants to determine whether the experiment procedure would

be successful and to validate if the user interfaces would perform smoothly. The pilot study had uncovered some issues, such as some of the time taken for a participant to complete a task was not stored in the database. Also, the instructions for some tasks were slightly enhanced to clarify further the desired process as well as the paper-based questionnaire was refined.

The data that was obtained from the five participants who participated in the pilot study was not considered for analysis. All of the pilot study participants' data were discarded and not involved in the real experiment. Since the participants of the pilot study were familiar with the tasks and that potentially could have affected the results, they were not involved in the real experiment.

3.4 Participants

The experiment was conducted using students from Laurentian University. Participants could have been anyone who uses the Internet on a regular basis. Since participants were involved in our study, permission was required in order to gain their participation. Permission was requested and granted from the Research Ethics Board (REB) department at Laurentian University. See Appendix B for the certificate of approval. The recruitment method consisted of word of mouth and handing out flyers with the study's information. Both males and females were used for the study.

As mentioned earlier, there were three devices used in the experiment: the PC, the SP, and the TB. The participant was required to perform the same five tasks for each device. This information was taken into account to predict how many participants we might need for the experiment and for the sake of obtaining accurate outcomes. The permutation and combination concepts were used to achieve that. Since there are three devices: 3! (3*2*1 = 6) and five tasks:

5! (5*4*3*2*1 = 120). Therefore, 6*120 = 720 participants were needed to achieve the goal of our experiment, but it was impractical to have this many participants.

Since there was no need to apply the permutation and combination concept on the order of the tasks, the concept was applied on the order of the devices. We had made the experiment for six orders, which are as follows:

- Order 1: PC SP TB
- Order 2: PC TB SP
- Order 3: SP PC TB
- Order 4: SP TB PC
- Order 5: TB PC SP
- Order 6: TB SP PC

The experiment was conducted with 37 participants, consisting of 31 males and 6 females from Laurentian University. The participants used in the study were in different programs, such as Chemical Engineering, Commerce, Computer Science, Economics, and Engineering. There were 21 participants from the Computer Science program and 16 participants from other programs. There were 24 graduate participants and 13 undergraduate participants. There were also 27 participants who were 27 years old or less and 9 participants who were older than 27 years old.

The participants were asked to sign the consent form after reading it carefully. The consent form was handed out to the participant before participating in the experiment. It listed the reason of the study and what the participant should do during the experiment. It had the declaration that informed the participants that they could withdraw at any time with no consequences if they

were not interested in the experiment. The experiment followed all of the guidelines stipulated by the REB. See Appendix C for the consent form.

Each participant was asked to participate voluntarily in the experiment. Since there were colors involved in the experiment, the participants needed no color impaired vision whereas glasses and contact lenses were permitted. If the participant would have had color impaired vision, his/her result had been discarded after finishing the experiment. In addition, the participants were given an oral description of the experiment. None of the participants left the experiment unless they finished the experiment. Also, all of the participants came on time as scheduled.

The 37 participants were divided into six groups. Each group consisted of 6 participants, except for group 6, which had 7 participants. The reason for this division was so each group could participate in one of the six orders from the counter-balance principle. The participants were informed to read the consent form to understand the purpose of the experiment and the rules and conditions for the experiment. The form needed to be signed and the questionnaire needed to be completed by the participant to continue with the experiment. The participants were also notified that there was a timer working in the background to measure the duration of the experiment to collect data.

3.5 Objective

The objective of conducting this experiment, as stated earlier, was testing the reliability of predictive models on the three different platforms: PC, SP, and TB. Since five user interface laws were used in our experiment, five tasks were designed. Each task imitated one user interface law, so each task had its own objective.

- Task 1: This task used Fitts' law and the objective was to measure the time taken for the participants to point at objects (buttons) on the three devices.
- Task 2: This task utilized Hick-Hyman law and the objective was to know how long it took the participants to make a decision when presented with multiple choices on the three devices.
- Task 3: This task was inspired by the Keystroke-Level model and the objective was to determine the time taken for the participants to complete a data entry task on the three devices.
- Task 4: This task used the principle of Weber's law and the objective was to measure the time taken for the participants to notice the difference threshold on the three devices.
- Task 5: The Serial Position Effect law was used in this task. The objective of the task was to determine the positions of the recalled items from a list as well as to verify whether there were differences in the responses between colors list and words list on the three devices.

3.6 Hypotheses

We started our experiment with a hypothesis for every task. After conducting the experiment, we could see whether to remain with the null hypothesis or reject it.

The Null Hypothesis: There is no difference in time taken for the participants when performing all of the tasks on PC, SP, and TB.

Since there were five tasks, five null hypotheses were stated, one null hypothesis per a task.

The Null Hypothesis for Task 1:

Task 1 was divided into three subtasks. There were three movements in this task: moving from the Clickme button to button "1", moving from button "1" to button "2", and moving from button "2" to button "3". *The Null Hypothesis for Task 1* was that there is no difference in the time taken for the participant to complete the task on all three devices.

- *The Null Hypothesis for subtask (a)*: There is no difference in the time taken for the participants to point at button "1" on all three devices.
- *The Null Hypothesis for subtask (b):* There is no difference in the time taken for the participants to point at button "2" on all three devices.
- *The Null Hypothesis for subtask (c):* There is no difference in the time taken for the participants to point at button "3" on all three devices.

The Null Hypothesis for Task 2:

There is no difference in the time taken to select the smallest green button on all three devices.

The Null Hypothesis for Task 3:

There is no difference in the time taken to fill in the form on all three devices.

The Null Hypothesis for Task 4:

There is no difference in the time taken to select the expanding rectangle on all three devices.

The Null Hypothesis for Task 5:

There is no difference in recalling a list of colors and a list of words on all three devices.

3.7 Method

Since we obtained permission to conduct the experiment and the participants were recruited, the experiment was ready to begin. The participant entered into the lab room to conduct the experiment. The lab room was only able to be accessed by us and was locked when it was in use. The participant was seated on an adjustable chair. Before starting the experiment, the participant was asked to sign the consent form and complete the questionnaire.

Regarding the design of the experiment, several programming languages were used in order to design our user interfaces, such as:

- HTML
- CSS
- JQuery
- JavaScript

By combining HTML, CSS and JavaScript technologies, the participant can see all of the components of the user interface, and they are all controlled by the computer's browser. When a developer models a user interface, it must meet the users' expectations and mental model. Since it was our main goal to test the reliability of the user interface laws, five tasks were developed. Each task represented one of the laws and consisted of more than one user interface. The sequence of our experiment is shown in Figure 3.6.

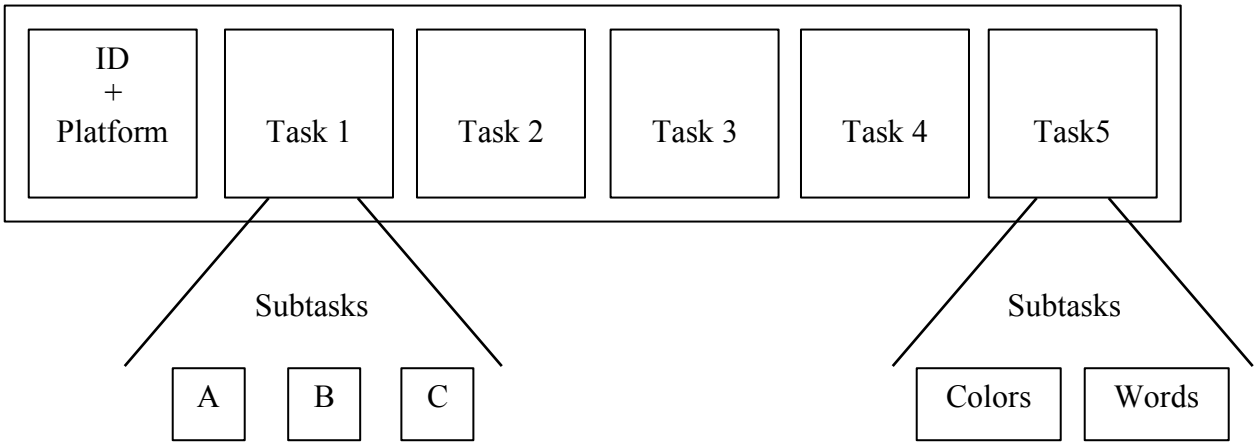

Figure 3.6 The sequence of the interfaces for the experiment

As mentioned earlier, many user interface laws were used in designing our HCI lab to satisfy the purpose of this research. The first user interface, which was the preface of our HCI lab, was designed using the preceding technologies. It was visible only by us, so that we could choose what platform we wanted to begin with (Figure 3.7). Also, Google's Chrome browser was used in the study. By typing the URL of our HCI lab, we were able to access the user interfaces. The URL: http://labofhci.cs.laurentian.ca was obtained from Laurentian University.

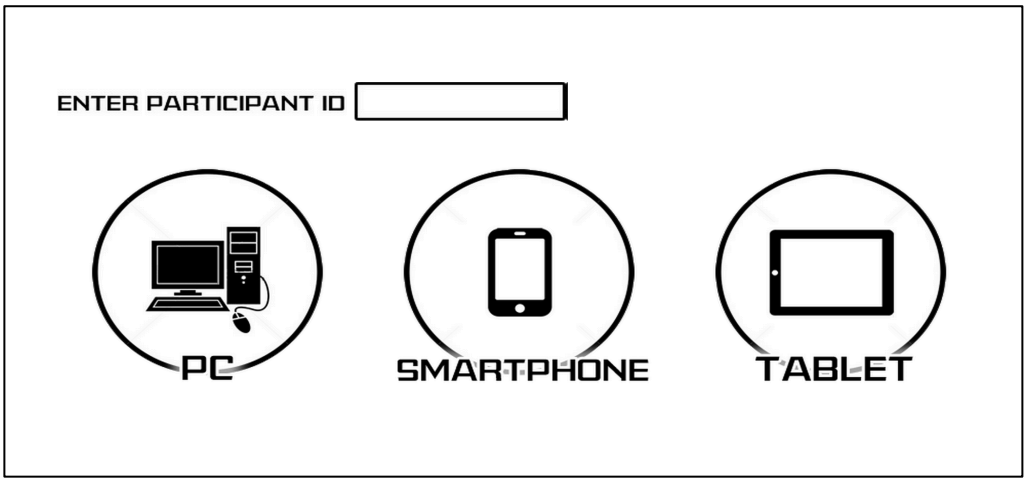

Figure 3.7 The preface interface for the experiment

Entering an ID number for each participant was the first step we did to conduct the experiment. This ID number was not identifying any aspect of the participants, as it was merely used to recognize the sequence of the participants in the database. We had to enter the participant ID before choosing the platform. This order needed to be followed to avoid an error message: "Error! Please enter a participant ID."

The participants were asked to conduct five tasks as stated earlier, each task representing one of the user interface laws.

3.7.1 Task1 (Click on the buttons):

This represented the main idea of Fitts' law that is a mathematical model that predicts how long it will take a user to point at a button. It takes into consideration the starting point of the cursor in relation to the button as well as the size of the button and its location (see section 2.2.2). The farther the user needs to move the mouse to reach a button, the more effort this will require from the user. The smaller the button, the more difficult it will be to click. In accordance with this, Task 1 was constructed following the Fitts' law theory. Therefore, many of the interfaces of the Task 1 were designed as shown in Figure 3.8.

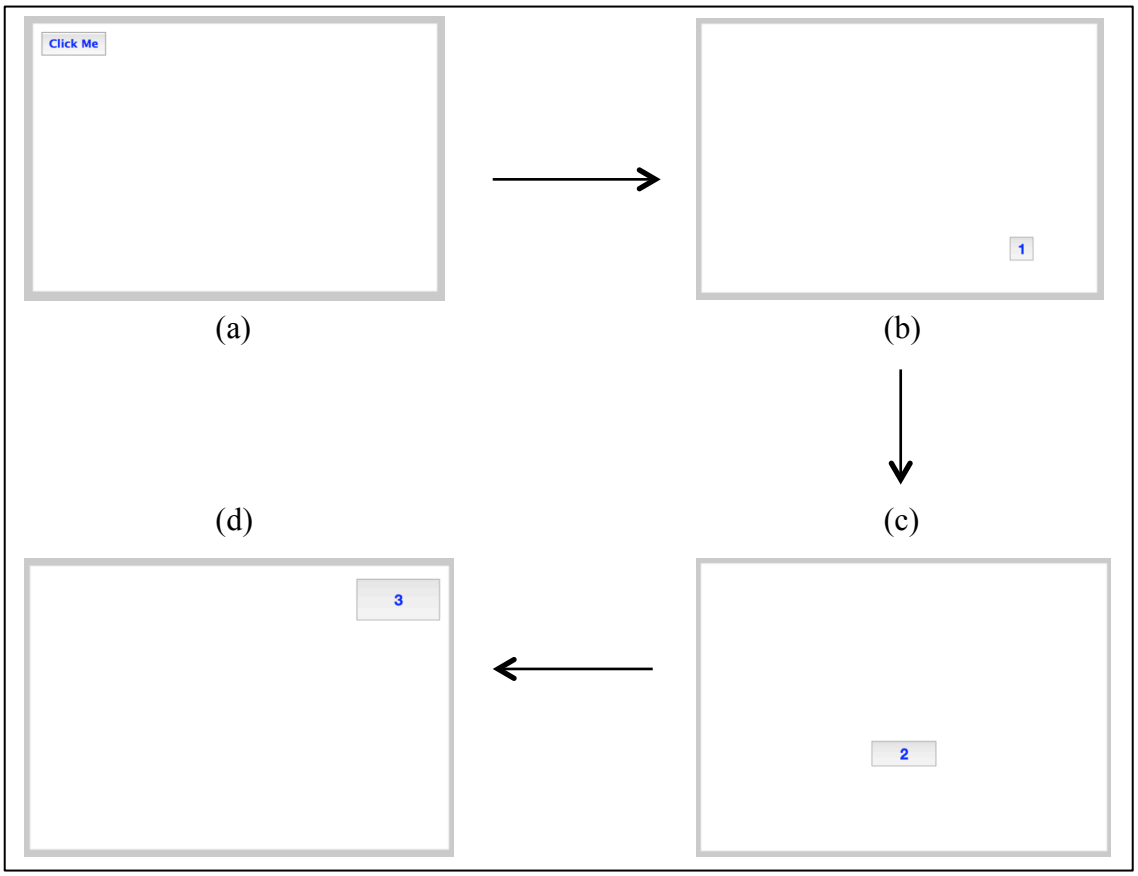

Figure 3.8 The interfaces of Task 1

When the participant pressed the Clickme button, another button (button "1") of a different size and in a different location appeared. This is shown in Figure 3.8 (a), (b). The participant was required to click this button. The time taken for the participant to travel from Clickme button to button "1" was recorded in the database for analysis.

After the participant clicked on button "1", another button (button "2") of a different size and in a different location appeared in the middle of the page. The participant was required to click on this button to proceed on in the experiment. The button "2" was similar in size to the Clickme button, but the distance was different between the Clickme button and button "1," and button "1" and button "2," the latter being shorter. This can be seen in Figure3.8 (c).

The time taken for the participant to click on button “2” was recorded in the database. After the participant clicked on button “2,” the third button (button “3”) of a different size and in a different location appeared at the top right corner of the page. It also needed to be clicked on in order to continue the experiment. Button “3” was different in the size of all other buttons and the distance was shorter than the distance between the Clickme button and button “1,” but was longer than button “1” and button “2.” This can be seen in Figure 3.8 (d).

The time taken for the participant to click on button “3” was recorded for analysis. After finishing the interfaces of Task 1, the Next button appeared on the interface and needed to be clicked on to continue to Task 2. The essential reason for this button was to let the participant move through the tasks with no interruptions and distractions.

3.7.2 Task 2 (Selecting a button among alternatives):

Task 2 represented the Hick-Hyman law that assesses the time taken for users to make a decision when presented with several choices. The law predicts that the fewer the number of alternative buttons, the less time it will take to make a decision and choose the correct one, and vice versa (see section 2.2.3). On this basis, the first interface of Task 2 was designed to meet the Hick-Hyman law requirements. The interface of Task 2 consisted of the instruction located above the working area. The other component of Task 2 was the Start button. This can be seen in Figure 3.9 (a).

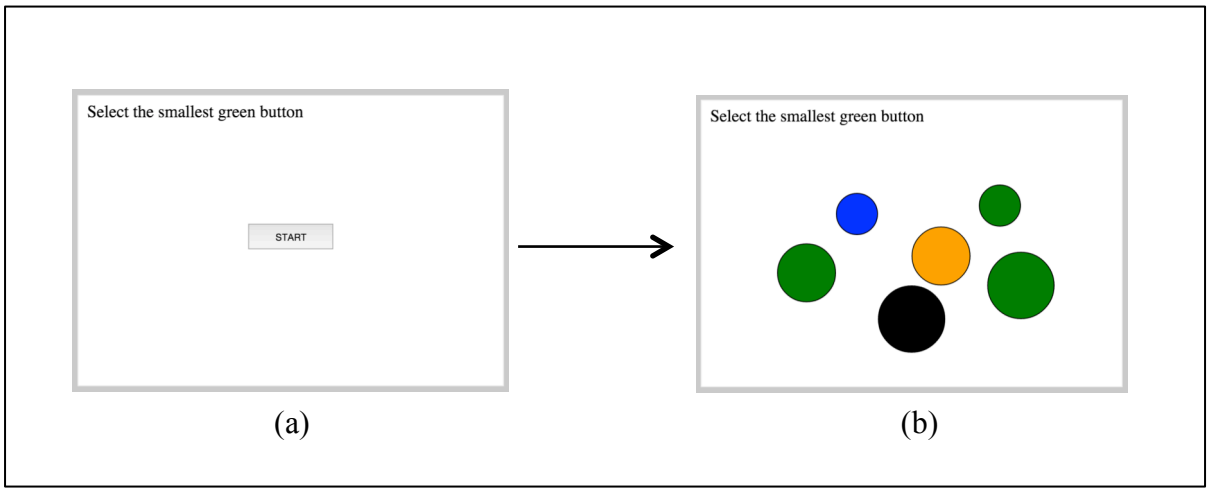

Figure 3.9 The interfaces of Task 2

The task began when the participants clicked on the Start button, but they were required to read the instruction at the beginning. The time taken to select the smallest green button was recorded as soon as the participant clicked on the Start button until clicking the intended button. On the second interface of Task 2 there were six buttons with various colors . See Figure 3.9 (b).

Since the participant was required to carry out this task on all devices: PC, SP, and TB, many variations of the above layout were designed with a different position of the smallest green button in effort to minimize any learning effect. This can be found in Appendix E. The learning effect might occur when the participant conducted Task 2 on all devices without changing the position of the smallest green button. The participant might perform Task 2 on the TB quicker than the PC if he/she started with the PC first since he/she already knew the place of the smallest green button. Subsequently, this might negatively affect our experiment.

3.7.3 Task 3 (Filling in a form):

This task is interested in testing the Keystroke-level model. The KLM consists of a set of operators: **K**, **P, B**, **H** and **M**. Each of these operators has a specific time (see section 2.2.4). To

meet the KLM requirements, the interfaces were designed. Task 3 consisted of two interfaces. The first interface was the same as the first interface of Task 2, which had instruction and a Start button in the middle of the page (Figure 3.10 (a)). The second interface contained the form that the participant was required to fill in after carefully reading the instructions. This is shown in Figure 3.10 (b).

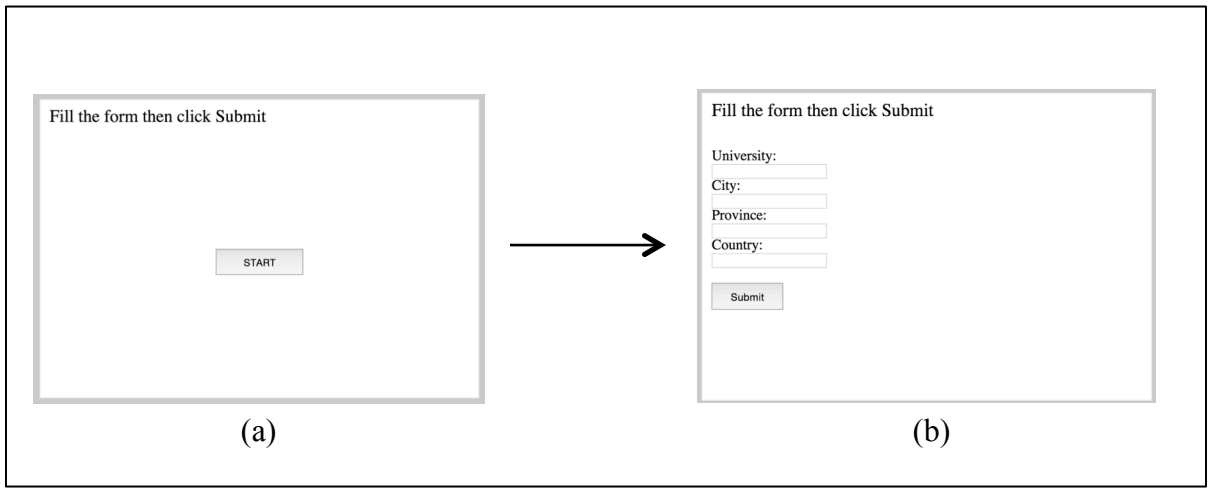

Figure 3.10 The interfaces of Task 3

Since we are interested in measuring the time taken for the participant to fill in the form, the time was recorded once the participant clicked on the Start button until the participant clicked on the Submit button. In this task, the style in which the participants filled in the form was observed for PC only. Some of the participants used the mouse to move between fields and others used the Tab key on the keyboard to move between the fields of the form. I refer to the former as mouse-based navigation and the latter as keyboard-based navigation.

3.7.4 Task 4 (Notice the different threshold):

Task 4 is concerned with testing Weber's law. Weber noticed that the relationship between initial stimuli intensity and the minimum detectable increment (see section 2.2.5). To gain a noticeable

variation in experience, the stimuli intensity needed to be altered. People had different levels of abilities in differentiating colors and this led us to choose the color black for this task. Task 4 consisted of two interfaces. The first interface was similar to those of Task 2 and Task 3 (see Figure 3.11 (a)). Therefore, six black vertical rectangular shapes were designed as the second interface of Task 4. This can be seen in Figure 3.11 (b).

