

ACIT5900
MASTER THESIS

in

**Applied Computer and Information
Technology (ACIT)**
September 2021

Cloud based services and operations

**An Usability and Universal Design
Investigation of Parallax Scrolling**

Suraj Pandey

Department of Computer Science
Faculty of Technology, Art and Design

OSLOMET

Preface

This is a study to investigate the usability and universal design of parallax scrolling in a website. This research represents the completion of our master's degree program in applied computer and information technology (ACIT) from the department of computer science and faculty of technology, art and design.

It would not have been possible to complete this thesis without the guidance and help of people who supported me during the writing process. Different people helped, encouraged, and guided me in the process of writing this thesis. At first, I would like to thank my supervisor **Dr. Pietro Murano** who guided me through the whole process until the end. I am very grateful to him for his guidance and suggestions that helps me in lot of ways to complete this research. I would also like to thank Department of Computer Science, OsloMet University for providing me the opportunity to work in this thesis project.

I would like to thank my family abroad for their patience and continuous support in my academic journey. I am very much thankful towards my friends for their support especially to the participants who helped me in this thesis. Without them it would not have been possible to successfully conclude my thesis. At last I would like to appreciate and express my gratitude for all the people who helped and supported me during my journey.

Suraj Pandey

OsloMet University, Oslo

September 14, 2021

Abstract

In this study, the usability and the universal design of parallax scrolling in a website was investigate with the help of experiment and two prototypes designed wholly for this research. The usability and universal design was evaluated with the help of factors like accuracy, efficiency and user satisfaction shown by the participants of the experiment while performing design tasks. Two different prototype websites were designed one with parallax scrolling and another without parallax scrolling. Tasks were designed in order to record the performance of participants and their opinion and feeling toward designed website. To measure the accuracy, efficiency (participant's performance) and user satisfaction in this study, total time taken to complete tasks, total number of error done and participant's opinion (post experiment questionnaire) were used. The data were collected after the experiment and those data were tested and analyzed with the help of statistical analysis tool and paired t-test method was used to test the data. From the analysis of the result of the test it was found that there was no significant difference in total task completion time, total number of errors done and participant's opinion for websites with and without parallax scrolling. However, on average participants preferred parallax scrolling over non parallax scrolling website. From the findings of the study, it was concluded that there was no impact or improvement of usability and universal design of the parallax scrolling in a website.

Keywords: parallax scrolling, usability, universal design, user's experience, prototype design and development, prototype website.

Table of Contents

1	Chapter 1: Introduction	1
1.1	Problem Statement	2
1.2	Research Questions	3
1.3	Conclusion.....	3
2	Chapter 2: Literature Review	4
2.1	Parallax Scrolling	4
2.2	User experience in parallax scrolling	5
2.3	Usability and effectiveness of parallax scrolling	6
2.4	Parallax scrolling and Universal design	7
2.5	Conclusion.....	8
3	Chapter 3: Methodology.....	9
3.1	Experimental Research Methodology:.....	10
3.2	Hypothesis:	11
3.3	Research Variables.....	12
3.3.1	Independent Variables:.....	13
3.3.2	Dependent Variable:	14
3.4	Research Design:.....	15
3.5	Factorial Design Concept	16
3.6	Within-Subject Design.....	17
4	Chapter 4: Prototype Development.....	19
4.1	Prototype Design Procedure	19
4.2	Technologies used in the Prototype Development	22
4.3	Parallax Technique used in Prototype	22
4.4	Prototype Website:.....	23
4.5	Prototype Evaluation:	25
5	Chapter 5: Data Collection Method	28
5.1	Tasks Design	29
5.2	Materials and Systems Required for the Experiment.....	30
5.3	Participants	30
5.4	Ethical Concern	31
5.5	Experiment Process.....	31
5.5.1	Pre-Experiment	31