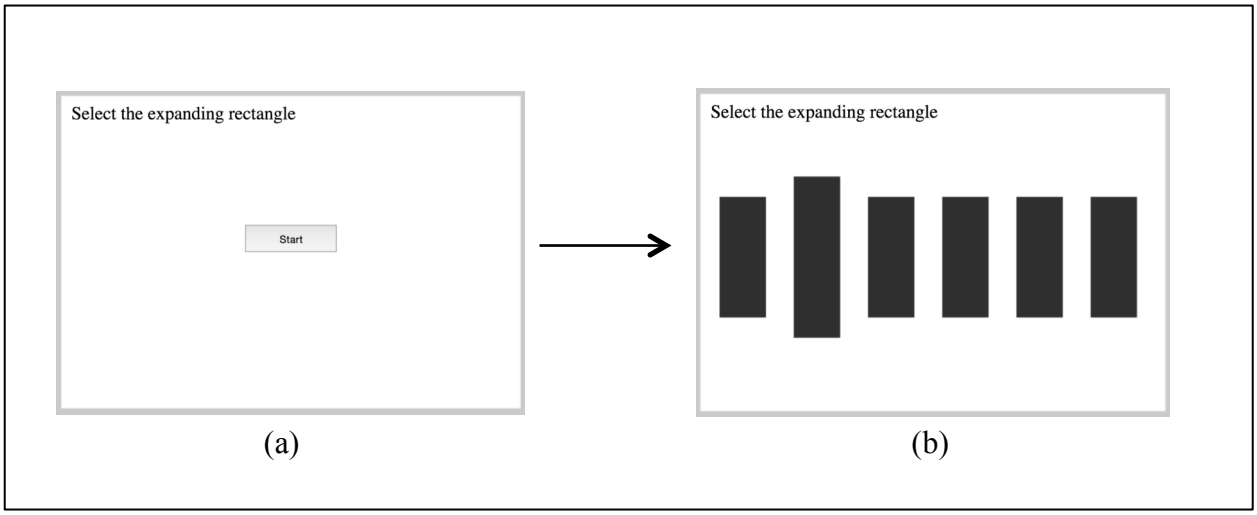

Figure 3.11 The interfaces of Task 4

The idea of this interface was that one of the rectangles was slightly expanding and the participant would select, when noticed, the expanding rectangle. The expanding rectangle expands in the length, rather than the width, by 0.1 pixel per 100 millisecond. After the instruction was read carefully by the participant, he/she clicked on the Start button to begin the task. The time taken for the participant to select the expanding rectangle was recorded in the database for analysis. To minimize the learning effect, variations of Figure 3.11 (b) were designed each with a different rectangle that expanded. This can be found in Appendix F.

3.7.5 Task 5 (Recalling items from color and word lists):

This task tests the principle of the Serial Position Effect law. This principle refers to finding the probability of recalling an item from a list differs according to the position of that item within that list (see section 2.2.6). People tend to retrieve the first few items of a list more frequently than the items in the middle, which is called the primacy effect. Furthermore, they retrieve items at the end of a list more frequently than the middle items, which is called the recency effect. To apply these principles of the Serial Position Effect, four interfaces of task 5 were designed. Task 5 was divided into two experiments A and B. Experiment A required the participant to recall a list of colors. It consisted of two interfaces. The first interface presented the participant with a list of colors, which the participant was required to remember. The second interface showed the colors that were shown before as well as five more colors from which to choose (Figure 3.12).

Since a similar study gave their participants 8 seconds to remember the colors [75], our participants were given 10 seconds for both reading the instructions and remembering the colors. Two more seconds were given for reading the instruction, and the remaining 8 seconds were for remembering the colors. There was a preface interface for task 5 that had the Start button in the middle of the page. The timer started counting the 10 seconds, once the participant clicked on the Start button. See Figure 3.12 (a).

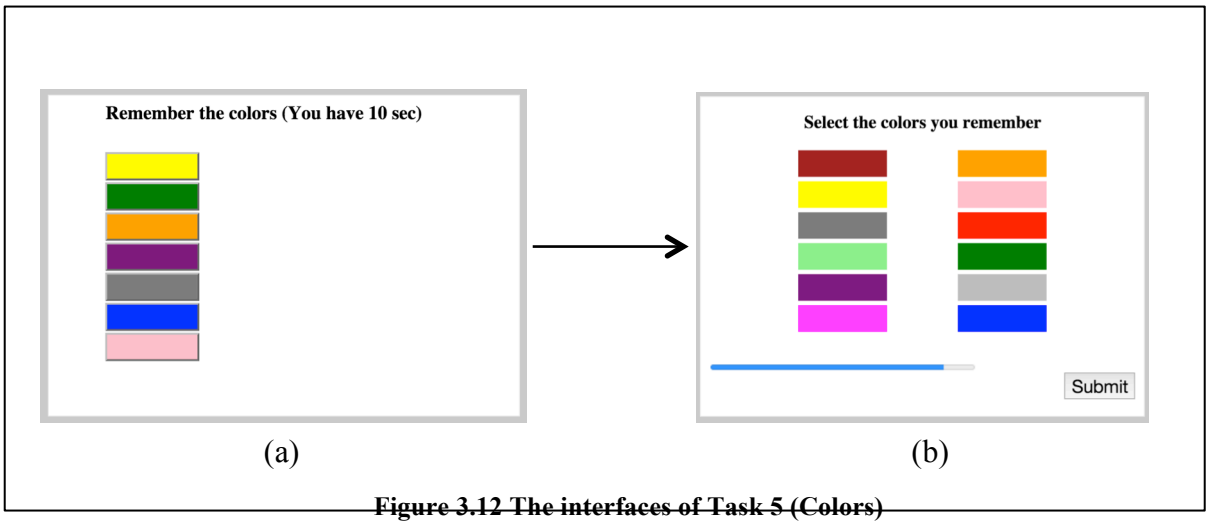

Figure 3.12 The interfaces of Task 5 (Colors)

When the timer reached the 10 seconds, the second interface with the twelve colors appeared. The participant was required to select the colors. In addition, there was a timer bar that gave 30 seconds to the participant to select the colors that were presented on the previous screen. This can be seen in Figure 3.12 (b). The selected colors were stored in the database for analysis. Since the participant was required to carry out this task on the three devices, many variations of the layout of Figure 3.12 (a) were designed with different colors in effort to minimize any learning effect that might occur. This is shown in Appendix G.

Experiment B of Task 5 was repeated exactly the same way, but this time with words, which were the months of the year. This is shown in Figure 3.13. Also, the variations of the layout of Figure 3.13 (a) can be seen in Appendix H.

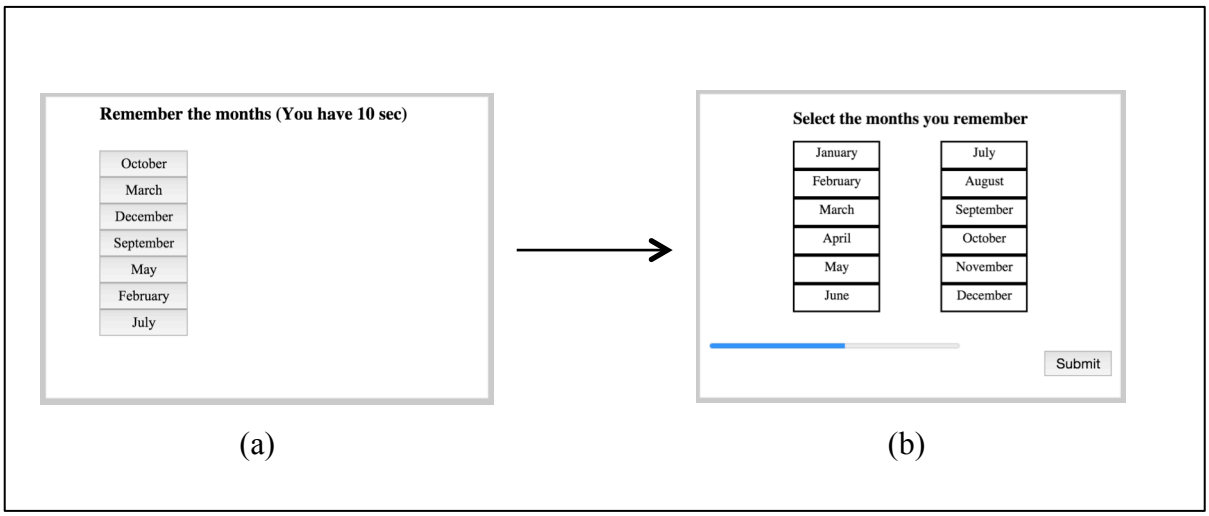

Figure 3.13 The interfaces of Task 5 (Words)

4. Results

The findings of the data analysis are presented in this chapter. ANOVA was used to identify the statistical differences in the mean time taken for the participants to perform the tasks on the three devices: the PC, the SP and the TB. The mean differences were tested by one-way analysis of variance with an alpha (P) level of 0.05. The SPSS software was used to analyze the findings of our experiment. Since we tested five predictive models in our experiment on the three devices, we designed five tasks where every task represented one predictive model. So, each task needed to be illustrated individually.

4.1 Task 1

The Fitts' law predicted that the time taken to complete this task was 2.510 seconds. As mentioned in the previous chapter, Task 1 was divided into 3 sub tasks. We analyzed the data for Task 1 as one task, and we also analyzed the data for Task 1 per each sub task. In Task 1, a number of outliers were found in the data on the three devices:

1. PC – 11 outliers found.
2. SP – 6 outliers found.
3. TB – 6 outliers found.

After removing the outliers, the overall mean time taken to complete the task on the three devices was calculated. This can be seen in Figure 4.1.

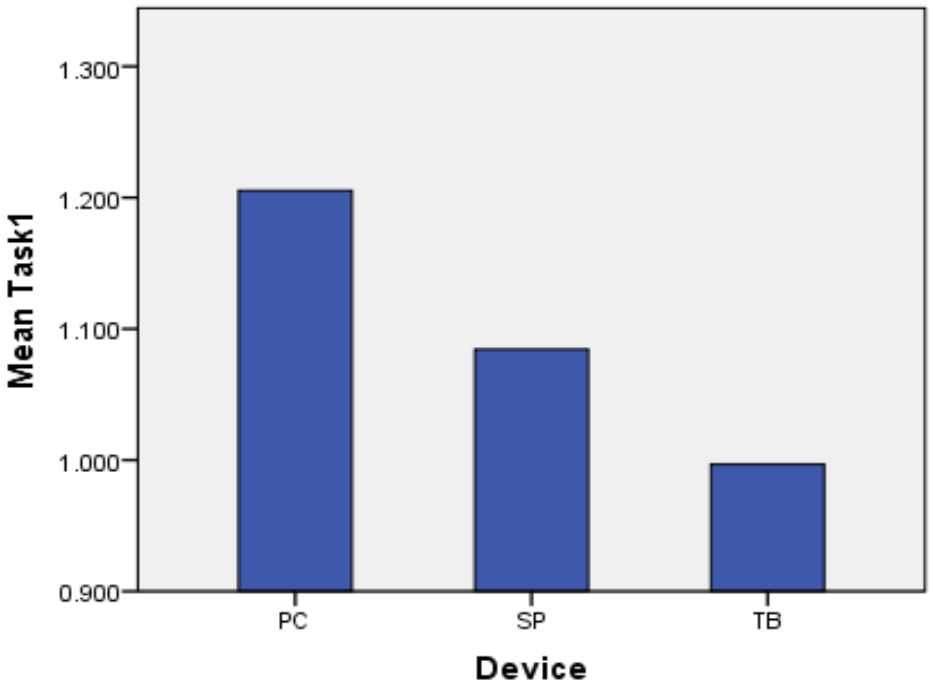

Figure 4.1 The mean time taken to perform Task 1 per device (time in seconds)

The bar chart points out that the participants took less time to perform the task using the TB device, with $\mu = 0.996$ seconds. However, the mean time taken to complete the task using the SP was $\mu = 1.084$ seconds and with the PC was $\mu = 1.205$ seconds. Table 4.1 shows the statistics for Task 1 on the three devices. The second column in the table shows the number of participants in the study. The devices are shown in the first column and the characteristics of the data are shown in other columns.

Table 4.1 Task 1 performed in the experiment (time in seconds)

Descriptives

Task1

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PC	100	1.20547	.538486	.053849	1.09862	1.31232	.583	3.013
SP	105	1.08444	.354880	.034633	1.01576	1.15312	.653	2.961
TB	105	.99667	.446843	.043607	.91019	1.08314	.551	2.727
Total	310	1.09375	.457999	.026013	1.04257	1.14494	.551	3.013

A significant difference was suggested by the one-way ANOVA results in the mean time taken for the participant to click on buttons, $F(2,307) = 5.512$, $p = 0.004$. The statistics for the time taken using the three devices are illustrated in Table 4.2.

Table 4.2 One-way ANOVA statistics for the time taken to perform Task 1

ANOVA

Task1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.247	2	1.123	5.512	.004
Within Groups	62.570	307	.204		
Total	64.817	309			

These are the results of Task 1. In the next pages, we will present the results of sub task (a), sub task (b) and sub task (c).

a) The Clickme button to button "1":

This was the first sub task of Task 1. The Fitts' law predicted that the time taken to complete this sub task was 3.470 seconds. The sub task was to measure the time taken for a participant to move from the Clickme button to button "1". The data for sub task (a) was analyzed and the number of outliers was found in the data as follows:

1. PC – 1 outlier.
2. SP – 3 outliers.
3. TB – 4 outliers.

After removing the outliers, the overall mean time taken on the three devices was calculated. This can be seen in Figure 4.2.

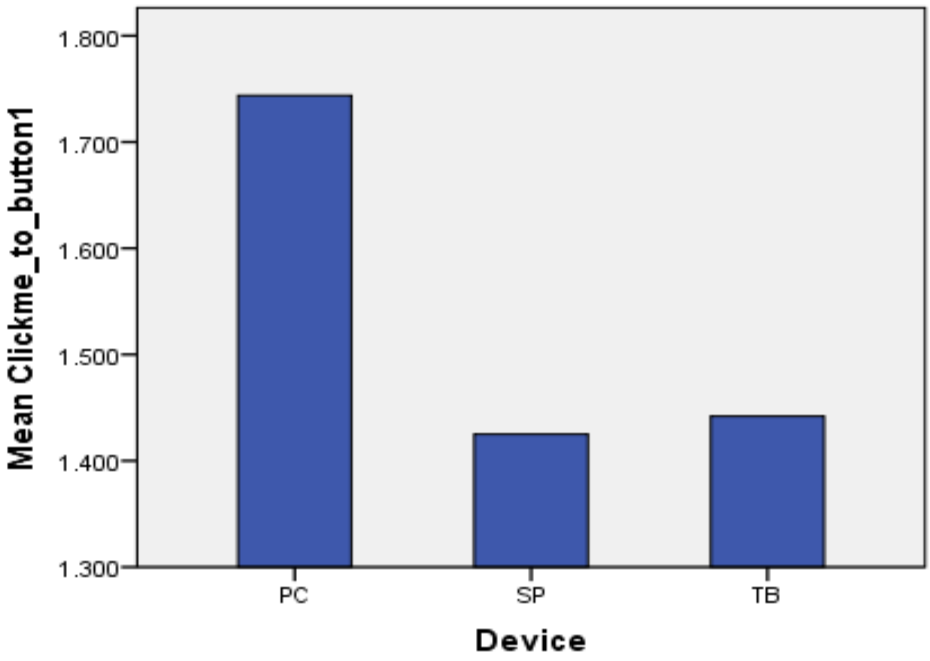

Figure 4.2 The mean time taken to perform sub task (a) per device (time in seconds)

The bar chart shows that the participants took less time to perform the sub task (a) using the SP device, with $\boldsymbol{\mu}$ = 1.424 seconds, whereas the mean time taken to complete this sub task using the TB was $\boldsymbol{\mu}$ = 1.442 seconds and with the PC was $\boldsymbol{\mu}$ = 1.743 seconds. Table 4.3 depicts the statistics for sub task (a) on the three devices.

Table 4.3 Sub task (a) performed in the experiment (time in seconds)

Descriptives

Clickme_to_Button1

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PC	36	1.74375	.541942	.090324	1.56038	1.92712	.803	3.013
SP	34	1.42497	.428418	.073473	1.27549	1.57445	.967	2.961
TB	33	1.44203	.541226	.094215	1.25012	1.63394	.739	2.727
Total	103	1.54185	.523663	.051598	1.43951	1.64420	.739	3.013

The one-way ANOVA suggested that there was a significant difference in the mean time taken to perform the sub task (a), $F(2,100) = 4.397$, $p = 0.015$. The statistics for the time taken using the three devices for sub task (a) are shown in Table 4.4.

Table 4.4 One-way ANOVA statistics for the time taken to perform sub task (a)

ANOVA

Clickme_to_Button1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.261	2	1.130	4.397	.015
Within Groups	25.710	100	.257		
Total	27.971	102			

a) Button "1" to button "2":

This was the second sub task of Task 1. The Fitts' law predicted that the time required to complete this sub task was 1.320 seconds. The sub task was to measure the time taken for a participant to move from button "1" and point to button "2". The data for sub task (b) was analyzed to gain the results. The number of outliers in the data when the participants using the PC was 3. Also, no outliers were found when the participants performed the sub task using the SP and the TB. After removing the outliers, the overall mean time taken on the three devices was calculated. This can be seen in Figure 4.3.

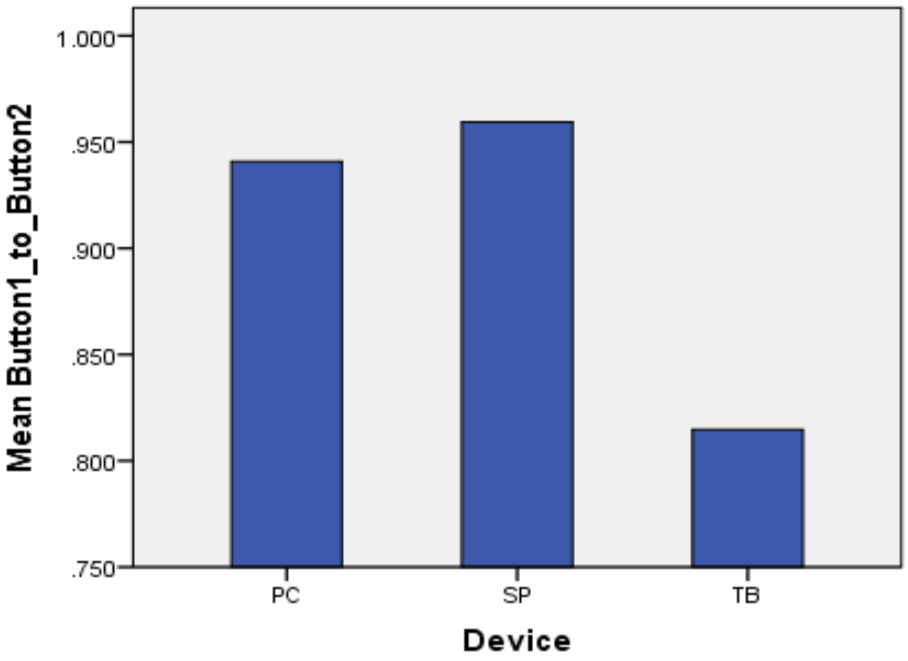

Figure 4.3 The mean time taken to perform sub task (b) per device (time in seconds)

The bar chart illustrates that the participants took less time to perform the sub task (b) using the TB device, with $\boldsymbol{\mu} = 0.814$ seconds, whereas the mean time taken to complete this sub task using the SP was $\boldsymbol{\mu} = 0.959$ seconds and with the PC was $\boldsymbol{\mu} = 0.940$ seconds. Table 4.5 shows the statistics for sub task (b) on the three devices.

Table 4.5 Sub task (b) performed in the experiment (time in seconds)

Descriptives

Button1_to_Button2

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PC	34	.94088	.206719	.035452	.86875	1.01301	.531	1.369
SP	37	.95946	.140247	.023056	.91270	1.00622	.751	1.305
TB	37	.81473	.179996	.029591	.75472	.87474	.552	1.280
Total	108	.90403	.186946	.017989	.86837	.93969	.531	1.369

The one-way ANOVA analyzed that there was a significant difference in the mean time taken to perform sub task (b), $F(2,105) = 7.271$, $p = 0.001$. The statistics for the time taken for sub task (b) using three devices are indicated in Table 4.6.

Table 4.6 One-way ANOVA statistics for the time taken to perform sub task (b)

ANOVA

Button1_to_Button2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.455	2	.227	7.271	.001
Within Groups	3.285	105	.031		
Total	3.740	107			

b) Button "2" to button "3":

This was the third sub task of Task 1. Fitts' law predicted that the time taken to complete this task was 2.740 seconds. The sub task was to measure the time taken for a participant to travel from button "2" and point to button "3". The data for sub task (c) was analyzed to gain the results. A number of outliers were found in the data:

1. PC – 6 outliers.
2. SP – 3 outliers.
3. TB – 2 outliers.

After removing the outliers, the overall mean time taken on the three devices was calculated. This is shown in Figure 4.4.

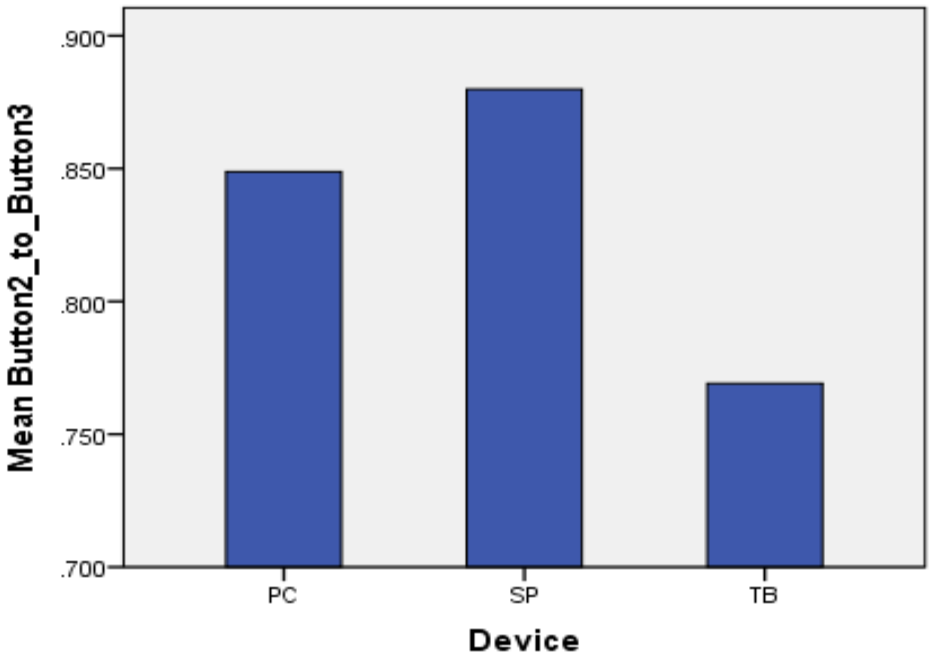

Figure 4.4 The mean time taken to perform sub task (c) per device (time in seconds)

The bar chart shows that the participants took less time to perform the sub task (c) using TB device, with $\boldsymbol{\mu}$ = 0.769 seconds whereas the mean time taken to perform this sub task using the SP was $\boldsymbol{\mu}$ = 0.879 seconds and with the PC was $\boldsymbol{\mu}$ = 0.848 seconds. Table 4.7 shows the statistics for sub task (c) on all three devices.

Table 4.7 Sub task (c) performed in the experiment (time in seconds)

Descriptives

Button2_to_Button3

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PC	31	.84881	.154637	.027774	.79209	.90553	.583	1.216
SP	34	.87991	.108695	.018641	.84199	.91784	.653	1.112
TB	35	.76909	.137475	.023237	.72186	.81631	.551	1.209
Total	100	.83148	.141248	.014125	.80345	.85951	.551	1.216

The one-way ANOVA suggested that there was a significant difference in the mean time taken to complete sub task (c), $F(2,97) = 6.245$, $p = 0.003$. The statistics for the time taken using three devices for sub task (c) are illustrated in Table 4.8.

Table 4.8 One-way ANOVA statistics for the time taken to perform sub task (c)

ANOVA

Button2_to_Button3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.225	2	.113	6.245	.003
Within Groups	1.750	97	.018		
Total	1.975	99			

4.2 Task 2

The Hick-Hyman law predicted that the time taken to complete this task was 1.200 seconds. The data for Task 2 was analyzed to verify whether there was a difference in the time taken by the participants to achieve the task on the three devices. In the data of Task 2, a number of outliers were found as follows:

1. PC – 6 outliers found.
2. SP – 4 outliers found.
3. TB – No outliers found.

After removing the outliers, the overall mean time taken for the participant to select the smallest green button on the three devices was calculated. The mean time taken to complete the task using the PC was $\mu = 1.844$ seconds, with the SP was $\mu = 1.792$ seconds and with the TB was $\mu = 1.662$ seconds. The one-way ANOVA suggested that there was no significant difference in the

mean time taken for the participant to make a decision on the three devices, F (2,98) = 0.531, p = 0.590.

4.3 Task 3

The KLM predicted that the time taken to complete this task was 15.840 seconds. After collecting the data for Task 3, the data was analyzed to show the results. There were some outliers found in the data as follows:

1. PC – No outliers found.
2. SP – 5 outliers found.
3. TB – 2 outliers found.

The overall mean time taken for the participant to fill in the form was calculated after eliminating the outliers. This can be seen in Figure 4.5.

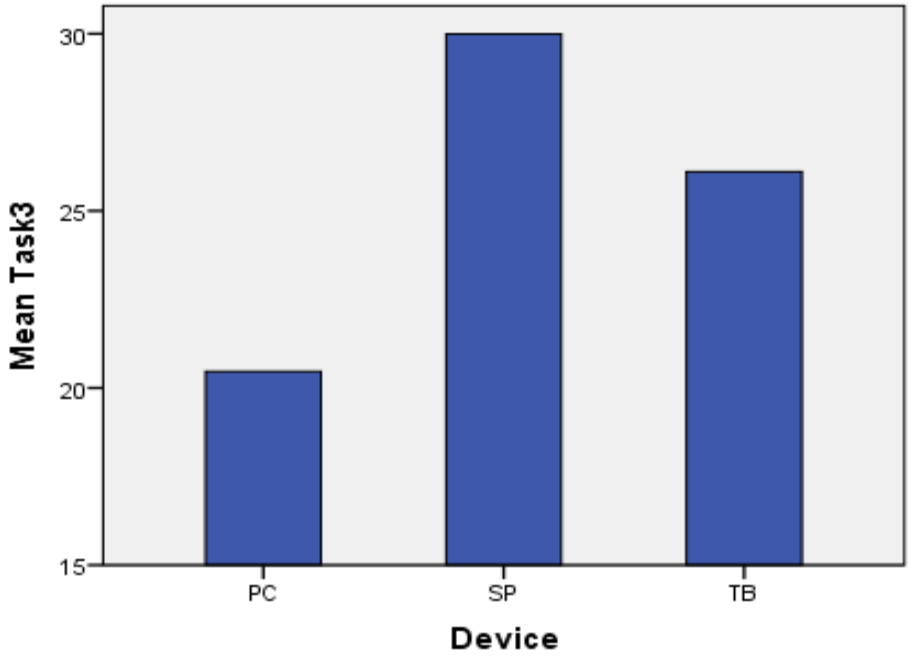

Figure 4.5 The mean time taken to perform Task 3 per device (time in seconds)

The bar chart illustrates the participants took less time to perform task 3 using PC, with μ = 20.465 seconds. Additionally, the mean time taken when using the SP was μ = 29.996 seconds and with the TB was μ = 26.101 seconds. Table 4.9 shows the statistics for Task 3 on the three devices**.**

Table 4.9 Task 3 performed in the experiment (time in seconds)

Descriptives

Task3

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PC	37	20.46597	6.910306	1.136047	18.16196	22.76998	9.283	36.932
SP	32	29.99663	8.554310	1.512203	26.91247	33.08078	15.131	48.532
TB	35	26.10169	6.450367	1.090311	23.88591	28.31746	11.794	41.331
Total	104	25.29512	8.241005	.808097	23.69245	26.89779	9.283	48.532

A significant difference was shown with the one-way ANOVA in the mean time taken for the participant to fill in the form, F (2,101) = 14.891, p = 0.000. The statistics for the time taken on the three devices for Task 3 are indicated in Table 4.10.

Table 4.10 One-way ANOVA statistics for the time taken to perform Task 3

ANOVA

Task3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1592.966	2	796.483	14.891	.000
Within Groups	5402.193	101	53.487		
Total	6995.159	103			

4.4 Task 4

The data for Task 4 was analyzed to notice whether there was a difference for the time taken by the participants to accomplish the task on each of the three devices. In the data of Task 4, there were 2 outliers found when using the TB. After removing the outliers, the overall mean time taken for the participant to notice the expanding rectangle on the three devices was calculated. The mean time taken when using the PC was μ = 6.800 seconds, with the SP it was μ = 6.748 seconds and with the TB was μ = 7.260 seconds. The one-way ANOVA indicated that there was no significant difference in the mean time taken for the participant to notice the different threshold, $F(2,106) = 0.395$, $p = 0.675$.

4.5 Task 5

In Task 5, the participant was asked to remember seven colors. Our concern in this task was to know the position of the recalled color. After collecting the data for Task 5, we verified how often the color in a specific position was recalled on each device throughout the experiment, finding the percentage of these instances. This task as mentioned in Chapter 3, was repeated the same way replacing colors with words.

As mentioned earlier, there were 37 participants. Since one of the participants did not select any answer in task 5, we discarded this participant's results from the data after the participant finished the experiment, resulting in data from only 36 participants. Table 4.11 shows the percentage of the recalled positions for both colors and words for PC.

Table 4.11 The percentage of recalled positions for PC

Color's position	Number of recalls	% Percentage	Word's position	Number of recalls	% Percentage
1	36	100	**1**	34	94.5
2	32	88.9	**2**	33	91.7
3	34	94.5	**3**	33	91.7
4	17	47.2	**4**	27	75
5	11	30.5	**5**	20	55.5
6	18	50	**6**	26	72.2
7	17	47.2	**7**	19	52.8

The percentage of the recalled positions for both colors and words for SP is shown in Table 4.12.

Table 4.12 The percentage of recalled positions for SP

Color's position	Number of recalls	% Percentage	Word's position	Number of recalls	% Percentage
1	28	77.8	**1**	30	83.3
2	20	55.5	**2**	27	75
3	24	66.7	**3**	28	77.8
4	27	75	**4**	26	72.2
5	28	77.8	**5**	30	83.3
6	27	75	**6**	27	75
7	24	66.7	**7**	25	69.4

For TB, the percentage of the recalled positions for both colors and words is revealed in Table 4.13.

Table 4.13 The percentage of recalled positions for TB

Color's position	Number of recalls	% Percentage	Word's position	Number of recalls	% Percentage
1	31	86.1	**1**	31	86.1
2	27	75	**2**	23	88.9
3	23	63.9	**3**	31	86.1
4	29	80.5	**4**	28	77.8
5	28	77.8	**5**	22	61.1
6	28	77.8	**6**	20	55.5
7	25	69.4	**7**	27	75

To clarify the above tables, we transformed each of the tables into charts. Figure 4.6 shows the relation between the position of color or word and the probability of recalling when using the PC.

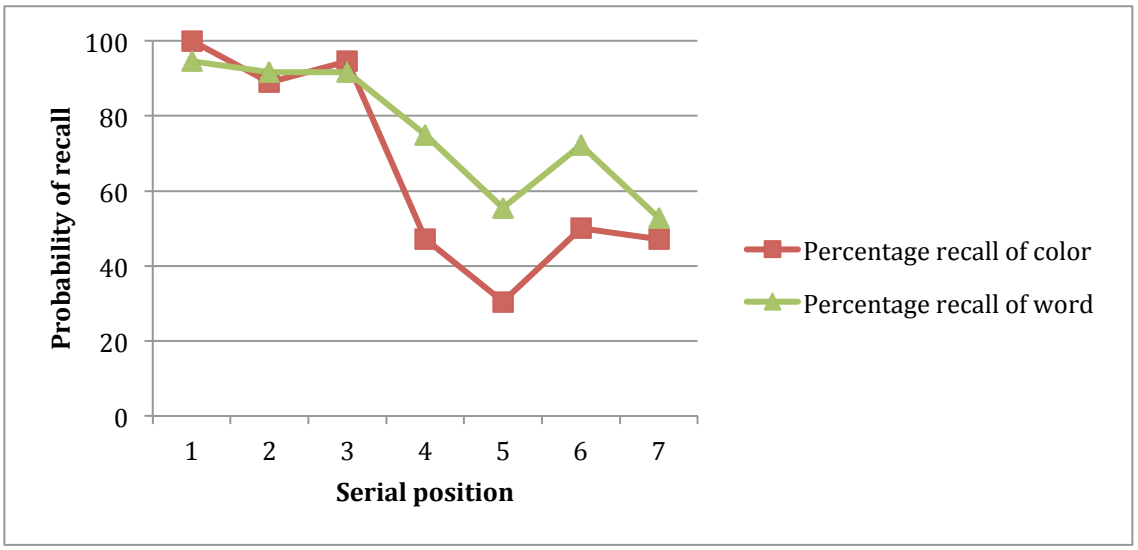

Figure 4.6 Probability of recall VS serial position for PC

Since the participants were asked to recall 7 colors and 7 words, the serial position of both the colors and words were represented on the X-axis, while the Y-axis represented the percentage of

the probability of recall. The relation between the position of the color or the word and the probability of recalling them is revealed for the use of the SP in Figure 4.7.

In Figure 4.8, the relation between the position of the color or the word and the probability of recalling is presented for the use of the TB.

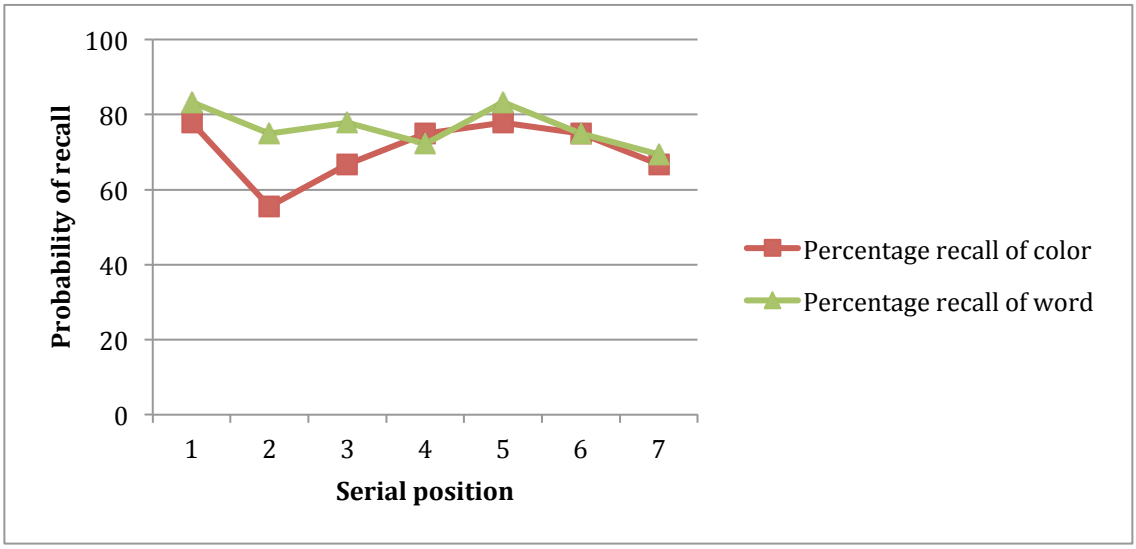

Figure 4.7 Probability of recall VS serial position for SP

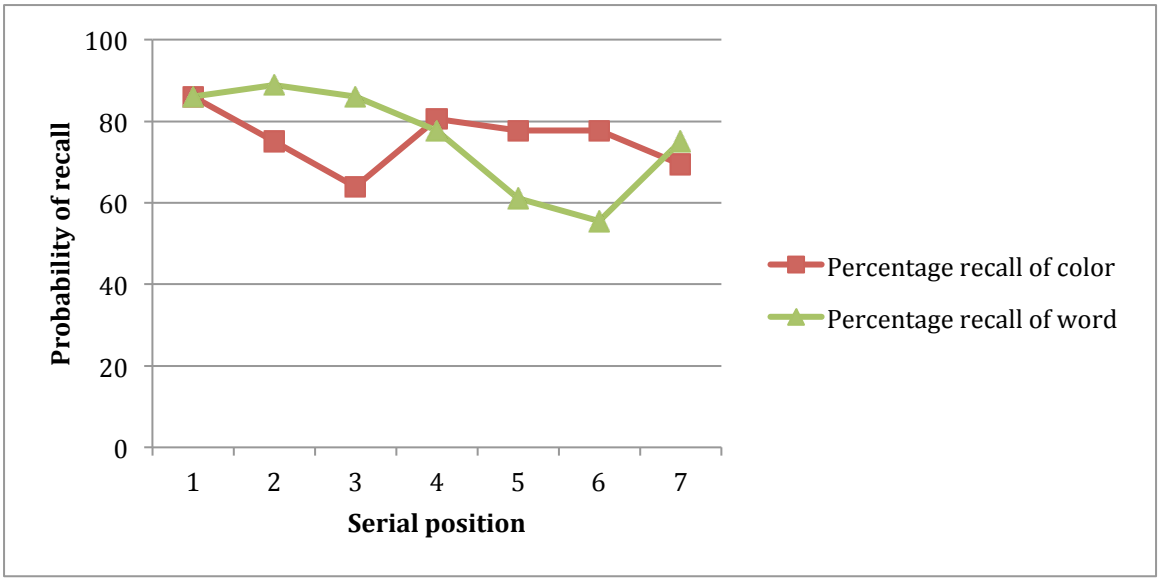

Figure 4.8 Probability of recall VS serial position for TB

Additionally, Cochran's Q test, which is designed to estimate differences across conditions in dichotomous results, was used in our study to analyze Task 5. In this task, we wanted to know whether the participant selected the correct color and word. So in dichotomous responses, (0s and 1s) were stored as our data to be analyzed by the non-parametric test Cochran's Q. Table 4.14 shows the descriptive statistics for the recalled colors' positions in the list of colors from position "1" to position "7" on the PC. Colors' positions are shown in the first column, the number of participants is shown in the second column, and the characteristics are shown in the other columns.

Table 4.14 Colors' positions descriptive statistics for PC

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
PC_Color_1	36	1.00	.000	1	1
PC_Color_2	36	.92	.280	0	1
PC_Color_3	36	.92	.280	0	1
PC_Color_4	36	.47	.506	0	1
PC_Color_5	36	.31	.467	0	1
PC_Color_6	36	.47	.506	0	1
PC_Color_7	36	.50	.507	0	1

Table 4.15 indicates the number of the color's position that was recalled correctly (value = 1) and the color's position that was not recalled correctly (value = 0). Also, Table 4.16 illustrates a significant difference in recalling the list of colors for the use of the PC. Asymptotic Significance (2-tailed) is less than 0.05 in this result, which shows the significant difference.

Table 4.15 Cochran's Q test for recalling colors on PC

Frequencies

	Value	
	0	1
PC_Color_1	0	36
PC_Color_2	3	33
PC_Color_3	3	33
PC_Color_4	19	17
PC_Color_5	25	11
PC_Color_6	19	17
PC_Color_7	18	18

Table 4.16 Cochran's Q test statistics for recalling colors on PC

Test Statistics

N	36
Cochran's Q	70.121[a]
df	6
Asymp. Sig.	.000

a. 1 is treated as a success.

The descriptive statistics for the recalled words' positions in the list of words from position "1" to position "7" on PC are shown in Table 4.17.

Table 4.17 Words' positions descriptive statistics on PC

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
PC_Word_1	36	.94	.232	0	1
PC_Word_2	36	.92	.280	0	1
PC_Word_3	36	.92	.280	0	1
PC_Word_4	36	.75	.439	0	1
PC_Word_5	36	.56	.504	0	1
PC_Word_6	36	.72	.454	0	1
PC_Word_7	36	.53	.506	0	1

Table 4.18 shows the number of the word's position that was recalled correctly. Table 4.19 illustrates a significant difference in recalling the list of words for the use of the PC since the Asymptotic Significance (2-tailed) is less than 0.05.

Table 4.18 Cochran's Q test for recalling words on PC

Frequencies

	Value	
	0	1
PC_Word_1	2	34
PC_Word_2	3	33
PC_Word_3	3	33
PC_Word_4	9	27
PC_Word_5	16	20
PC_Word_6	10	26
PC_Word_7	17	19

Table 4.19 Cochran's Q test statistics for recalling words on PC

Test Statistics

N	36
Cochran's Q	34.563[a]
df	6
Asymp. Sig.	.000

a. 1 is treated as a success.

The results point out that there is no significant difference in recalling not only the list of colors, but also the list of words for the use of the SP. Moreover, in recalling the list of colors on the TB, the results show that there is no significant difference. Table 4.20 shows the descriptive statistics for the recalled words' positions in the list of words from position "1" to position "7" on TB.

Table 4.20 Words' positions descriptive statistics on TB

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
TB_Word_1	36	.86	.351	0	1
TB_Word_2	36	.89	.319	0	1
TB_Word_3	36	.86	.351	0	1
TB_Word_4	36	.78	.422	0	1
TB_Word_5	36	.61	.494	0	1
TB_Word_6	36	.56	.504	0	1
TB_Word_7	36	.75	.439	0	1

Table 4.21 depicts the number of the participants who recalled the correct word for each word's position and who did not. Table 4.22 illustrates a significant difference in the performance of the users for recalling the list of words for the use of the TB since the Asymptotic Significance (2-tailed) is less than 0.05.

Table 4.21 Cochran's Q test for recalling words on TB

Frequencies

	Value	
	0	1
TB_Word_1	5	31
TB_Word_2	4	32
TB_Word_3	5	31
TB_Word_4	8	28
TB_Word_5	14	22
TB_Word_6	16	20
TB_Word_7	9	27

Table 4.22 Cochran's Q test statistics for recalling words on TB

Test Statistics

N	36
Cochran's Q	20.146[a]
df	6
Asymp. Sig.	.003

a. 1 is treated as a success.

5. Discussion

In this chapter, the findings, presented in Chapter 4 will be discussed. We will discuss each task individually.

5.1 Task 1

The time taken for the participant to complete Task 1 was measured and analyzed for all three devices. The experimental results suggest that the TB provided the best performance time. The participants performed much better in pointing at buttons on the screen of the TB device than that of the PC and the SP. The difference in pointing methods in Task 1 must be taken into account. The participants used the mouse to point at buttons on the PC screen, but fingers were used to perform the same task on both the SP and TB.

The results were as anticipated: using a mouse to point at buttons on the PC screen made the task more challenging than if they used their fingers to achieve the task. The task was easier to complete on both the SP and the TB than on the PC due to the different pointing methods. Also, the predicted time by the modeling was much longer than the usability time and was not predicting well even for PC. The probable reason behind that is using the advanced technologies such as the laser mouse that was used in our experiment instead of the ball mouse. Furthermore, users currently can adjust the mouse pointer speed, which may influence the time taken to click on a button.

The experiment recorded many different overshooting cases where the participant tried to click on the smallest sized button (button “1”). In addition, the maximum time taken occurred on the PC while the minimum time occurred on the TB.

Based on the findings, the null hypothesis is rejected in favor of the alternative hypothesis: there is a difference in the time taken to accomplish the task on all devices and was quickest on the TB. As known, Task 1 was divided into 3 sub tasks. Each sub task will be discussed individually.

a) Clickme button to button "1":

Pointing at a small size button is a difficult task, especially if the button is located far away from the starting point. The results of sub task (a) revealed that the participants' performance was better on the SP and the TB, with a slight advantage for the SP. Based on these results, the null hypothesis is rejected in favor of the alternative hypothesis: there is a difference in the time taken to point at button "1" on the SP and the TB comparing to the PC.

b) Button "1" to button "2":

Pointing at a button is an easy task to do when the distance is short. The results for sub task (b) illustrated that the TB was the device on which the participants performed their best. The SP recorded the highest mean time taken to accomplish the sub task (b), with a slight difference from the PC. Based on the results, the null hypothesis is rejected in favor of the alternative hypothesis: there is a difference in the time taken to point at button 2 on the TB compared to the other devices.

c) Button "2" to button "3":

In accordance with the results, pointing at a large button with a short distance is the easiest task to complete. The results of sub task (c) pointed out that the participants' performances were better on the TB than the PC and the SP. This leads us to reject the null hypothesis in favor of the alternative hypothesis: there is a difference in the time taken to point at button 3 on TB comparing to others.

5.2 Task 2

The results suggest that the majority of the participants agreed with the fact that Task 2 was an easy task to perform on all three devices. There was no significant difference in the time taken to select the smallest green button on each device. The time that the participants needed to make a decision among alternatives was relatively similar on all devices. In this case, the null hypothesis is not rejected, which states that there is no difference in the time taken to select the smallest green button among alternatives on all devices.