5.5.2	Real Experiment	32
5.5.3	Post-Experiment.....	33
5.6	Quantitative Data Analysis.....	33
6	Chapter 6: Data Analysis and Result	35
6.1	Demographic Information of Participants	35
6.2	Performance of Participants on Experimental Condition	38
6.2.1	Total time to complete tasks	38
6.2.2	Total number of errors found while completing tasks	41
6.3	Analysis of Opinion on Experimental Conditions.....	43
6.3.1	Analysis on questions regarding experiment conditions.....	43
6.4	Analysis of Opinion on Prototype and Task Design	49
7	Chapter 7: Discussion.....	50
7.1	Summary of Analysis of Result.....	50
7.2	Comparison with Previous Study	52
7.3	Limitations of the Study	53
8	Chapter 8: Conclusion	55
8.1	Future Work.....	56
	References	57
9	Appendices.....	60
9.1	Appendix A.....	60
9.1.1	Consent Form.....	60
9.2	Appendix B	62
9.2.1	Pre-experiment Questionnaire	62
9.2.2	Post-Experiment Questionnaire.....	64
9.2.3	Randomization or Counterbalance of participants.....	66
9.2.4	Participants performance Sheet	67
9.3	Appendix C	68
9.3.1	Participants Data.....	68
9.3.2	Statistic Table	71

List of Figures

Figure 2-1 Parallax effect caused by motion of different backgrounds.....	4
Figure 3-1: True Experiment	16
Figure 3-2: Within-subject design	18
Figure 4-1: Paper-based design architecture for the prototype.....	20
Figure 4-2: Electronic wireframe of the prototype website with the Home page and Takeaway page	21
Figure 4-3: Screenshot of Home page of the prototype.....	24
Figure 4-4: Screenshot of the Takeaway page of the prototype	24
Figure 4-5: Testing of the website with SortSite application.....	26
Figure 4-6: Report after testing the website	26
Figure 4-7: Report after the issues are fixed	27
Figure 6-1: Percentage of participants according to age group, education and profession	36
Figure 6-2: Percentage of participants in terms of computer use experience, reason for using internet, experience of website visit and device used to visit website.	37
Figure 6-3: Percentage of participants in terms of use of scrolling in website, visit of animated webpage, an idea about parallax scrolling and idea about the universal design.	37
Figure 6-4: Bar graph and line graph for mean of total completion time in parallax and non-parallax scrolling.....	39
Figure 6-5: Bar graph and line graph for mean error found in parallax and non-parallax website.....	42
Figure 6-6: Opinion of participants regarding tasks design and prototype design in percentage	49

List of Tables

Table 3-1: factorial design of independent variables	17
Table 5-1: Task Group A.....	29
Table 5-2: Task Group B	30
Table 6-1: Normality test of total task completion time	38
Table 6-2: Mean and standard deviation for total task completion time in parallax scrolling and non-parallax scrolling	39
Table 6-3: Result of the Paired t-test for total time taken to complete tasks with the significant value	40
Table 6-4: Normality distribution test for total number of errors found	41
Table 6-5: Mean and standard deviation for total number of errors in parallax scrolling and non-parallax scrolling	41
Table 6-6: Result of the Paired t-test for error while completing tasks with the significant value	42
Table 6-7: Paired t-test result for question I found it interesting while scrolling.....	44
Table 6-8: Paired t-test result for question I found it pleasant while scrolling.	45
Table 6-9: Paired t-test result for question I found it pleasant while scrolling.	47
Table 6-10: Paired t-test result for question I prefer.....	48

An Usability and Universal Design Investigation of Parallax Scrolling

1 Chapter 1: Introduction

With the development of technology, the use of the internet has also increased. More and more people are involved in the use of the internet due to its benefits day by day ("Measuring digital development: Facts and figures 2019 [PDF File]," 2019). This has also advanced the services provided by the internet to the users. Different services are provided with the help of websites through the internet. These websites hold lots of information that a user might need to fulfill the goal that they have in their mind. That information may or may not be contained on the same page and required more pages that are accessed with the help of a gesture called scrolling. It is performed with the help of a mouse usually with the built-in scroll wheel in the case of PC's and with the help of a touchpad in laptops and in touchscreen-based devices using finger swipe (Murano & Sharma, 2020).

In the early ages of the website and webpage design, scrolling was not given so much thought and importance. With the development of web accessibility, different scrolling techniques are put upfront for webpages and user interfaces. This helps the user to access the information on the web page and get the consumer more involved with the website and make it interesting (Sharma, 2019). Parallax scrolling is one of the techniques which are used on websites that is more appealing and interesting to use. With the increase of internet users, the web surfers want more interesting effects and visualization on the websites so that they can enjoy the tasks done during the search (Frederick, Mohler, Vorvoreanu, & Glotzbach, 2015).