5.3 Task 3

Participants' performance in filling in the form was measured and analyzed on the three devices. The experimental results suggest that the PC provided quickest time taken to fill in the form. The participants performed much better in filling in the form on the PC device than the SP and the TB. Most of the participants using the PC in this task used the Tab key on the keyboard to move between the form fields and used the mouse to click on the Submit button.

The different types of the keyboards that were used in filling in the form in Task 3 must be taken into consideration, as it may alter the results. Many participants, in general, are more familiar with the physical keyboard because they have been in use for much longer than the touch keyboard on SPs and TBs. Additionally: some participants used the muscle memory technique to type on the physical keyboard, resulting in reduced time taken to fill in the form.

The results were as expected: the time it takes the touch keyboard to appear, after the participant clicked on the intended field of the form, took a great amount of time on both the SP and the TB. Moreover, the participants of the SP and the TB needed to scroll down every time to choose the

second field in the form, which indeed affected the time taken to achieve filling in the form. The task was much easier to do on the PC than on both the SP and TB. The experiment recorded less time taken for conducting the task on the TB than the SP. Based on the findings, the null hypothesis is rejected in favor of the alternative hypothesis: there is a difference in the time taken to achieve the task on all devices, and it was conducted rapidly on the PC.

5.4 Task 4

The results indicated that the time taken for the participants was similar on all devices, so their ability to notice minute differences in shapes with colors was almost identical on each platform. There was no significant difference in the time taken to detect the just noticeable difference (JND) on the PC, SP and TB. Based on these results, the null hypothesis is not rejected, which states that there is no difference in the time taken to detect the just noticeable difference on the three devices.

5.5 Task 5

The positions of the recalled colors and words were recorded and analyzed for the three devices. The Serial Position Effect law indicates that people tend to recall items at the end of a list more reliably and that the first few items are recalled more frequently than the items in the middle (see section 2.2.6).

The experimental results suggest that recalling a list of items on all three devices was not following the principle of Serial Position Effect. Using the PC, for instance, participants tended to recall colors in positions “1”, “2,” and “3” more than colors in other positions in the list of colors. The same in the list of words, participants tended to recall words in positions “1”, “2,”

and “3” more than the words in positions “4”, “5”, “6,” and “7”. Furthermore, colors’ positions “4”, “5,” and “6” were recalled less than words’ positions “4”, “5,” and “6”. Positions “2” and “3” in both colors and words lists were almost recalled identically.

In accordance with the SP’s results, items in positions “4”, “5,” and “6” were recalled slightly more than the item in position “7” in both color and word lists. In the list of colors, color in position “2” was recalled less than colors in positions “1” and “5”. Moreover, positions “4” and “7” of colors and words were recalled almost identically by users while position “6” was identically recalled in both lists.

In accordance with the results of TB, the results indicate that the participants recalled items in positions “4” and “5” more than items in position “2” and “7” in the color list, as well as they recalled item in positions “7” less than items in positions “3” and “4” in the word list. Also, in the list of words, participants tended to recall words in positions “1”, “2,” and “3” more than the words in positions “5” and “6”. Position “4” in the list of colors and words was recalled almost identically by participants, while position “1” was identically recalled in both lists. Recalling position “3” in the list of colors was less than recalling position “3” in the list of words, whereas the opposite was occurred when recalling position “6”.

For comparing the recalling of the colors’ positions on the three devices (PC, SP, and TB), interesting results were found. Colors in positions “1”, “2,” and “3” were recalled on PC more than TB and SP. Color in position “5” was identically recalled on both SP and TB and was recalled more than on PC. Also, colors in positions “4” and “6” were recalled on TB more than on SP and PC. There was no significant difference in recalling colors in position “7” on all devices.

On the other hand, in the list of words, there were no significant differences in recalling the words in positions “1”, “2”, “3”, “4,” and “6” on all devices. However, participants tended to recall the word in position “5” on SP more than on PC as well as they tended to recall the word in position “7” on PC less than on TB. Based on the findings, the null hypothesis is rejected in favor of the alternative hypothesis: There is a difference in recalling a list of colors and words on the three devices.

In addition to the overall results of the five tasks, we analyzed the data according to age, gender, program and degree to try to find significant differences. No significant differences were found, except that the just noticeable difference on TB between graduate and undergraduate students was significantly different.

Summary

In Table 5.1, the differences between the predicted time by the models and the mean time taken to complete a task by the participants for Task 1 to Task 4 are presented.

Table 5.1 Usability VS Modeling

Task#	**Usability**			**Modeling**
	PC	SP	TB	
Task 1	1.542	0.904	0.831	2.510
Task 1 (a)	1.744	1.425	1.442	3.470
Task 1 (b)	0.941	0.959	0.815	1.320
Task 1 (c)	0.849	0.880	0.769	2.740
Task 2	1.844	1.792	1.663	1.200
Task 3	20.466	29.997	26.102	13.840
Task 4	6.800	6.749	7.260	6.930

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In accordance with the above table, the predictive models predicted the time taken to complete the tasks. Since our main goal was to test the reliability of predictive models on three different devices, the time taken was predicted for each task using the predictive models. Then, we compared the predicted time by modeling with the mean of the time taken for the participants to accomplish the task.

Even though the predictive models that we utilized were applicable to the PC, the time predicted by the models was different than the time needed by the participants. Only the time predicted by Weber's law was almost similar to the time taken by the participants on the PC. This means that the predictive models predicted incorrect time for almost all the tasks in accordance with the above table.

Hick-Hyman law and KLM predicted times were much less than the usability time on all three devices. Also, the participants took more time to achieve the task that applied KLM model, especially on the SP and the TB. The probable reason was the input method (touch keyboard and fingers) that the participants used was as opposed to the input method that the model used (physical keyboard and mouse).

In regard to recalling items, the recall results were not in confirmation with what the Serial Position Effect predicts. The possible reasons for interference could be that the recalling could be influenced by other factors such as the brightness of color or personal bias to certain colors or words only. Moreover, past research was conducted on an auditory basis unlike our study. In our study, we asked the participants to recall both colors and words on a visual basis.

As stated in Chapter 2, the user interface laws were introduced a long time ago, such as Fitt's law in 1954, Hick-Hyman in 1953, KLM in 1983, Weber's law in 1834, and Serial Position Effect in

1902. In response to this fact, we argue that the laws are out of date. This is obvious by looking at the previous table where the time predicted by modeling was quite different than the usability time. Also, we suggest that predictive models need some modifications to be compatible with the modern devices with different screen sizes that we have today.

6. Conclusions

In this thesis research, we tested the reliability of predictive models on the personal computer, the smartphone and the tablet. To achieve this, various aspects of HCI were absorbed in detail such as user interface laws, web page designs, and data collection. Also, an HCI lab was constructed and designed to conduct the experiment and obtain the results.

We conducted an experiment on all three devices to achieve our goal. Also, five tasks were designed to test the reliability of predictive models where each task represented one of the user interface laws. The time taken for the participants to accomplish each task was our focus and needed to be collected for analysis. By collecting data, we obtained large sets of data and its analysis was time consuming.

Task 1 was designed to test one of the user interface laws, which is Fitts' law. The task was concerned with the time taken to point at buttons on the devices' screen while taking in consideration the starting point of that movement. The findings of Task 1 disproved the hypothesis that the performance of participants was identical on the PC, the SP and the TB. The participants performed much better to point at buttons on the screen of the TB device than the screen of both the PC and the SP. Moreover, the results indicated that some of the participants using the PC conducted many cases of overshooting to point at the smallest and farthest button when using a mouse to achieve the task.

Another user interface law was tested, Hick-Hyman law, when we designed Task 2. This task concerned with the reaction time and the time taken for the participant to make a decision, among alternatives on all three devices. The findings of Task 2 confirmed the null hypothesis that the time taken for the participants to complete the task was almost identical when using the

PC, SP and TB. Therefore, there were no significant differences in selecting the smallest green button among six colored buttons.

The Keystroke-Level model (KLM) was tested after designing Task 3. The KLM estimates task execution time from a specified design and particular scenario of the task. Task 3 focused on the time taken for the participants to fill in the form, which consisted of 4 fields, and then clicking on the Submit button. The experiment findings for Task 3 disproved the null hypothesis that the time taken for the participants to perform the task was identically when using the PC, SP and TB. The participants performed much better to fill in the form on the screen of the PC device than the SP and the TB. The reason for this result was due to using different keyboards in filling in the form in Task 3. Furthermore, the participants took much more time in filling the form on the SP and the TB because they needed to scroll down to reach to the intended field of the form.

Task 4 was designed to test another user interface law, which was Weber's law. The task was concerned with the users' ability of noticing minute differences in shapes filled with black color on all three devices. The findings of the experiment for Task 4 proved the null hypothesis that the time taken for the participants to accomplish the task was almost identically when using the PC, SP, and TB with no significant differences in detecting the just noticeable differences.

The fifth user interface law, the Serial Position Effect, was tested when we designed Task 5. The Serial Position Effect law reveals that the first few items and items at the end of a list are tended to be recalled more reliably than the middle items. We provided two lists for the participants to test: a list of seven colors and a list of seven words. The experiment's results for task 5 showed that participants tended to recall certain items in the middle more than the items at the end of the

list on all three devices. The probable reason for this result could be the dependency of recalling on other factors, such as brightness of color or personal bias to certain colors or words.

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Appendix A

Preface interface source code for the experiment

```
<?php
session_start();
if(!isset($_SESSION["id"])){

}else{
	$random = $_SESSION["id"];
}
?>
<!DOCTYPE HTML>
<html>
	<head>
		<title>Choose your platform</title>
		<script src="jquery-1.11.1.min.js"> </script>
		<style>
			.inputBox{
				height: 40px;
				width: 206px;
				background-image: url('entryBox.jpg');
				text-indent: 5px;
				font-size: 20px;
				border: 0px;
				top: -16px;
				position: relative;
			}
		</style>
		<script>
			function openPage(url){
			var idvalue = document.getElementById('idid').value;
				if(idvalue.length > 0 && idvalue != " "){
					$.post( "newParticipant.php", {ident: idvalue})
					.done(function( data ) {
						if(data != "success"){
							alert("Error! " + data);
						}else{
							window.location = url;
						}
					});
				}else{
					alert("Error! Please enter a participant ID");
				}
			}
		</script>
	</head>
	<body>
		<table style="position: relative; width:900px; height:300px; margin:0 auto; top:200px">
			<tr>
				<td colspan=3>
			<img src="entryText.jpg" /> <input type="text" name="idname" id="idid"
class="inputBox"/>
			</td>
			</tr>
			<tr>
```

```
                                        <td style="width:300px;"><img style="cursor:pointer;"
onclick="openPage('/pc/page1.php')" src="PCIcon.png" /></td>
                                        <td style="width:300px;"><img style="cursor:pointer;"
onclick="openPage('/smartphone/page1S.php')" src="SPIcon.png" /></td>
                                        <td style="width:300px;"><img style="cursor:pointer;"
onclick="openPage('/tablet/page1T.php')" src="TIcon.png" /></td>
                                </tr>
                        </table>
                </body>
</html>
```

The code of the interfaces of Task 1 for (PC, SP, and TB)

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
        <head>
                <title>HCI Experiment1</title>
                <script src="jquery-1.11.1.min.js"> </script>
                <style>
                        html, body
                        {
                                background-color: #ccc;
                                padding: 15px;
                                width: 90%;
                                height: 90%;
                        }
                        * {
                                margin: 0px;
                                padding: 0px;
                          }

                        h1
                        {
                                color: 333;
                                text-align: center;
                                margin-bottom: 50px;
                        }
                        p
                        {
                          font-size: 20px;
                          text-align: left;
                          //color: red;
                                margin-bottom: 20px;
                        }
                        ol
                        {
                                font-size: 20px;
                                margin-left: 50px;
                        }
                        #outer
                        {
                                width: 100%;
```

```
}

#inner
{
	margin: 0 auto;
	padding: 10px;
	background-color: #fff;
	border: 1px solid #eee;
	width: 480px;
	height: 320px;
}
#btn1
{
	width:80px;
	height:30px;
	left:0;
	top:0;
}
#btn2
{
	width:30px;
	height:30px;
	margin-left:380px;
	margin-top:260px;
	display: none;
}
#btn3
{
	width:80px;
	height:30px;
	margin-left:200px;
	margin-top:200px;
	display: none;
}
#btn4
{
	width:100px;
	height:50px;
	margin-left:380px;
	margin-top:5px;
	display: none;
}
#imgimg
{
margin-left: 100px;
//margin-top: 10px;
z-index: 10000;
float: right;
display: none;
}
#II
{
margin-bottom:0px;
margin-left:250px;

}
</style>
```

```
	</head>
	<body onmousemove="traceMouse(event)">
		<h1>1 out of 5
		</h1>
		<div id="outer">
<p id="II">Press Click me then follow the numbers</p>
</form><br><div id="inner">

<button id="btn1" onclick="clicked_(1)"><span style="color:blue;font-weight:bold; font-size:14px;">Click
Me</span></button>
<button id="btn2" onclick="clicked_(2)" onmouseover="hoverButton()" onmouseout="endHover()"><span
style="pointer-events: none;color:blue;font-weight:bold; font-size:18px;">1</span></button>
			<button id="btn3" onclick="clicked_(3)"><span style="color:blue;font-weight:bold;
font-size:18px;">2</span></button>
			<button id="btn4" onclick="clicked_(4)"><span style="color:blue;font-weight:bold;
font-size:18px;">3</span></button>
		</div></div>

		<a href="page2.php">
		<img id="imgimg" src="next.gif"  height="100" width="200" align="right">
		</a>
	</body>
	<script>
		var times = new Array();

		var state = 0;
		function hoverButton(){
			if(state == 0){
				state = 1;
			}
		}

		var maxy = 0;
		var maxx = 0;
		var curx = 0;
		var cury = 0;
		function traceMouse(e){
			if(state == 1 || state == 2){
				curx = e.clientX;
				cury = e.clientY;
				if(curx > maxx){ maxx = curx; }
				if(cury > maxy){ maxy = cury; }
			}
		}

		var exitPointX;
		var exitPointY;
		function endHover(){
			if(state == 1){
				state = 2;
				exitPointX = curx;
				exitPointY = cury;
			}
		}

		function clicked_(x)
		{
```

```
if(x == 2){
	if(state == 1){
		state = 3;		//No Overshoot
	}else if(state == 2){
		state = 4;		//We overshot the button
	}
}

var t = new Date();
times[x] = t;

document.getElementById("btn"+x).style.display = 'none';
if(x != 4)
{
	document.getElementById("btn"+(x+1)).style.display = 'inline';


}
if(x == 4)
{

var s = times[2] - times[1];
var n = times[3] - times[2];
var r = times[4] - times[3];
var overshootX;
var overshootY;

if(state == 3){
	overshootX = 0;
	overshootY = 0;
}else if(state == 4){
	overshootX = maxx - exitPointX;
	overshootY = maxy - exitPointY;
}

var id = "<?php echo($_SESSION["id"]); ?>";
$.post( "saveResults.php", { ident: id, field: "test1_firstsecond", value: s })
.done(function( data ) {
	if(data != "success"){
		alert("Error saving results " + data);
	}
});

$.post( "saveResults.php", { ident: id, field: "test1_secondthird", value: n })
.done(function( data ) {
	if(data != "success"){
		alert("Error saving results " + data);
	}
});

$.post( "saveResults.php", { ident: id, field: "test1_thirdfourth", value: r })
.done(function( data ) {
	if(data != "success"){
		alert("Error saving results " + data);
	}
});
```

```
                        $.post( "saveResults.php", { ident: id, field: "test1_overshoot_x", value: overshootX })
                        .done(function( data ) {
                                if(data != "success"){
                                        alert("Error saving results " + data);
                                }
                        });

                        $.post( "saveResults.php", { ident: id, field: "test1_overshoot_y", value: overshootY })
                        .done(function( data ) {
                                if(data != "success"){
                                        alert("Error saving results " + data);
                                }
                        });
                                document.getElementById('II').style.display = 'none';
                                document.getElementById('imgimg').style.display = 'inline';
                        }

                }
</script>

        </script>
</html>
```

The code of the interfaces of Task 2 for PC

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
	<head>
		<title>HCI Experiment2</title>
		<script src="jquery-1.11.1.min.js"> </script>
		<style>
			html, body
			{
				background-color: #ccc;
				padding: 15px;
				width: 90%;
			}
* {

		margin: 0px;

		padding: 0px;

		}

			h1
			{
				color: 333;
				text-align: center;
				margin-bottom: 50px;
			}

			p
			{
			  font-size: 20px;
			  text-align: left;
			  //color: red;
			}

			ol
			{
				font-size: 20px;
				margin-left: 50px;

			}

			#outer
			{
				width: 100%;
			}

			#inner
			{
				margin: 0 auto;
				padding: 10px;
				background-color: #fff;
```

```
        border: 1px solid #eee;
        width: 480px;
        height: 320px;
        position: relative;
}
#btn1
{
        width:100px;
        height:30px;
        margin-left:190px;
        margin-top:120px;
        z-index: 1;
        position: absolute;
}
#btn2
{
        width:70px;
        height:70px;
        background-color: green;
        display: none;
        margin-left:80px;
        margin-top:140px;
        z-index: 10;
        position: absolute;
        border-radius: 100%;
border: 1px solid #000;
}
#btn3
{
        width:50px;
        height:50px;
        display: none;
        background-color: green;
        margin-left:320px;
        margin-top:70px;
        z-index: 100;
        position: absolute;
        border-radius: 100%;
border: 1px solid #000;
}
#btn4
{
        width:70px;
        height:70px;
        background-color: orange;
        display: none;
        margin-left:240px;
        margin-top:120px;
        z-index: 1000;
        position: absolute;
        border-radius: 100%;
border: 1px solid #000;
}
#btn5
{
        width:80px;
        height:80px;
```

```
                    background-color: black;
                    color: white;
                    display: none;
                    margin-left:200px;
                    margin-top:190px;
                    z-index: 10000;
                    position: absolute;
                    border-radius: 100%;
                border: 1px solid #000;
                }
                #btn6
                {
                    width:80px;
                    height:80px;
                    background-color: green;
                    display: none;
                    margin-left:330px;
                    margin-top:150px;
                    z-index: 100000;
                    position: absolute;
                    border-radius: 100%;
                border: 1px solid #000;
                }
                #btn7
                {
                    width:50px;
                    height:50px;
                    background-color: blue;
                    color: white;
                    display: none;
                    margin-left:150px;
                    margin-top:80px;
                    z-index: 1000000;
                    position: absolute;
                    border-radius: 100%;
                border: 1px solid #000;
                }
                #imgimg
                {
                margin-left: 100px;
                //margin-top: 10px;
                z-index: 10000;
                float: right;
                display: none;
                }
                #II
                {
                }
                </style>
</head>
<body>
        <h1>2 out of 5</h1>


        <div id="outer"><div id="inner">
        <p id="II">Select the smallest green button</p>
```

```
                        <button id="btn1" onclick="clicked_(1)">START</button>
                        <button id="btn2" onclick="clicked_(2)"></button>
                        <button id="btn3" onclick="clicked_(3)"></button>
                        <button id="btn4" onclick="clicked_(4)"></button>
                        <button id="btn5" onclick="clicked_(5)"></button>
                        <button id="btn6" onclick="clicked_(6)"></button>
                        <button id="btn7" onclick="clicked_(7)"></button>


                </div></div>
                <a href="page3.php">
                <img id="imgimg" src="next.gif"  height="100" width="200" align="right">
                </a>
        </body>
        <script>
                var times = new Array();
                function clicked_(x)
                {
                        var d = new Date();
                        times[x] = d;

                        document.getElementById("btn"+x).style.display = 'none';
                        for(var i = 2; i < 8;i++)
                                document.getElementById("btn"+i).style.display = 'inline';

                        if(x == 3)
                        {
                                var s = times[3] - times[1];
                                var id = "<?php echo($_SESSION["id"]); ?>";
                                $.post( "saveResults.php", { ident: id, field: "test2_time", value: s })
                                .done(function( data ) {
                                        if(data != "success"){
                                                alert("Error saving results " + data);
                                        }
                                });

                                document.getElementById("II").style.display = 'none';
                                document.getElementById('imgimg').style.display = 'inline';
                                for(var i = 2; i < 8;i++)
                                document.getElementById("btn"+i).style.display = 'none';
                        }
                }
        </script>
</html>
```

The code of the interfaces of Task 2 for SP

```
 <?php
session_start();
?>
```

```
<!DOCTYPE html>
<html>
	<head>
		<title>HCI Experiment2</title>
		<script src="jquery-1.11.1.min.js"> </script>
		<style>
			html, body
			{
				background-color: #ccc;
				padding: 15px;
				width: 90%;
			}
* {

		margin: 0px;

		padding: 0px;

		}

			h1
			{
				color: 333;
				text-align: center;
				margin-bottom: 50px;
			}

			p
			{
			  font-size: 20px;
			  text-align: left;
			  //color: red;
			}

			ol
			{
				font-size: 20px;
				margin-left: 50px;

			}

			#outer
			{
				width: 100%;
			}

			#inner
			{
				margin: 0 auto;
				padding: 10px;
				background-color: #fff;
				border: 1px solid #eee;
				width: 480px;
				height: 320px;
				position: relative;
			}
			#btn1
```

```
{
	width:100px;
	height:30px;
	margin-left:190px;
	margin-top:120px;
	z-index: 1;
	position: absolute;
}
#btn2
{
	width:70px;
	height:70px;
	background-color: green;
	display: none;
	margin-left:80px;
	margin-top:140px;
	z-index: 10;
	position: absolute;
	border-radius: 100%;
border: 1px solid #000;
}
#btn3
{
	width:80px;
	height:80px;
	display: none;
	background-color: black;
	margin-left:320px;
	margin-top:70px;
	z-index: 100;
	position: absolute;
	border-radius: 100%;
border: 1px solid #000;
}
#btn4
{
	width:70px;
	height:70px;
	background-color: orange;
	display: none;
	margin-left:240px;
	margin-top:120px;
	z-index: 1000;
	position: absolute;
	border-radius: 100%;
border: 1px solid #000;
}
#btn5
{
	width:50px;
	height:50px;
	background-color: green;
	color: white;
	display: none;
	margin-left:200px;
	margin-top:190px;
	z-index: 10000;
```

```
                        position: absolute;
                        border-radius: 100%;
                border: 1px solid #000;
                }
                #btn6
                {
                        width:80px;
                        height:80px;
                        background-color: green;
                        display: none;
                        margin-left:330px;
                        margin-top:170px;
                        z-index: 100000;
                        position: absolute;
                        border-radius: 100%;
                border: 1px solid #000;
                }
                #btn7
                {
                        width:50px;
                        height:50px;
                        background-color: blue;
                        color: white;
                        display: none;
                        margin-left:150px;
                        margin-top:80px;
                        z-index: 1000000;
                        position: absolute;
                        border-radius: 100%;
                border: 1px solid #000;
                }
                #imgimg
                {
                margin-left: 100px;
                //margin-top: 10px;
                z-index: 10000;
                float: right;
                display: none;
                }
                #II
                {
                }
                </style>
</head>
<body>
        <h1>2 out of 5</h1>
        <div id="outer"><div id="inner">
        <p id="II">Select the smallest green button</p>
                <button id="btn1" onclick="clicked_(1)">START</button>
                <button id="btn2" onclick="clicked_(2)"></button>
                <button id="btn3" onclick="clicked_(3)"></button>
                <button id="btn4" onclick="clicked_(4)"></button>
                <button id="btn5" onclick="clicked_(5)"></button>
                <button id="btn6" onclick="clicked_(6)"></button>
                <button id="btn7" onclick="clicked_(7)"></button>
        </div></div>
        <a href="page3S.php">
```

```
                <img id="imgimg" src="next.gif"  height="100" width="200" align="right">
                </a>
        </body>
        <script>
                var times = new Array();
                function clicked_(x)
                {
                        var d = new Date();
                        times[x] = d;

                        document.getElementById("btn"+x).style.display = 'none';
                        for(var i = 2; i < 8;i++)
                                document.getElementById("btn"+i).style.display = 'inline';
                        if(x == 5)
                        {
                                var s = times[5] - times[1];
                                var id = "<?php echo($_SESSION["id"]); ?>";
                                $.post( "saveResults.php", { ident: id, field: "test2_time", value: s })
                                .done(function( data ) {
                                        if(data != "success"){
                                                alert("Error saving results " + data);
                                        }
                                });
                                document.getElementById("II").style.display = 'none';
                                document.getElementById('imgimg').style.display = 'inline';
                                for(var i = 2; i < 8;i++)
                                document.getElementById("btn"+i).style.display = 'none';
                        }
                }
        </script>
</html>
```

The code of the interfaces of Task 2 for TB

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
        <head>
                <title>HCI Experiment2</title>
                <script src="jquery-1.11.1.min.js"> </script>
                <style>
```

```
		html, body
		{
			background-color: #ccc;
			padding: 15px;
			width: 90%;
		}
* {

	margin: 0px;

	padding: 0px;

	}

		h1
		{
			color: 333;
			text-align: center;
			margin-bottom: 50px;
		}

		p
		{
		  font-size: 20px;
		  text-align: left;
		  //color: red;
		}

		ol
		{
			font-size: 20px;
			margin-left: 50px;

		}

		#outer
		{
			width: 100%;
		}

		#inner
		{
			margin: 0 auto;
			padding: 10px;
			background-color: #fff;
			border: 1px solid #eee;
			width: 480px;
			height: 320px;
			position: relative;
		}
		#btn1
		{
			width:100px;
			height:30px;
			margin-left:190px;
			margin-top:120px;
			z-index: 1;
```

```
        position: absolute;
}
#btn2
{
        width:50px;
        height:50px;
        background-color: green;
        display: none;
        margin-left:120px;
        margin-top:140px;
        z-index: 10;
        position: absolute;
        border-radius: 100%;
border: 1px solid #000;
}
#btn3
{
        width:70px;
        height:70px;
        display: none;
        background-color: green;
        margin-left:320px;
        margin-top:70px;
        z-index: 100;
        position: absolute;
        border-radius: 100%;
border: 1px solid #000;
}
#btn4
{
        width:70px;
        height:70px;
        background-color: orange;
        display: none;
        margin-left:230px;
        margin-top:110px;
        z-index: 1000;
        position: absolute;
        border-radius: 100%;
border: 1px solid #000;
}
#btn5
{
        width:80px;
        height:80px;
        background-color: green;
        color: white;
        display: none;
        margin-left:200px;
        margin-top:190px;
        z-index: 10000;
        position: absolute;
        border-radius: 100%;
border: 1px solid #000;
}
#btn6
{
```

```
                        width:80px;
                        height:80px;
                        background-color: black;
                        display: none;
                        margin-left:330px;
                        margin-top:150px;
                        z-index: 100000;
                        position: absolute;
                        border-radius: 100%;
                border: 1px solid #000;
                }
                #btn7
                {
                        width:50px;
                        height:50px;
                        background-color: blue;
                        color: white;
                        display: none;
                        margin-left:150px;
                        margin-top:80px;
                        z-index: 1000000;
                        position: absolute;
                        border-radius: 100%;
                border: 1px solid #000;
                }
                #imgimg
                {
                margin-left: 100px;
                //margin-top: 10px;
                z-index: 10000;
                float: right;
                display: none;
                }
                #II
                {
                }
                </style>
</head>
<body>
        <h1>2 out of 5</h1>
        <div id="outer"><div id="inner">
        <p id="II">Select the smallest green button</p>
                <button id="btn1" onclick="clicked_(1)">START</button>
                <button id="btn2" onclick="clicked_(2)"></button>
                <button id="btn3" onclick="clicked_(3)"></button>
                <button id="btn4" onclick="clicked_(4)"></button>
                <button id="btn5" onclick="clicked_(5)"></button>
                <button id="btn6" onclick="clicked_(6)"></button>
                <button id="btn7" onclick="clicked_(7)"></button>
        </div></div>
        <a href="page3T.php">
        <img id="imgimg" src="next.gif"  height="100" width="200" align="right">
        </a>
</body>
<script>
        var times = new Array();
        function clicked_(x)
```

```
		{
			var d = new Date();
			times[x] = d;
			document.getElementById("btn"+x).style.display = 'none';
			for(var i = 2; i < 8;i++)
				document.getElementById("btn"+i).style.display = 'inline';
			if(x == 2)
			{
				var s = times[2] - times[1];
				var id = "<?php echo($_SESSION["id"]); ?>";
				$.post( "saveResults.php", { ident: id, field: "test2_time", value: s })
				.done(function( data ) {
					if(data != "success"){
						alert("Error saving results " + data);
					}
				});

				document.getElementById("II").style.display = 'none';
				document.getElementById('imgimg').style.display = 'inline';
				for(var i = 2; i < 8;i++)
				document.getElementById("btn"+i).style.display = 'none';
			}
		}
	</script>
</html>
```

The code of the interfaces of Task 3 for all devices

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
	<head>
		<title>HCI Experiment 3</title>
		<script src="jquery-1.11.1.min.js"> </script>
	</head>
	<style>
			html, body
			{
				background-color: #ccc;
				padding: 15px;
				width: 90%;
```

```
                }
* {
        margin: 0px;
        padding: 0px;
        }
                h1
                {
                        color: 333;
                        text-align: center;
                        margin-bottom: 50px;
                }
                p
                {
                  font-size: 20px;
                  text-align: left;
                }
                ol
                {
                        font-size: 20px;
                        margin-left: 50px;
                }
                #outer
                {
                        width: 100%;
                }

                #inner
                {
                        margin: 0 auto;
                        padding: 10px;
                        background-color: #fff;
                        border: 1px solid #eee;
                        width: 480px;
                        height: 320px;
                        position: relative;
                }
                #btn1
                {
                        width:100px;
                        height:30px;
                        margin-left:190px;
                        margin-top:140px;
                        position: absolute;
                        z-index: 100;
                }

                #btn2
                {
                        width:80px;
                        height:30px;
                        position: absolute;
                        z-index: 1000;
                }
                #frm
                {
                        margin: 30px;
                        text-align: left;
```

```
                        display: none;
                }
                #imgimg
                {
                margin-left: 100px;
                //margin-top: 10px;
                z-index: 10000;
                float: right;
                display: none;
                }

                #imgimgimg
                {
                margin-left: 100px;
                margin-bottom: 100px;
                float: right;
                display: none;
                }
                #II
                {
                }
                </style>
<body>
<h1>3 out of 5</h1>
        <div id="outer"><div id="inner">
        <p id="II">Fill the form then click Submit</p>
        <button id="btn1" onclick="clicked_(1)">START</button>

        <div id="frm">
                <br/><br>
                University: <br/> <input type="text" name="university"><br>
                City:<br/> <input type="text" name="city"><br>
                Province: <br/> <input type="text" name="province"><br>
                Country: <br/> <input type="text" name="country"><br><br>
                <button id="btn2" onclick="clicked_(2)">Submit</button>
        </div>
        </div></div>
        <a href="page4T.php">
        <img id="imgimg" src="next.gif"  height="100" width="200" align="right">
        </a>
</body>
<script>
        var times = new Array();
        function clicked_(x)
        {
                var d = new Date();
                times[x] = d;
                document.getElementById("btn1").style.display = 'none';
                document.getElementById('frm').style.display = 'inline';

                if(x == 2)
                {
                var s = times[2] - times[1];

                        var id = "<?php echo($_SESSION["id"]); ?>";
                        $.post( "saveResults.php", { ident: id, field: "test3_time", value: s })
                        .done(function( data ) {
```

```
                                        if(data != "success"){
                                                alert("Error saving results " + data);
                                        }
                                });
                                document.getElementById('II').style.display = 'none';
                                document.getElementById('imgimg').style.display = 'inline';
                                document.getElementById('frm').style.display = 'none';

                        }
                return true;
                }
        </script>
</html>
```

The code of the interfaces of Task 4 for PC

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
 <head>
  <title>HCI Experiment4</title>
  <script src="jquery-1.11.1.min.js"> </script>
  <style>
   html, body
   {
    background-color: #ccc;
    padding: 15px;
    width: 90%;
   }
   * {
                margin: 0px;
                padding: 0px;
                }

   h1
   {
    color: 333;
    text-align: center;
    margin-bottom: 50px;
   }
   p
   {
     font-size: 20px;
     text-align: left;
     margin-bottom: 20px:
   }

   ol
                {
                        font-size: 20px;
                        margin-left: 50px;
```

```
                                }

 #outer
 {
  width: 100%;
 }

 #inner
 {
  margin: 0 auto;
  padding: 10px;
  background-color: #fff;
  border: 1px solid #eee;
  width: 480px;
  height: 320px;
 }
 #btn
 {
  width:100px;
  height:30px;
  margin-left:190px;
  margin-top:110px;
 }
 #imgimg
                                {
                                margin-left: 100px;
                                z-index: 10000;
                                float: right;
                                display: none;
                                }
                                #II
                                {
                                }
 </style>
</head>
<body>
 <h1>4 out of 5</h1>
 <div id="outer"><div id="inner">
 <p id="II">Select the expanding rectangle</p>
  <canvas id="cnv" width="480" height="320" style="display: none"></canvas>
  <button id="btn" onclick="strt()">Start</button>
 </div></div>
 <a href="page5.php">
 <img id="imgimg" src="next.gif"  height="100" width="250" align="right">
 </a>
</body>
<script>
function strt()
{
          document.getElementById("btn").style.display = 'none';
  document.getElementById("cnv").style.display = 'inline';
  init();
}
 var times = new Array();
 function clicked_(x)
 {
```

```
 var d = new Date();
 times[x] = d;
 document.getElementById("btn"+x).style.display = 'none';
 for(var i = 2; i <= 8;i++)
  document.getElementById("btn"+i).style.display = 'inline';


}
function Shape(x, y, w, h, fill)
{
 this.x = x;
 this.y = y;
 this.w = w;
 this.h = h;
 this.fill = fill;
}
var elem = document.getElementById('cnv');
var myRect = [];
var xx = 0;
var rnd = Math.floor(Math.random() * 1) + 1;
var k = true;
function init()
{
        if (elem.getContext)
        {
                myRect.push(new Shape(10, 80, 50, 130, "#333"));
                myRect.push(new Shape(90, 80, 50, 130, "#333"));
                myRect.push(new Shape(170, 80, 50, 130, "#333"));
                myRect.push(new Shape(250, 80, 50, 130, "#333"));
                myRect.push(new Shape(330, 80, 50, 130, "#333"));
                myRect.push(new Shape(410, 80, 50, 130, "#333"));
                context = elem.getContext('2d');
                for (var i in myRect)
                {
                        oRec = myRect[i];
                        context.fillStyle = oRec.fill;
                        context.fillRect(oRec.x, oRec.y, oRec.w, oRec.h);
                }
                animate(rnd);
        }
}
function animate(c)
{
 xx = xx + .1;
 oRec = myRect[c]
 context.fillRect(oRec.x, oRec.y-(xx/2), oRec.w, oRec.h+xx);
 if(k)
        setTimeout(function(){animate(c)}, 100);
}
function collides(rects, x, y) {
  var isCollision = false;
     var left = rects[rnd].x, right = rects[rnd].x+rects[rnd].w;
     var top = rects[rnd].y, bottom = rects[rnd].y+rects[rnd].h;
     if (right >= x
        && left <= x
        && bottom >= y
        && top <= y) {
```

```
            isCollision = rects[rnd];
        }
        return isCollision;
    }
    elem.addEventListener('click', function(e)
    {
        var rect = collides(myRect, e.offsetX, e.offsetY);
        if (rect)
        {

        var s = xx*1000;
        var n = xx+" px";

                    var id = "<?php echo($_SESSION["id"]); ?>";
                                $.post( "saveResults.php", { ident: id, field: "test4_time", value: s })
                                .done(function( data ) {
                                    if(data != "success"){
                                        alert("Error saving results " + data);
                                    }
                                });
                                $.post( "saveResults.php", { ident: id, field: "test4_change", value: n })
                                .done(function( data ) {
                                    if(data != "success"){
                                        alert("Error saving results " + data);
                                    }
                                });
            k = false;
               document.getElementById("cnv").style.display = 'none';
               document.getElementById("II").style.display = 'none';

            document.getElementById('imgimg').style.display = 'inline';
        }
    }, false);
 </script>
</html>
```

The interfaces of Task 4 code for SP

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
 <head>
  <title>HCI Experiment4</title>
  <script src="jquery-1.11.1.min.js"> </script>
  <style>
   html, body
   {
    background-color: #ccc;
    padding: 15px;
    width: 90%;
   }
```

```
* {

		margin: 0px;

		padding: 0px;

		}

h1
{
 color: 333;
 text-align: center;
 margin-bottom: 50px;
}
p
{
   font-size: 20px;
   text-align: left;
   margin-bottom: 20px:
   //color: red;
}

ol
			{
				font-size: 20px;
				margin-left: 50px;

			}

#outer
{
 width: 100%;
}

#inner
{
 margin: 0 auto;
 padding: 10px;
 background-color: #fff;
 border: 1px solid #eee;
 width: 480px;
 height: 320px;
}
#btn
{
 width:100px;
 height:30px;
 margin-left:190px;
 margin-top:110px;
}

#imgimg
			{
			margin-left: 100px;
			//margin-top: 10px;
			z-index: 10000;
			float: right;
```

```
                                display: none;
                                }

                                #II
                                {
                                }
 </style>
</head>
<body>
 <h1>4 out of 5</h1>


 <div id="outer"><div id="inner">
 <p id="II">Select the expanding rectangle</p>
  <canvas id="cnv" width="480" height="320" style="display: none"></canvas>
  <button id="btn" onclick="strt()">Start</button>
 </div></div>

 <a href="page5S.php">
 <img id="imgimg" src="next.gif"  height="100" width="250" align="right">
 </a>

</body>
<script>

function strt()
{
          document.getElementById("btn").style.display = 'none';
  document.getElementById("cnv").style.display = 'inline';
  init();
}

 var times = new Array();
 function clicked_(x)
 {
  var d = new Date();
  times[x] = d;

  document.getElementById("btn"+x).style.display = 'none';
  for(var i = 2; i <= 8;i++)
   document.getElementById("btn"+i).style.display = 'inline';


 }


 function Shape(x, y, w, h, fill)
 {
  this.x = x;
  this.y = y;
  this.w = w;
  this.h = h;
  this.fill = fill;
 }

 var elem = document.getElementById('cnv');
 var myRect = [];
```

```
var xx = 0;
var rnd = Math.floor(Math.random() * 1) + 3;
var k = true;
function init()
{
        if (elem.getContext)
        {
                myRect.push(new Shape(10, 80, 50, 130, "#333"));
                myRect.push(new Shape(90, 80, 50, 130, "#333"));
                myRect.push(new Shape(170, 80, 50, 130, "#333"));
                myRect.push(new Shape(250, 80, 50, 130, "#333"));
                myRect.push(new Shape(330, 80, 50, 130, "#333"));
                myRect.push(new Shape(410, 80, 50, 130, "#333"));
                context = elem.getContext('2d');
                for (var i in myRect)
                {
                        oRec = myRect[i];
                        context.fillStyle = oRec.fill;
                        context.fillRect(oRec.x, oRec.y, oRec.w, oRec.h);
                }

                animate(rnd);
        }
}

function animate(c)
{
 xx = xx + .1;
 oRec = myRect[c]
 context.fillRect(oRec.x, oRec.y-(xx/2), oRec.w, oRec.h+xx);
 if(k)
        setTimeout(function(){animate(c)}, 100);
}

function collides(rects, x, y) {
  var isCollision = false;
     var left = rects[rnd].x, right = rects[rnd].x+rects[rnd].w;
     var top = rects[rnd].y, bottom = rects[rnd].y+rects[rnd].h;
     if (right >= x
        && left <= x
        && bottom >= y
        && top <= y) {
        isCollision = rects[rnd];
  }
  return isCollision;
}

elem.addEventListener('click', function(e)
{
     var rect = collides(myRect, e.offsetX, e.offsetY);
     if (rect)
     {

     var s = xx*1000;
     var n = xx+" px";
        //alert("time" + xx*1000);
        //alert("change " + xx + " px");
```

```
        k = false;

                        var id = "<?php echo($_SESSION["id"]); ?>";
                        $.post( "saveResults.php", { ident: id, field: "test4_time", value: s })
                                .done(function( data ) {
                                        if(data != "success"){
                                                alert("Error saving results " + data);
                                        }
                                });
                                $.post( "saveResults.php", { ident: id, field: "test4_change", value: n })
                                .done(function( data ) {
                                        if(data != "success"){
                                                alert("Error saving results " + data);
                                        }
                                });
           document.getElementById("cnv").style.display = 'none';
           document.getElementById("II").style.display = 'none';
         document.getElementById('imgimg').style.display = 'inline';
      }
   }, false);
 </script>
</html>
```

The code of the interfaces of Task 4 for TB

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
 <head>
  <title>HCI Experiment4</title>
  <script src="jquery-1.11.1.min.js"> </script>
  <style>
   html, body
   {
    background-color: #ccc;
    padding: 15px;
    width: 90%;
   }
   * {

                margin: 0px;

                padding: 0px;

                }

  h1
   {
    color: 333;
    text-align: center;
    margin-bottom: 50px;
```

```
}
p
{
  font-size: 20px;
  text-align: left;
  margin-bottom: 20px:
  //color: red;
}

ol
                        {
                                font-size: 20px;
                                margin-left: 50px;

                        }

#outer
{
 width: 100%;
}

#inner
{
 margin: 0 auto;
 padding: 10px;
 background-color: #fff;
 border: 1px solid #eee;
 width: 480px;
 height: 320px;
}
#btn
{
 width:100px;
 height:30px;
 margin-left:190px;
 margin-top:110px;
}

#imgimg
                        {
                        margin-left: 100px;
                        //margin-top: 10px;
                        z-index: 10000;
                        float: right;
                        display: none;
                        }

                        #II
                        {
                        }
 </style>
</head>
<body>
 <h1>4 out of 5</h1>


 <div id="outer"><div id="inner">
```

```
<p id="II">Select the expanding rectangle</p>
 <canvas id="cnv" width="480" height="320" style="display: none"></canvas>
 <button id="btn" onclick="strt()">Start</button>
</div></div>

<a href="page5T.php">
<img id="imgimg" src="next.gif"  height="100" width="250" align="right">
</a>

</body>
<script>

function strt()
{
        document.getElementById("btn").style.display = 'none';
  document.getElementById("cnv").style.display = 'inline';
  init();
}

 var times = new Array();
 function clicked_(x)
 {
 var d = new Date();
 times[x] = d;

 document.getElementById("btn"+x).style.display = 'none';
 for(var i = 2; i <= 8;i++)
  document.getElementById("btn"+i).style.display = 'inline';


 }


 function Shape(x, y, w, h, fill)
 {
 this.x = x;
 this.y = y;
 this.w = w;
 this.h = h;
 this.fill = fill;
 }

 var elem = document.getElementById('cnv');
 var myRect = [];
 var xx = 0;
 var rnd = Math.floor(Math.random() * 1) + 5;
 var k = true;
 function init()
 {
        if (elem.getContext)
        {
                myRect.push(new Shape(10, 80, 50, 130, "#333"));
                myRect.push(new Shape(90, 80, 50, 130, "#333"));
                myRect.push(new Shape(170, 80, 50, 130, "#333"));
                myRect.push(new Shape(250, 80, 50, 130, "#333"));
                myRect.push(new Shape(330, 80, 50, 130, "#333"));
                myRect.push(new Shape(410, 80, 50, 130, "#333"));
```

```
                context = elem.getContext('2d');
                for (var i in myRect)
                {
                        oRec = myRect[i];
                        context.fillStyle = oRec.fill;
                        context.fillRect(oRec.x, oRec.y, oRec.w, oRec.h);
                }

                        animate(rnd);
        }
}

function animate(c)
{
 xx = xx + .1;
 oRec = myRect[c]
 context.fillRect(oRec.x, oRec.y-(xx/2), oRec.w, oRec.h+xx);
 if(k)
        setTimeout(function(){animate(c)}, 100);
}

function collides(rects, x, y) {
  var isCollision = false;
     var left = rects[rnd].x, right = rects[rnd].x+rects[rnd].w;
     var top = rects[rnd].y, bottom = rects[rnd].y+rects[rnd].h;
     if (right >= x
        && left <= x
        && bottom >= y
        && top <= y) {
        isCollision = rects[rnd];
  }
  return isCollision;
}
 elem.addEventListener('click', function(e)
 {
     var rect = collides(myRect, e.offsetX, e.offsetY);
     if (rect)
     {
     var s = xx*1000;
     var n = xx+" px";
                        var id = "<?php echo($_SESSION["id"]); ?>";
                        $.post( "saveResults.php", { ident: id, field: "test4_time", value: s })
                        .done(function( data ) {
                                if(data != "success"){
                                        alert("Error saving results " + data);
                                }
                        });
                        $.post( "saveResults.php", { ident: id, field: "test4_change", value: n })
                        .done(function( data ) {
                                if(data != "success"){
                                        alert("Error saving results " + data);
                                }
                        });
        k = false;
           document.getElementById("cnv").style.display = 'none';
           document.getElementById("II").style.display = 'none';
        document.getElementById('imgimg').style.display = 'inline';
```

```
        }
    }, false);
 </script>
</html>
```

The code of the interfaces of Task 5 for PC

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
        <head>
                <title>HCI Experiment5-1-1</title>
                <style>
                        html, body
                        {
                                background-color: #ccc;
                                padding: 15px;
                                width: 90%;
                        }
* {

                margin: 0px;

                padding: 0px;

                }

                        h1
                        {
                                color: 333;
                                text-align: center;
                                margin-bottom: 50px;
                        }

                        p
                        {
                          font-size: 20px;
                          text-align: left;
                          //color: red;
                        }

                        ol
                        {
                                font-size: 20px;
                                margin-left: 50px;
```

```
}

#outer
{
        width: 100%;
}

#inner
{
        margin: 0 auto;
        padding: 10px;
        background-color: #fff;
        border: 1px solid #eee;
        width: 480px;
        height: 320px;
}
#btn1
{
        width:100px;
        height:30px;
        margin-left:190px;
        margin-top:140px;

}

#timer
{
        width:100px;
        height:30px;
        margin-left:290px;
        float: right;
   display: none;
   font-size: 20px;

}

#btn2
{
        width:100px;
        height:30px;
        margin-top: 30px;
        margin-left: 50px;
        display: none;
        background-color: yellow;

}
#btn3
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        background-color: green;

}
#btn4
{
```

```
                width:100px;
                height:30px;
                margin-left: 50px;
                display: none;
                background-color: orange;

        }
        #btn5
        {
                width:100px;
                height:30px;
                margin-left: 50px;
                background-color: purple;
                color: white;
                display: none;


        }
        #btn6
        {
                width:100px;
                height:30px;
                margin-left: 50px;
                background-color: gray;
                display: none;

        }
        #btn7
        {
                width:100px;
                height:30px;
                margin-left: 50px;
                background-color: blue;
                color: white;
                display: none;
        }
        #btn8
        {
                width:100px;
                height:30px;
                margin-left: 50px;
                //margin:10px 80px 100px 50px;
                background-color: pink;
                color: white;
                display: none;
        }
        #btn9
        {
        color: black;
        text-align:center;
        display:none;
        font-weight:bold;
        margin: 100px 50px;
        }
        </style>
</head>
<body>
```

```
		<h1>5 out of 5</h1>



		<div id="outer"><div id="inner">
			<button id="btn1" onclick="init()">START</button>
			<p id="btn9" onclick="clicked_(9)">Remember the colors (You have 10 sec)</p><br>
			<button id="btn2" onclick="clicked_(2)"></button><br>
			<button id="btn3" onclick="clicked_(3)"></button><br>
			<button id="btn4" onclick="clicked_(4)"></button><br>
			<button id="btn5" onclick="clicked_(5)"></button><br>
			<button id="btn6" onclick="clicked_(6)"></button><br>
			<button id="btn7" onclick="clicked_(7)"></button><br>
			<button id="btn8" onclick="clicked_(8)"></button><br/>
			<button id="timer"></button>
		</div></div>



	</body>
	<script>

		function init()
		{
			document.getElementById('btn1').style.display = 'none';
			for(var i = 2; i <= 9;i++)
				document.getElementById("btn"+i).style.display = 'inline';

			timer();
		}

		var x = 0
		function timer()
		{
			document.getElementById('timer').innerHTML = x;
			if(x < 13)
			{
				x++;
				setTimeout(function(){timer();}, 1000);
			}
			else
				window.location.href = "page5-1.php";
		}



	</script>
</html>
```

The code of the interfaces of Task 5 for SP

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
	<head>
		<title>HCI Experiment5-1-1</title>
		<script src="jquery-1.11.1.min.js"> </script>
		<style>
			html, body
			{
				background-color: #ccc;
				padding: 15px;
				width: 90%;
			}
* {

		margin: 0px;

		padding: 0px;

		}

			h1
			{
				color: 333;
				text-align: center;
				margin-bottom: 50px;
			}

			p
			{
			  font-size: 20px;
			  text-align: left;
			  //color: red;
			}

			ol
			{
				font-size: 20px;
				margin-left: 50px;

			}

			#outer
			{
```

```
        width: 100%;
}

#inner
{
        margin: 0 auto;
        padding: 10px;
        background-color: #fff;
        border: 1px solid #eee;
        width: 480px;
        height: 320px;
}
#btn1
{
        width:100px;
        height:30px;
        margin-left:190px;
        margin-top:140px;

}

#timer
{
        width:100px;
        height:30px;
        margin-left:290px;
        float: right;
   display: none;
   font-size: 20px;

}

#btn2
{
        width:100px;
        height:30px;
        margin-top: 30px;
        margin-left: 50px;
        display: none;
        background-color: silver;

}
#btn3
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        background-color: purple;

}
#btn4
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
```

```
                    background-color: brown;

                }
                #btn5
                {
                    width:100px;
                    height:30px;
                    margin-left: 50px;
                    background-color: green;
                    color: white;
                    display: none;


                }
                #btn6
                {
                    width:100px;
                    height:30px;
                    margin-left: 50px;
                    background-color: red;
                    display: none;

                }
                #btn7
                {
                    width:100px;
                    height:30px;
                    margin-left: 50px;
                    background-color: fuchsia;
                    color: white;
                    display: none;
                }
                #btn8
                {
                    width:100px;
                    height:30px;
                    margin-left: 50px;
                    //margin:10px 80px 100px 50px;
                    background-color: lightgreen;
                    color: white;
                    display: none;
                }
                #btn9
                {
                color: black;
                text-align:center;
                display:none;
                font-weight:bold;
                margin: 100px 20px;
                }
                </style>
</head>
<body>
        <h1>5 out of 5</h1>
```

```
		<div id="outer"><div id="inner">
			<button id="btn1" onclick="init()">START</button>
			<p id="btn9" onclick="clicked_(9)">Remember the colors (You have 10 sec)</p><br>
			<button id="btn2" onclick="clicked_(2)"></button><br>
			<button id="btn3" onclick="clicked_(3)"></button><br>
			<button id="btn4" onclick="clicked_(4)"></button><br>
			<button id="btn5" onclick="clicked_(5)"></button><br>
			<button id="btn6" onclick="clicked_(6)"></button><br>
			<button id="btn7" onclick="clicked_(7)"></button><br>
			<button id="btn8" onclick="clicked_(8)"></button><br/>
			<button id="timer"></button>
		</div></div>



	</body>
	<script>

		function init()
		{
			document.getElementById('btn1').style.display = 'none';
			for(var i = 2; i <= 9;i++)
				document.getElementById("btn"+i).style.display = 'inline';

			timer();
		}

		var x = 0
		function timer()
		{
			document.getElementById('timer').innerHTML = x;
			if(x < 13)
			{
				x++;
				setTimeout(function(){timer();}, 1000);
			}
			else
				window.location.href = "page5S-1.php";
		}



	</script>
</html>
```

The code of the interfaces of Task 5 for TB

```
<!DOCTYPE html>
<html>
	<head>
		<title>HCI Experiment5-1-1</title>
		<style>
			html, body
			{
				background-color: #ccc;
				padding: 15px;
				width: 90%;
			}
* {

		margin: 0px;

		padding: 0px;

		}

			h1
			{
				color: 333;
				text-align: center;
				margin-bottom: 50px;
			}

			p
			{
			  font-size: 20px;
			  text-align: left;
			  //color: red;
			}

			ol
			{
				font-size: 20px;
				margin-left: 50px;

			}

			#outer
			{
				width: 100%;
			}

			#inner
			{
				margin: 0 auto;
				padding: 10px;
				background-color: #fff;
				border: 1px solid #eee;
				width: 480px;
				height: 320px;
```

```
}
#btn1
{
        width:100px;
        height:30px;
        margin-left:190px;
        margin-top:140px;

}

#timer
{
        width:100px;
        height:30px;
        margin-left:290px;
        float: right;
   display: none;
   font-size: 20px;

}

#btn2
{
        width:100px;
        height:30px;
        margin-top: 30px;
        margin-left: 50px;
        display: none;
        background-color: red;

}
#btn3
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        background-color: lightgreen;

}
#btn4
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        background-color: fuchsia;

}
#btn5
{
        width:100px;
        height:30px;
        margin-left: 50px;
        background-color: blue;
        color: white;
        display: none;
```

```
		}
		#btn6
		{
			width:100px;
			height:30px;
			margin-left: 50px;
			background-color: yellow;
			display: none;

		}
		#btn7
		{
			width:100px;
			height:30px;
			margin-left: 50px;
			background-color: silver;
			color: white;
			display: none;
		}
		#btn8
		{
			width:100px;
			height:30px;
			margin-left: 50px;
			//margin:10px 80px 100px 50px;
			background-color: orange;
			color: white;
			display: none;
		}
		#btn9
		{
		color: black;
		text-align:center;
		display:none;
		font-weight:bold;
		margin: 100px 10px;
		}
		</style>
</head>
<body>
	<h1>5 out of 5</h1>


	<div id="outer"><div id="inner">
		<button id="btn1" onclick="init()">START</button>
		<p id="btn9" onclick="clicked_(9)">Remember the colors (You have 10 sec)</p><br>
		<button id="btn2" onclick="clicked_(2)"></button><br>
		<button id="btn3" onclick="clicked_(3)"></button><br>
		<button id="btn4" onclick="clicked_(4)"></button><br>
		<button id="btn5" onclick="clicked_(5)"></button><br>
		<button id="btn6" onclick="clicked_(6)"></button><br>
		<button id="btn7" onclick="clicked_(7)"></button><br>
		<button id="btn8" onclick="clicked_(8)"></button><br/>
		<button id="timer"></button>
```

```
		</div></div>



	</body>
	<script>

		function init()
		{
			document.getElementById('btn1').style.display = 'none';
			for(var i = 2; i <= 9;i++)
				document.getElementById("btn"+i).style.display = 'inline';

			timer();
		}

		var x = 0
		function timer()
		{
			document.getElementById('timer').innerHTML = x;
			if(x < 13)
			{
				x++;
				setTimeout(function(){timer();}, 1000);
			}
			else
				window.location.href = "page5T-1.php";
		}



	</script>
</html>
```

The code of the interfaces of Task 5 (colors to be selected from) for all devices

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
	<head>
		<title>HCI Experiment5-1-2</title>
		<script src="jquery-1.11.1.min.js"> </script>
		<style>
			html, body
			{
				background-color: #ccc;
				padding: 15px;
				width: 90%;
			}
* {

		margin: 0px;
		padding: 0px;
		}
			h1
			{
				color: 333;
				text-align: center;
				margin-bottom: 50px;
			}

			p
			{
			  font-size: 20px;
			  text-align: left;
			  //color: red;
			}

			#outer
			{
				width: 100%;
			}

			#inner
			{
				margin: 0 auto;
				padding: 10px;
				background-color: #fff;
				border: 1px solid #eee;
				width: 480px;
				height: 340px;
			}



			#btn2
			{
```

```
        width:100px;
        height:30px;
        background-color: brown;

}
#btn3
{
        width:100px;
        height:30px;
        background-color: yellow;

}
#btn4
{
        width:100px;
        height:30px;
        background-color: gray;

}
#btn5
{
        width:100px;
        height:30px;
        background-color: lightgreen;
        color: white;


}
#btn6
{
        width:100px;
        height:30px;
        background-color: purple;

}
#btn7
{
        width:100px;
        height:30px;
        background-color: fuchsia;
        color: white;
}
#btn8
{
        width:100px;
        height:30px;
        background-color: orange;
        color: white;
}
#btn9
{
        width:100px;
        height:30px;
        background-color: pink;
        color: white;
```

```
}
#btn10
{
	width:100px;
	height:30px;
	background-color: red;
	color: white;
}
#btn11
{
	width:100px;
	height:30px;
	background-color: green;
	color: white;
}
#btn12
{
	width:100px;
	height:30px;
	background-color: silver;
	color: white;
}
#btn13
{
	width:100px;
	height:30px;
	background-color: blue;
	color: white;
}
#right_
{
	float: right;
	margin-top: 5px;
	margin-right: 100px;
}

#left_
{
	float: left;
	margin-top: 5px;
	margin-left: 100px;
}
#btn20
{
	color: black;
	text-align:center;
	font-weight:bold;
	margin: 10px 80px;
}

#btn22
{
	text-align:center;
	//font-weight:bold;
	width:80px;
	height:30px;
	margin-left:290px;
```

```
                        float: right;
                    font-size: 20px;
                    margin-top: 0px;
                }

                .btn
                {
                        margin-top: 5px;
                }


                #pi
                {
                margin-top:30px;
                float: left;
                }
                </style>
        </head>
        <body onload="start()">
                <h1>5 out of 5</h1>

                <div id="outer"><div id="inner">
                                        <p id="btn20" onclick="clicked_(20)">Select the colors you
remember</p>
                                        <p id="timie"></p>

                        <div id="left_">
                        <div class="btn" id="btn2" onclick="clicked_(false, 2)"></div>
                        <div class="btn" id="btn3" onclick="clicked_(true, 3)"></div>
                        <div class="btn" id="btn4" onclick="clicked_(true, 4)"></div>
                        <div class="btn" id="btn5" onclick="clicked_(false, 5)"></div>
                        <div class="btn" id="btn6" onclick="clicked_(true, 6)"></div>
                        <div class="btn" id="btn7" onclick="clicked_(false, 7)"></div>
                        </div><div id="right_">
                        <div class="btn" id="btn8" onclick="clicked_(true, 8)"></div>
                        <div class="btn" id="btn9" onclick="clicked_(true, 9)"></div>
                        <div class="btn" id="btn10" onclick="clicked_(false, 10)"></div>
                        <div class="btn" id="btn11" onclick="clicked_(true, 11)"></div>
                        <div class="btn" id="btn12" onclick="clicked_(false, 12)"></div>
                        <div class="btn" id="btn13" onclick="clicked_(true, 13)"></div>
                        </div>
                        <progress id="pi" max="100" value="0" style="width: 300px"></progress>

                        <button id="btn22" onclick="clickeded_(22)">Submit</button>

                </div></div>

        </body>
        <script>
                var times = new Array();
                var xx = 0;
                var catched = 0;
                var btn = new Array();
                var t = 0;

                btn[2] = false;
                btn[3] = false;
```

```
		btn[4] = false;
		btn[5] = false;
		btn[6] = false;
		btn[7] = false;
		btn[8] = false;
		btn[9] = false;
		btn[10] = false;
		btn[11] = false;
		btn[12] = false;
		btn[13] = false;

		function clicked_(x, i)
		{

			btn[i] = !btn[i];

				if(btn[i] && xx < 7)
				{
					document.getElementById("btn"+i).style.boxShadow = "inset 0px 0px
10px 0px #000";
					xx++;
					if(x)
						catched++;
					btn[i] = true;
				}
				else if(btn[i] && xx == 7)
					btn[i] = !btn[i];
				else
				{
					document.getElementById("btn"+i).style.boxShadow = "0px 0px 0px
0px #000";
					xx--;
					if(x)
						catched--;
					btn[i] = false;
				}
		}

		function start()
		{
			// put what happen on start here
			t = 0;
			timer();
		}

		function timer()
		{
		  document.getElementById("timie").style.display = 'none';

			if(t <+ 30)
			{
				document.getElementById("timie").innerHTML = t;
				t++;
				setTimeout(function(){timer()}, 1000);
			}
			else
			{
```

```
                        document.getElementById("timie").innerHTML = "time over";
                        stop();
                }
        }

        setInterval (loading, 300);

function loading()
        {
                var progress = document.getElementById("pi");
                var value = Number(progress.getAttribute("value"));
                progress.setAttribute("value", value + 1);

        }


                function stop()
                {

                        window.location.href = "page6.php";
                }


                function clickeded_(x)
                {
                        var d = new Date();
                        times[x] = d;


                        var s="";
                        for (i = 2; i < 14; i++) {
                        if(btn[i]==true)
                                s= s + "\r\n" +("Color "+ (i-1) + " Selected") ;
                        }

                        var id = "<?php echo($_SESSION["id"]); ?>";
                                $.post( "saveResults.php", { ident: id, field: "test5_colors_selected", value: s })
                                .done(function( data ) {
                                        if(data != "success"){
                                                alert("Error saving results " + data);
                                        }
                                });

                        if(x == 22)
                        {
                                window.location.href = "page6.php";
                        }

                }


        </script>
</html>
```

The code of the interfaces of Task 5 (words) for PC

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
	<head>
		<title>HCI Experiment5-2-1</title>
		<style>
			html, body
			{
				background-color: #ccc;
				padding: 15px;
				width: 90%;
			}
* {
		margin: 0px;
		padding: 0px;

		}
			h1
			{
				color: 333;
				text-align: center;
				margin-bottom: 50px;
			}
			p
			{
			  font-size: 20px;
			  text-align: left;
			}
			ol
			{
				font-size: 20px;
				margin-left: 50px;
			}
			#outer
			{
				width: 100%;
			}
			#inner
			{
				margin: 0 auto;
				padding: 10px;
				background-color: #fff;
				border: 1px solid #eee;
				width: 480px;
				height: 320px;
			}
			#btn1
			{
				width:100px;
				height:30px;
				margin-left:190px;
				margin-top:140px;
```

```
        display: none;
}
#timer
{
        width:100px;
        height:30px;
        margin-left:290px;
        float: right;
   display: none;
   font-size: 20px;
}
#btn2
{
        width:100px;
        height:30px;
        margin-top: 30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;
}
#btn3
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;
}
#btn4
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;

}
#btn5
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;
}
#btn6
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;
```

```
		}
		#btn7
		{
			width:100px;
			height:30px;
			margin-left: 50px;
			display: none;
			font-size: 16px;
			font-family: times new roman;
		}
		#btn8
		{
			width:100px;
			height:30px;
			margin-left: 50px;
			display: none;
			font-size: 16px;
			font-family: times new roman;
		}
		#btn9
		{
		color: black;
		text-align:center;
		display:none;
		font-weight:bold;
		margin: 100px 50px;
		font-size: 20px;
		}
		</style>
</head>
<body onload="init()">
	<h1>5 out of 5</h1>
	<div id="outer"><div id="inner">
		<button id="btn1" onclick="init()">START</button>
		<p id="btn9" onclick="clicked_(9)">Remember the months (You have 10 sec)</p><br>
		<button id="btn2" onclick="clicked_(2)">October</button><br>
		<button id="btn3" onclick="clicked_(3)">March</button><br>
		<button id="btn4" onclick="clicked_(4)">December</button><br>
		<button id="btn5" onclick="clicked_(5)">September</button><br>
		<button id="btn6" onclick="clicked_(6)">May</button><br>
		<button id="btn7" onclick="clicked_(7)">February</button><br>
		<button id="btn8" onclick="clicked_(8)">July</button><br/>
		<button id="timer"></button>
	</div></div>
</body>
<script>
	function init()
	{
		document.getElementById('btn1').style.display = 'none';
		for(var i = 2; i <= 9;i++)
			document.getElementById("btn"+i).style.display = 'inline';
		timer();
	}
	var x = 0
	function timer()
	{
		document.getElementById('timer').innerHTML = x;
```

```
                        if(x < 13)
                        {
                                x++;
                                setTimeout(function(){timer();}, 1000);
                        }
                        else
                                window.location.href = "page6-1.php";
                }
        </script>
</html>
```

The code of the interfaces of Task 5 (words) for SP

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
        <head>
                <title>HCI Experiment5-2-1</title>
                <script src="jquery-1.11.1.min.js"> </script>
                <style>
                        html, body
                        {
                                background-color: #ccc;
                                padding: 15px;
                                width: 90%;
                        }
* {
                margin: 0px;
                padding: 0px;
                }
                        h1
                        {
                                color: 333;
                                text-align: center;
                                margin-bottom: 50px;
                        }
                        p
                        {
                          font-size: 20px;
                          text-align: left;
                        }

                        ol
                        {
                                font-size: 20px;
                                margin-left: 50px;
                        }
                        #outer
                        {
                                width: 100%;
                        }
```

```
#inner
{
	margin: 0 auto;
	padding: 10px;
	background-color: #fff;
	border: 1px solid #eee;
	width: 480px;
	height: 320px;
}
#btn1
{
	width:100px;
	height:30px;
	margin-left:190px;
	margin-top:140px;
	display: none;
}
#timer
{
	width:100px;
	height:30px;
	margin-left:290px;
	float: right;
   display: none;
   font-size: 20px;
}
#btn2
{
	width:100px;
	height:30px;
	margin-top: 30px;
	margin-left: 50px;
	display: none;
	font-size: 16px;
	font-family: times new roman;
}
#btn3
{
	width:100px;
	height:30px;
	margin-left: 50px;
	display: none;
	font-size: 16px;
	font-family: times new roman;
}
#btn4
{
	width:100px;
	height:30px;
	margin-left: 50px;
	display: none;
	font-size: 16px;
	font-family: times new roman;
}
#btn5
{
```

```
                width:100px;
                height:30px;
                margin-left: 50px;
                display: none;
                font-size: 16px;
                font-family: times new roman;
        }
        #btn6
        {
                width:100px;
                height:30px;
                margin-left: 50px;
                display: none;
                font-size: 16px;
                font-family: times new roman;
        }
        #btn7
        {
                width:100px;
                height:30px;
                margin-left: 50px;
                display: none;
                font-size: 16px;
                font-family: times new roman;

        }
        #btn8
        {
                width:100px;
                height:30px;
                margin-left: 50px;
                display: none;
                font-size: 16px;
                font-family: times new roman;
        }
        #btn9
        {
        color: black;
        text-align:center;
        display:none;
        font-weight:bold;
        margin: 100px 20px;
        font-size: 20px;
        }
        </style>
</head>
<body onload="init()">
        <h1>5 out of 5</h1>
        <div id="outer"><div id="inner">
                <button id="btn1" onclick="init()">START</button>
                <p id="btn9" onclick="clicked_(9)">Remember the months (You have 10 sec)</p><br>
                <button id="btn2" onclick="clicked_(2)">November</button><br>
                <button id="btn3" onclick="clicked_(3)">May</button><br>
                <button id="btn4" onclick="clicked_(4)">June</button><br>
                <button id="btn5" onclick="clicked_(5)">August</button><br>
                <button id="btn6" onclick="clicked_(6)">January</button><br>
                <button id="btn7" onclick="clicked_(7)">April</button><br>
```

```
                <button id="btn8" onclick="clicked_(8)">October</button><br/>
                <button id="timer"></button>
            </div></div>
        </body>
        <script>
            function init()
            {
                document.getElementById('btn1').style.display = 'none';
                for(var i = 2; i <= 9;i++)
                    document.getElementById("btn"+i).style.display = 'inline';
                timer();
            }
            var x = 0
            function timer()
            {
                document.getElementById('timer').innerHTML = x;
                if(x < 13)
                {
                    x++;
                    setTimeout(function(){timer();}, 1000);
                }
                else
                    window.location.href = "page6S-1.php";
            }
        </script>
</html>
```

The code of the interfaces of Task 5 (words) for TB

```
<!DOCTYPE html>
<html>
        <head>
            <title>HCI Experiment5-2-1</title>
            <style>
                html, body
                {
                    background-color: #ccc;
                    padding: 15px;
                    width: 90%;
                }
* {
            margin: 0px;
            padding: 0px;
            }
                h1
                {
                    color: 333;
                    text-align: center;
                    margin-bottom: 50px;
                }
```

```
p
{
  font-size: 20px;
  text-align: left;
}
ol
{
        font-size: 20px;
        margin-left: 50px;
}

#outer
{
        width: 100%;
}

#inner
{
        margin: 0 auto;
        padding: 10px;
        background-color: #fff;
        border: 1px solid #eee;
        width: 480px;
        height: 320px;
}
#btn1
{
        width:100px;
        height:30px;
        margin-left:190px;
        margin-top:140px;
        display: none;
}
#timer
{
        width:100px;
        height:30px;
        margin-left:290px;
        float: right;
        display: none;
        font-size: 20px;

}

#btn2
{
        width:100px;
        height:30px;
        margin-top: 30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;

}
#btn3
{
```

```
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;

}
#btn4
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;

}
#btn5
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;


}
#btn6
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;

}
#btn7
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;

}
#btn8
{
        width:100px;
        height:30px;
        margin-left: 50px;
        display: none;
        font-size: 16px;
        font-family: times new roman;
```

```
                        }
                        #btn9
                        {
                        color: black;
                        text-align:center;
                        display:none;
                        font-weight:bold;
                        margin: 100px 20px;
                        font-size: 20px;

                        }
                        </style>
        </head>
        <body onload="init()">
                <h1>5 out of 5</h1>
                <div id="outer"><div id="inner">
                        <button id="btn1" onclick="init()">START</button>
                        <p id="btn9" onclick="clicked_(9)">Remember the months (You have 10 sec)</p><br>
                        <button id="btn2" onclick="clicked_(2)">June</button><br>
                        <button id="btn3" onclick="clicked_(3)">November</button><br>
                        <button id="btn4" onclick="clicked_(4)">April</button><br>
                        <button id="btn5" onclick="clicked_(5)">July</button><br>
                        <button id="btn6" onclick="clicked_(6)">February</button><br>
                        <button id="btn7" onclick="clicked_(7)">March</button><br>
                        <button id="btn8" onclick="clicked_(8)">September</button><br/>
                        <button id="timer"></button>
                </div></div>
        </body>
        <script>

                function init()
                {
                        document.getElementById('btn1').style.display = 'none';
                        for(var i = 2; i <= 9;i++)
                                document.getElementById("btn"+i).style.display = 'inline';
                        timer();
                }
                var x = 0
                function timer()
                {
                        document.getElementById('timer').innerHTML = x;
                        if(x < 13)
                        {
                                x++;
                                setTimeout(function(){timer();}, 1000);
                        }
                        else
                                window.location.href = "page6T-1.php";
                }
        </script>
</html>
```

The code of the interfaces of Task 5 (words to be selected from) for all devices

```
<?php
session_start();
?>
<!DOCTYPE html>
<html>
	<head>
		<title>HCI Experiment5-2-2</title>
		<script src="jquery-1.11.1.min.js"> </script>
		<style>
			html, body
			{
				background-color: #ccc;
				padding: 15px;
				width: 90%;
			}
* {
		margin: 0px;

		padding: 0px;
		}
			h1
			{
				color: 333;
				text-align: center;
				margin-bottom: 50px;
			}
			p
			{
			  font-size: 20px;
			  text-align: left;
			  //color: red;
			}
			#outer
			{
				width: 100%;
			}
			#inner
			{
				margin: 0 auto;
				padding: 10px;
				background-color: #fff;
				border: 1px solid #eee;
				width: 480px;
				height: 340px;
			}
			#btn2
			{
				width:100px;
				height:30px;
				text-align:center;
				line-height: 27px;
				border: 2px solid;
			}
```

```
#btn3
{
	width:100px;
	height:30px;
	text-align:center;
	line-height: 27px;
	border: 2px solid;
}
#btn4
{
	width:100px;
	height:30px;
	text-align:center;
	line-height: 27px;
	border: 2px solid;
}
#btn5
{
	width:100px;
	height:30px;
	text-align:center;
	line-height: 27px;
	border: 2px solid;
}
#btn6
{
	width:100px;
	height:30px;
	text-align:center;
	line-height: 27px;
	border: 2px solid;
}
#btn7
{
	width:100px;
	height:30px;
	text-align:center;
	line-height: 27px;
	border: 2px solid;
}
#btn8
{
	width:100px;
	height:30px;
	text-align:center;
	line-height: 27px;
	border: 2px solid;
}
#btn9
{
	width:100px;
	height:30px;
	text-align:center;
	line-height: 27px;
	border: 2px solid;
}
#btn10
```

```
{
	width:100px;
	height:30px;
	border: 2px solid;
	text-align:center;
	line-height: 27px;
}
#btn11
{
	width:100px;
	height:30px;
	border: 2px solid;
	text-align:center;
	line-height: 27px;
}
#btn12
{
	width:100px;
	height:30px;
	text-align:center;
	line-height: 27px;
	border: 2px solid;
}
#btn13
{
	width:100px;
	height:30px;
	text-align:center;
	line-height: 27px;
	border: 2px solid;
}
#right_
{
	float: right;
	margin-top: 5px;
	margin-right: 100px;
}

#left_
{
	float: left;
	margin-top: 5px;
	margin-left: 100px;
}
#btn20
{
	color: black;
	text-align:center;
	font-weight:bold;
	margin: 10px;
}

#btn22
{
	text-align:center;
	width:80px;
	height:30px;
```

```
                        margin-left:290px;
                        float: right;
                    font-size: 16px;
                    margin-top: 0px;
                }
                #pi
                {
                margin-top:30px;
                float: left;
                }
                </style>
        </head>
        <body onload="start()">
                <h1>5 out of 5</h1>
                <div id="outer"><div id="inner">
                        <p id="btn20" onclick="clicked_(20)">Select the months you remember</p>
                                <p id="timie"></p><div id="left_">
                        <div value="January" class="btn" id="btn2" onclick="clicked_(false, 2)">January</div>
                        <div value="February" class="btn" id="btn3" onclick="clicked_(true,
3)">February</div>
                        <div value="March" class="btn" id="btn4" onclick="clicked_(true, 4)">March</div>
                        <div value="April" class="btn" id="btn5" onclick="clicked_(false, 5)">April</div>
                        <div value="May" class="btn" id="btn6" onclick="clicked_(true, 6)">May</div>
                        <div value="June" class="btn" id="btn7" onclick="clicked_(false, 7)">June</div>
                        </div><div id="right_">
                        <div value="July" class="btn" id="btn8" onclick="clicked_(true, 8)">July</div>
                        <div value="August" class="btn" id="btn9" onclick="clicked_(true, 9)">August</div>
                        <div value="September" class="btn" id="btn10" onclick="clicked_(false,
10)">September</div>
                        <div value="October" class="btn" id="btn11" onclick="clicked_(true,
11)">October</div>
                        <div value="November" class="btn" id="btn12" onclick="clicked_(false,
12)">November</div>
                        <div value="December" class="btn" id="btn13" onclick="clicked_(true,
13)">December</div>
                        </div>
                        <progress id="pi" max="100" value="0" style="width: 300px"></progress>
                        <button id="btn22" onclick="clickeded_(22)">Submit</button>
                </div></div>
        </body>
        <script>
                var times = new Array();
                var xx = 0;
                var catched = 0;
                var btn = new Array();
                var t = 0;
                btn[2] = false;
                btn[3] = false;
                btn[4] = false;
                btn[5] = false;
                btn[6] = false;
                btn[7] = false;
                btn[8] = false;
                btn[9] = false;
                btn[10] = false;
                btn[11] = false;
                btn[12] = false;
```

```
		btn[13] = false;
		function clicked_(x, i)
		{
			btn[i] = !btn[i];
				if(btn[i] && xx < 7)
				{
				document.getElementById("btn"+i).style.boxShadow = "inset 0px 0px 10px 0px
#000";
					xx++;
					if(x)
						catched++;
					btn[i] = true;
				}
				else if(btn[i] && xx == 7)
					btn[i] = !btn[i];
				else
				{
			document.getElementById("btn"+i).style.boxShadow = "0px 0px 0px 0px #000";
					xx--;
					if(x)
					catched--;
					btn[i] = false;
				}
		}
		function start()
		{
			t = 0;
			timer();
		}
		function timer()
		{
		  document.getElementById("timie").style.display = 'none';
			if(t <+ 30)
			{
				document.getElementById("timie").innerHTML = t;
				t++;
				setTimeout(function(){timer()}, 1000);
			}
			else
			{
				document.getElementById("timie").innerHTML = "time over";
				stop();
			}
		}
		setInterval (loading, 300);
function loading()
	{
		var progress = document.getElementById("pi");
		var value = Number(progress.getAttribute("value"));
		progress.setAttribute("value", value + 1);

	}
		function stop()
		{
			window.location.href = "page7.php";
		}
		function clickeded_(x)
```

```
		{
			var d = new Date();
			times[x] = d;
			var s="";
			var temps;
			var progresses;
			for (i = 2; i < 14; i++) {
				if(btn[i]==true)
				{
					progresses = document.getElementById("btn"+i);
					temps = progresses.getAttribute("value");
					s= s + "\r\n" + temps ;
				}
				}

			var id = "<?php echo($_SESSION["id"]); ?>";
				$.post( "saveResults.php", { ident: id, field: "test6_months_selected", value: s })
				.done(function( data ) {
					if(data != "success"){
						alert("Error saving results " + data);
					}
				});
			if(x == 22)
			{
				window.location.href = "page7.php";
			}
		}
	</script>
</html>
```

The code of the appreciation interface for all devices

```
html>
	<head>
		<title>xxx</title>
		<style>
			html, body
			{
				background-color: #ccc;
				padding: 15px;
				width: 90%;
			}
		h1
		{
		margin: 50px 50px;
		color: blue;
		text-align: center;
		}

		#hi
		{
		margin-left: 380px;;
		}
		</style>
	</head>
```

```
        <h1>THANK YOU <br>FOR YOUR PARTICIPATION</h1>
        <img id="hi" src="smile.png" height="100" width="100">
        <body>
        </body>

</html>
```

APPENDIX B

Laurentian University Research Ethics Board approval

APPROVAL FOR CONDUCTING RESEARCH INVOLVING HUMAN SUBJECTS

Research Ethics Board – Laurentian University

This letter confirms that the research project identified below has successfully passed the ethics review by the Laurentian University Research Ethics Board (REB). Your ethics approval date, other milestone dates, and any special conditions for your project are indicated below.

TYPE OF APPROVAL / New X / Modifications to project / Time extension	
Name of Principal Investigator and school/department	Basim Alsalmi (Math and Computer Science) Ratvinder Singh Grewal (Supervisor, Math and Computer Science)
Title of Project	Testing the reliability of predictive models on different devices.
REB file number	2014-02-03
Date of original approval of project	February 27, 2014
Date of approval of project modifications or extension *(if applicable)*	
Final/Interim report due on	February 27, 2015

Conditions placed on project	Final report due on February 27, 2015

During the course of your research, no deviations from, or changes to, the protocol, recruitment or consent forms may be initiated without prior written approval from the REB. If you wish to modify your research project, please refer to the Research Ethics website to complete the appropriate REB form.

All projects must submit a report to REB at least once per year. If involvement with human participants continues for longer than one year (e.g. you have not completed the objectives of the study and have not yet terminated contact with the participants, except for feedback of final results to participants), you must request an extension using the appropriate REB form.

In all cases, please ensure that your research complies with Tri-Council Policy Statement (TCPS). Also please quote your REB file number on all future correspondence with the REB office.

Congratulations and best of luck in conducting your research.

Susan James, Chair

Laurentian University Research Ethics Board

APPENDIX C

The experiment's consent

Please read the following in regards to your participation in the study entitled "***Testing the reliability of predictive models on three different devices***"

My name is Basim ALsalmi. I am a MSc student in the Department of Math and Computer Science at Laurentian University. I'm conducting a research on how the websites apply the laws and models of user interface design to facilitate the users navigation and utility.
Benefits of this study include testing the reliability of predictive models on three different mediums. Predictive modeling is the process by which a model is created or chosen to try to best predict the probability of an outcome. The study will also help me complete my MSc thesis. There should be no risk to you performing the tasks. If you get frustrated, you can withdraw from the experiment. The study will take approximately **10 minutes** of your time and will involve performing few tasks.

Before starting the study, please be advised that there is a **timer program** working in the background to measure the time and to collect data.

Tasks to be performed may vary on provided websites: you will be handed a task sheet that includes some of the following tasks: **(1)** Click some buttons **(2)** Select a smallest button among alternatives **(3)** Fill a form **(4)** Select an expanding rectangle among alternatives **(5)** Remembering and recalling colours and words.

Your participation in this study is strictly voluntary. You have the right to withdraw and leave the room of the study at any time without any consequences. If you have any questions or concerns about the study or about being a subject, you can call my supervisor Dr. Ratvinder Singh Grewal in his office at 705-675-1151, ext. 2351 or toll free at 1-800-461-4030. You also can contact me through my supervisor. Your identity will not be revealed at any time. The results from this study will be part of my MSc thesis.

We will take all the measures to ensure anonymity and confidentiality of the respondents. Also, no personal Identification is stored, and the data will be kept for at most six months after finishing the study.

For questions or concerns regarding the ethical conduct of this study please contact:
Research Ethics Officer, Laurentian University Research Office, telephone:

705-675-1151 ext 2436 or toll free at 1-800-461-4030 or email:

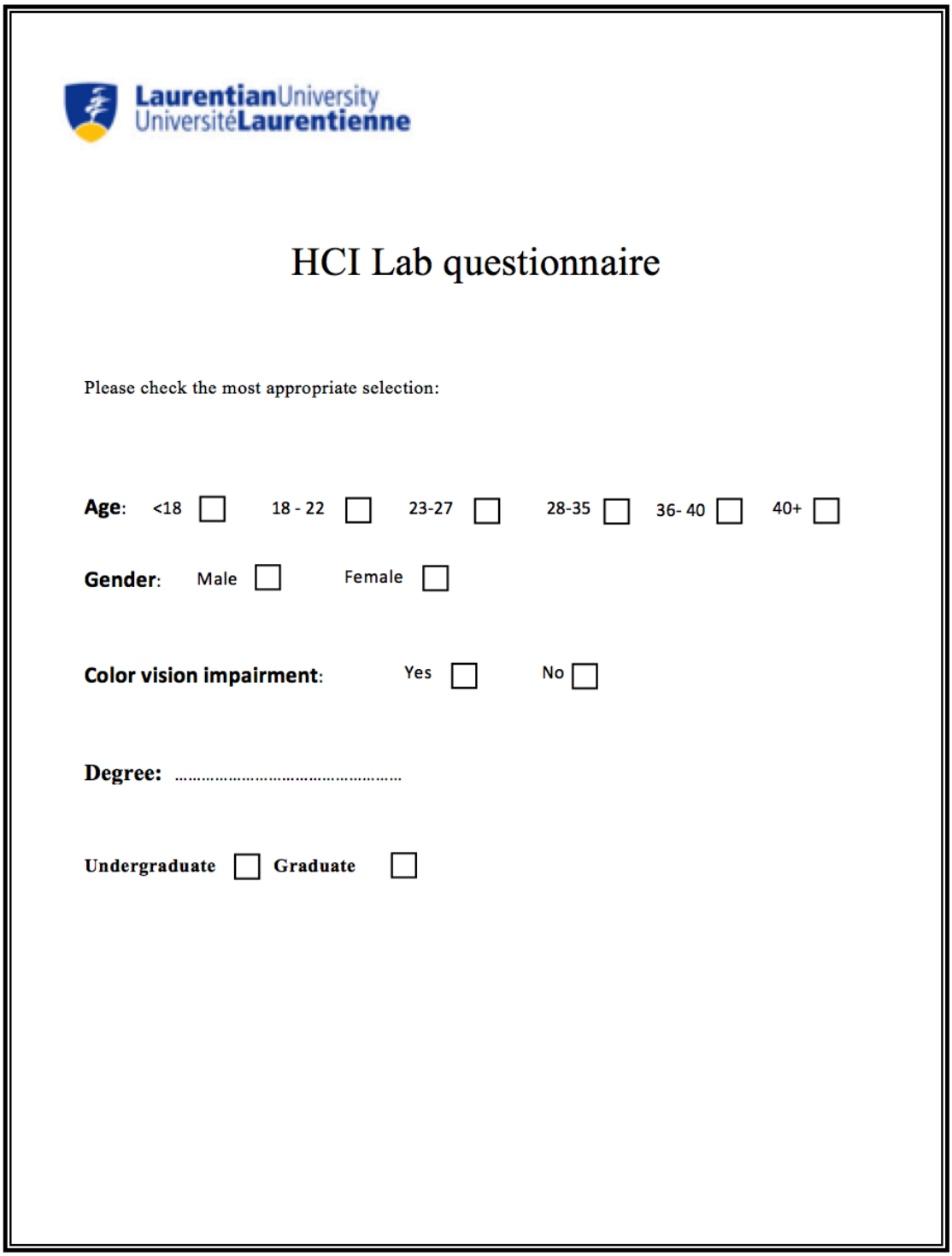
ethics@laurentian.ca

By writing your name and signing below, you agree that you have read the above statements and freely consent to participate in this research

Name: signature: Date:

APPENDIX D

The HCI Lab questionnaire



LaurentianUniversity
UniversitéLaurentienne

HCI Lab questionnaire

Please check the most appropriate selection:

Age: <18 ☐ 18 - 22 ☐ 23-27 ☐ 28-35 ☐ 36- 40 ☐ 40+ ☐

Gender: Male ☐ Female ☐

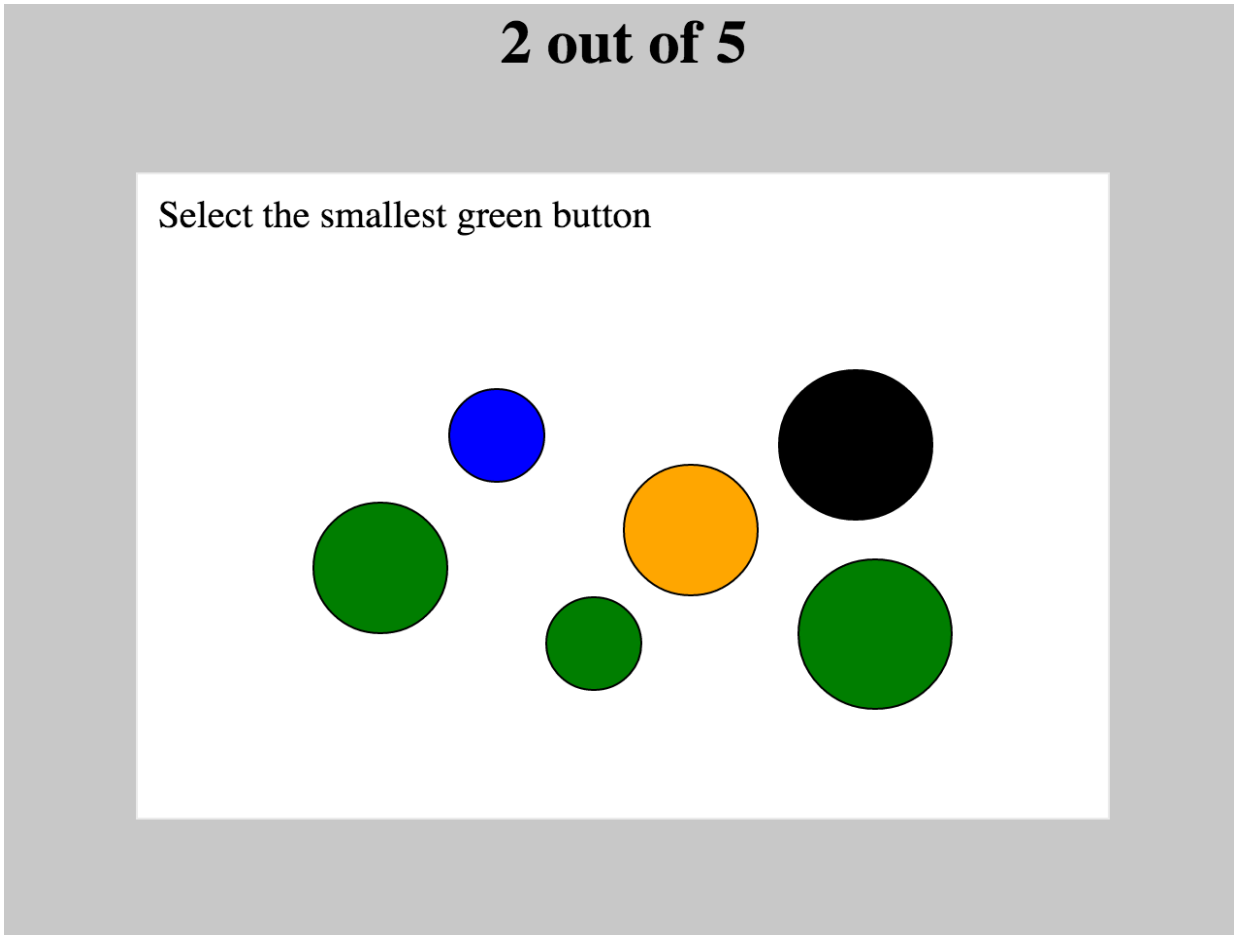
Color vision impairment: Yes ☐ No ☐

Degree: .....

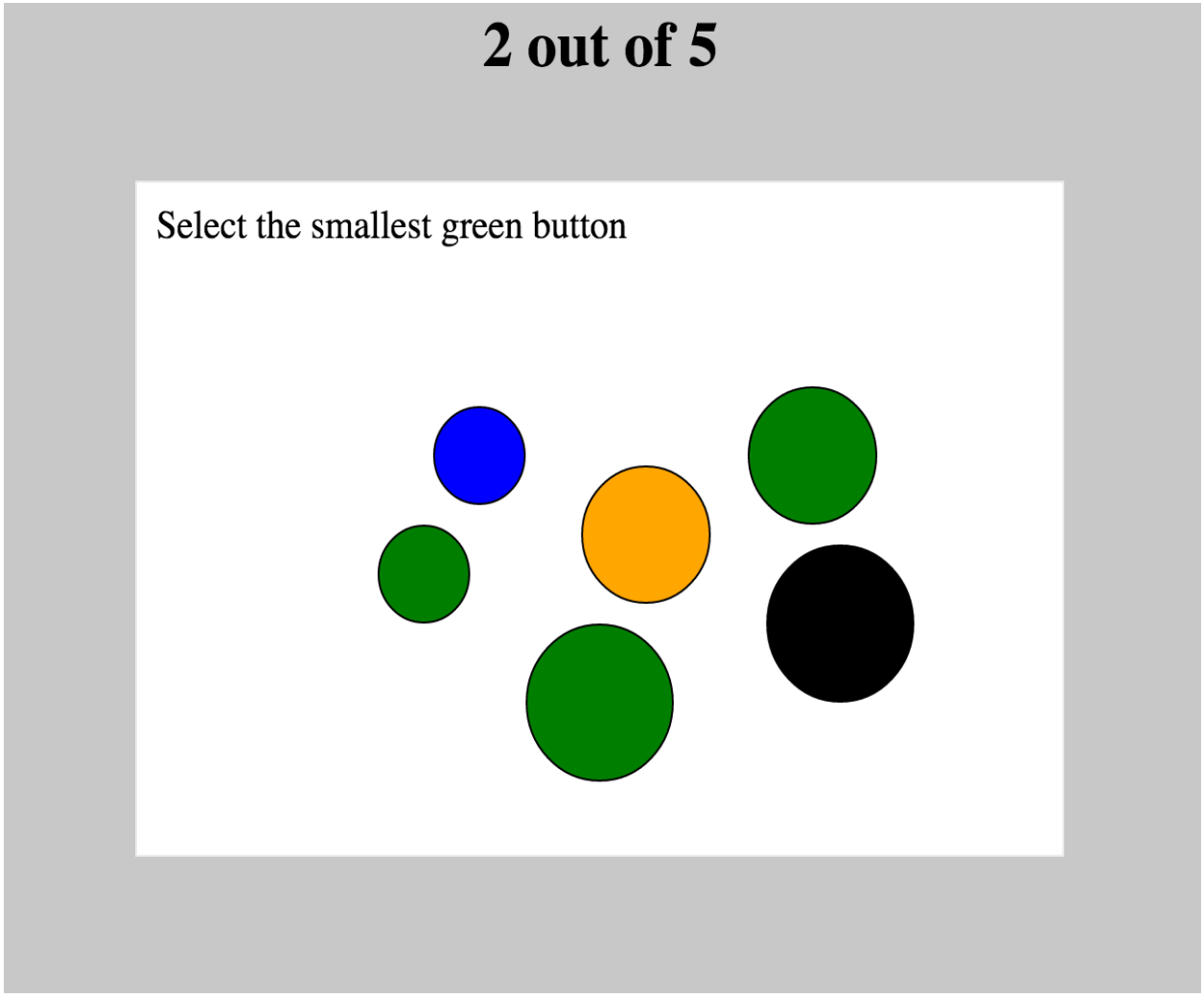
Undergraduate ☐ **Graduate** ☐

APPENDIX E

A screenshot of Task 2 for SP

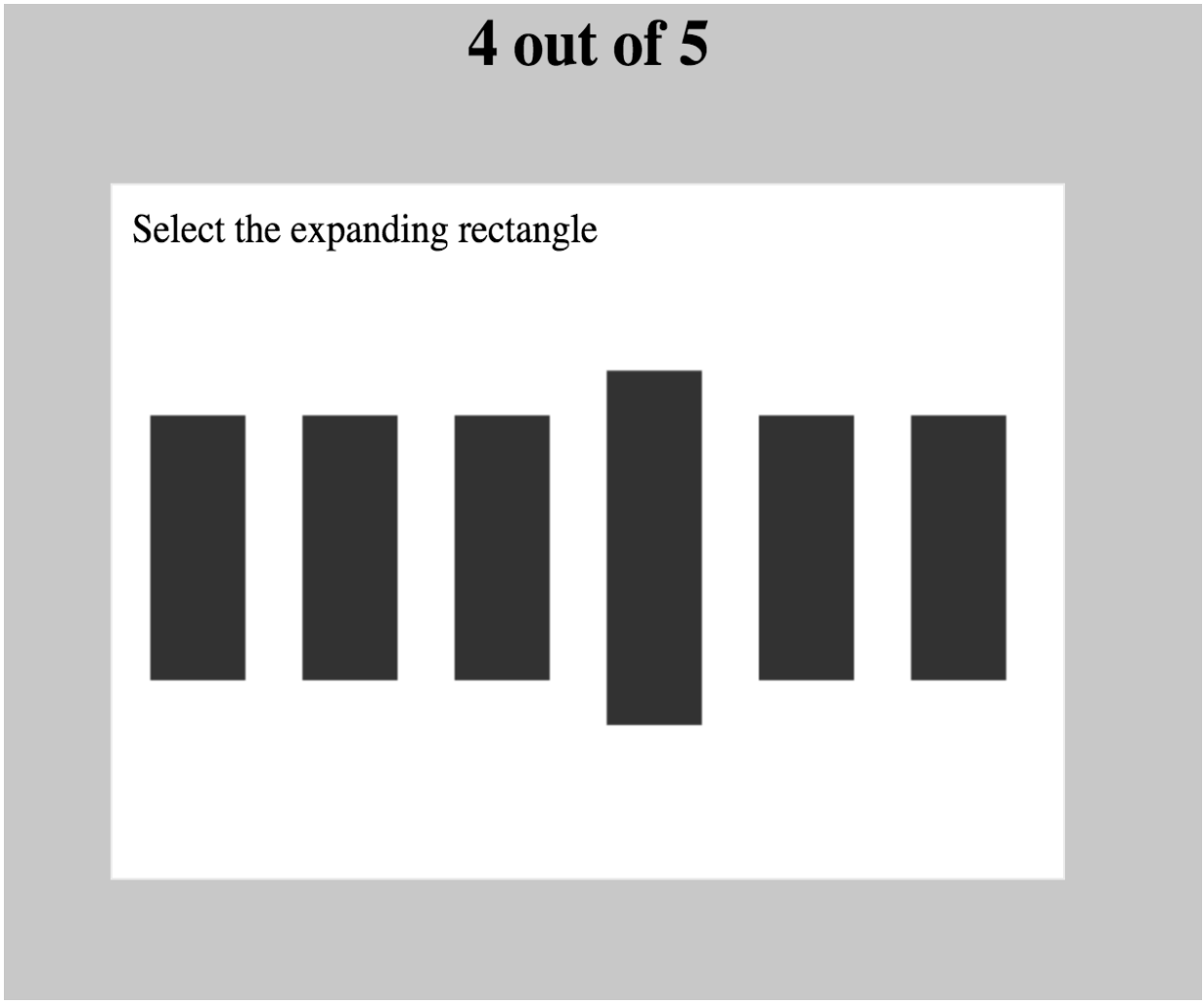


A screenshot of Task 2 for TB

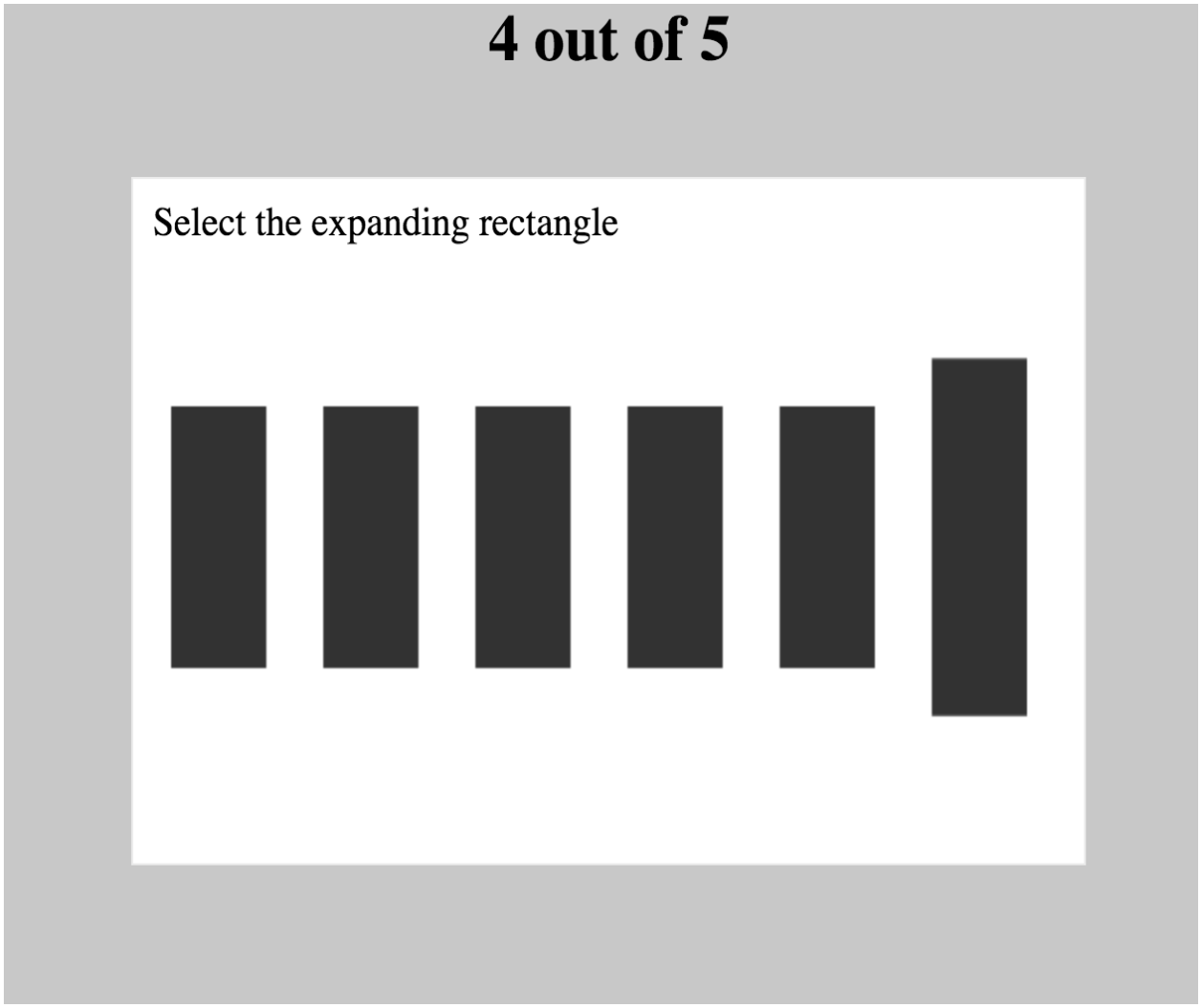


APPENDIX F

A screenshot of Task 4 for SP

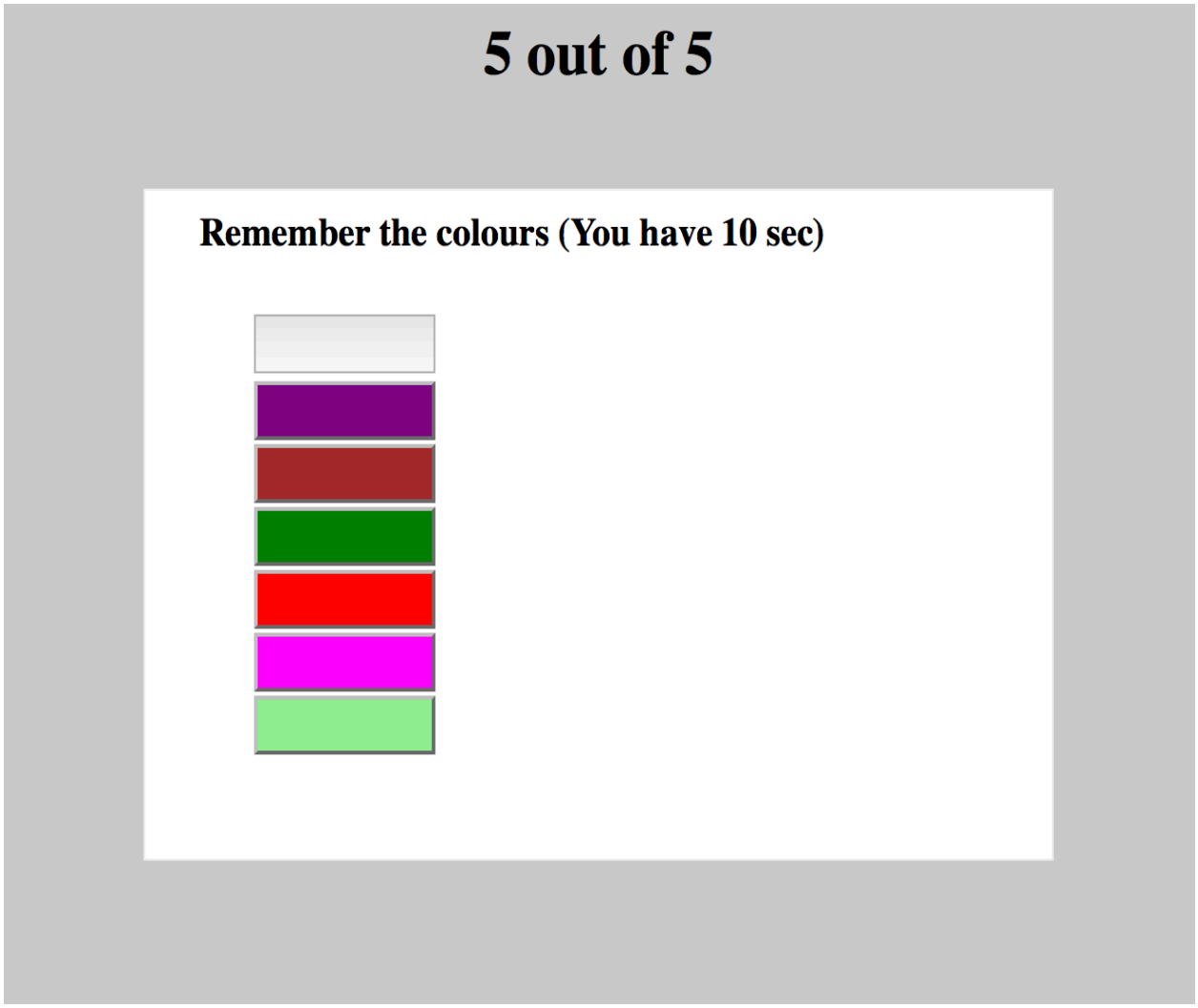


A screenshot of Task 4 for TB

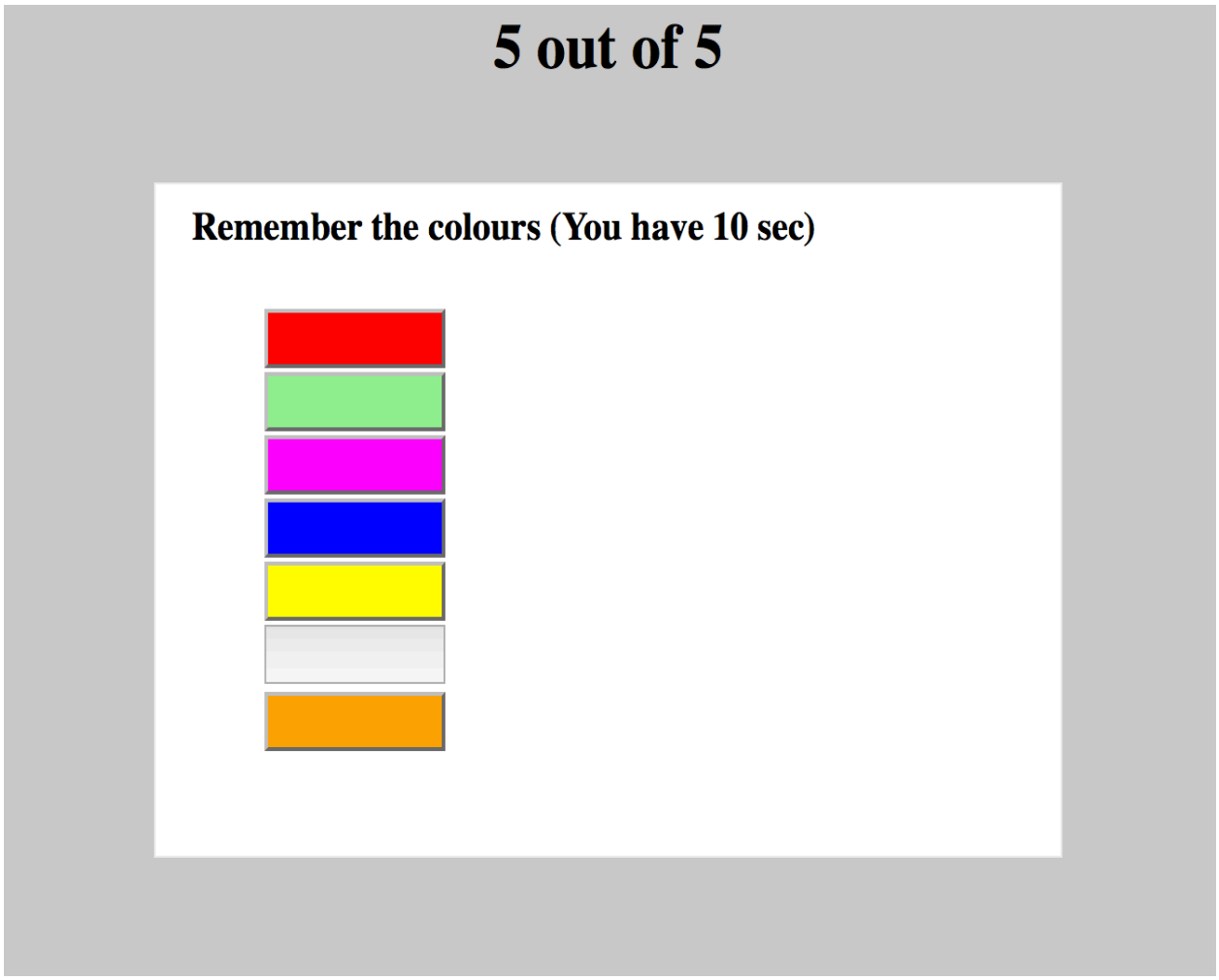


APPENDIX G

A screenshot of Task 5 (colors) for SP

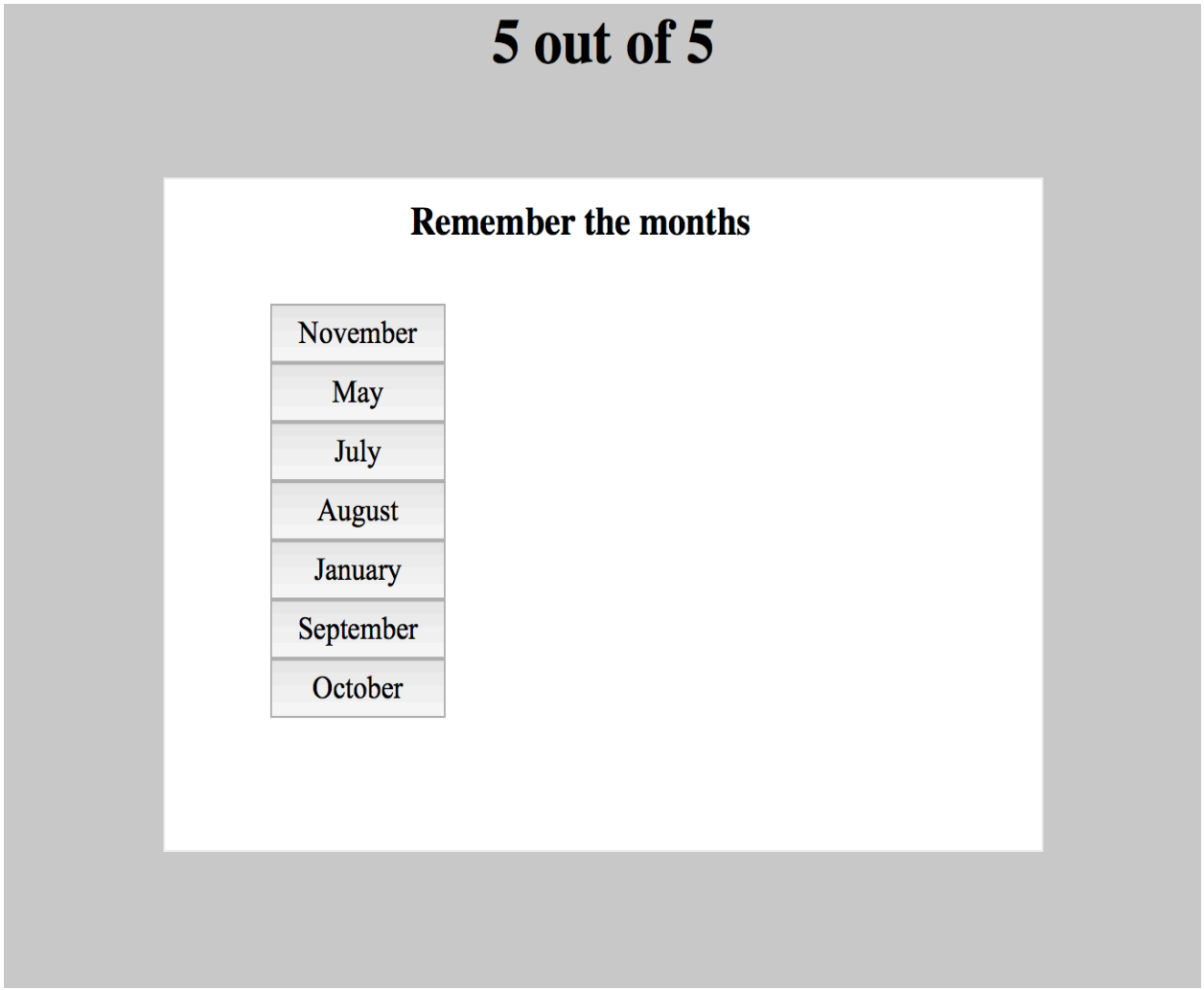


A screenshot of Task 5 (colors) for TB



APPENDIX H

A screenshot of Task 5 (words) for SP



A screenshot of Task 5 (words) for TB