User experience is an important factor while surfing on the internet in order to gather information or may to do a particular task. This is influenced by the usability and the efficiency of the website and affects the overall experience of the consumer (Mahardika, Wibirama, Ferdiana, & Kusumawardani, 2018). Not only that, the esthetic of the website

and the webpage can affect the experience of users directly or indirectly (Frederick et al., 2015). This also determines the usability effectiveness of the elements used in the website.

In this study, the usability and the Universal Design of the parallax scrolling will be investigated with the help of experimental methods and qualitative data analysis.

Parallax scrolling is the effect that can be seen in a website that is created with the help of different layers in a website, designed in a way that seems to move at a different speed or in a different direction producing an animation effect (Sherwin, 2019).

Usability is the quality of a website which helps to identify how easy the website is to use by a user (Nielsen, 2012). Universal design is a design of any product in such a manner in which all people can use the product without any assistance or any other specialized design and also without a need for adaptation (Mace, 1997). Hence, the study analyzes the usability and universal design aspect of a website with parallax scrolling. Prototype websites will be designed with the two conditions in order to do the experiment, one website with no parallax scrolling, and another website with subtle parallax scrolling. There will be a comparison between two prototypes and the data collected from the experiment will be used to investigate the parallax scrolling, its usability and its universal design.

1.1 Problem Statement

Every study has its fair share of problems that are solved or pointed out along with the progression of the study. With every technique used on a website, there are some advantages and disadvantages included. This same for the parallax scrolling that is used in websites for animation effects. Some issues and problems of the parallax scrolling used in websites are going to be analyzed in this study.

Parallax scrolling on a web page is visualized as the movement of different layers that show the animated effect on a web page. According to (Sherwin, 2019) using parallax scrolling some users might feel dizzy due to the parallax effect and too much movement of the layers and text.

(Sherwin, 2019) also pointed out that the content on the webpage with the parallax effect is hard to control. Sometimes the pages take a longer time to load or the scrolling

effect of the page is too fast for the user to read.

According to (Summers & Hinojosa, 2020) the color contrast between the color of the text and the color of the background can create problems to see the content of the webpage.

1.2 Research Questions

In this study, there will be two main research questions that will relate to the usability and the universal design of the parallax scrolling.

1. Does parallax scrolling increases the usability of a website for users?
2. Do the use of parallax scrolling helps in the universal design of the website?

1.3 Conclusion

The purpose of this chapter is to introduce the topic of the study and different aspects it holds and expect to solve different problems introduces in this chapter in further study. The problem statement and the research questions were also introduced in this chapter with some insights of different researchers on the study they have done on the similar field earlier. A brief introduction of parallax scrolling, the usability of parallax scrolling, and Universal design were provided in this chapter. In the next chapter, a literature review of the parallax scrolling and topic related to parallax scrolling like user experience, usability, and universal design will be discussed, and understand a little more about the topic itself.

2 Chapter 2: Literature Review

In this chapter, the studies that are done previously by different researchers in a similar topic in this study will be mentioned. It will help in the identification of the possible gap that can be found and analyze the studies that will provide the conclusion and the relevant solution in the research field of the provided topic.

Here in this study, different research papers, articles and web contents will be discussed which are related to the parallax scrolling, the usability of the scrolling (parallax scrolling), different challenges and issues related to parallax scrolling. The connection of parallax scrolling with a universal design will also be investigated.

2.1 Parallax Scrolling

Parallax scrolling is the effect seen on the webpage while it is scrolled up and down. It gives the perception of 3D to the eyes of the user (Fu, 2016). Parallax scrolling is one of the techniques which are used in the website to invoke the animation effects on the webpage. With the help of parallax scrolling which allows different backgrounds in a webpage to move at different speeds which creates an illusion of three-dimensional effects (Frederick et al., 2015). The website which implements parallax scrolling simply has a single page rather than multiple pages with the continuous display without loading or opening to other pages, unlike other conventional websites. On the single page, all the elements required for the parallax effect are placed and scrolling enables the effects to be visible to the user. There elements like text, image, videos, etc. are placed in the webpage and while scrolling the website the parallax effect takes upon these elements and is seen as appearing and disappearing in the page due to being in motion at different speeds (Ku, 2015).

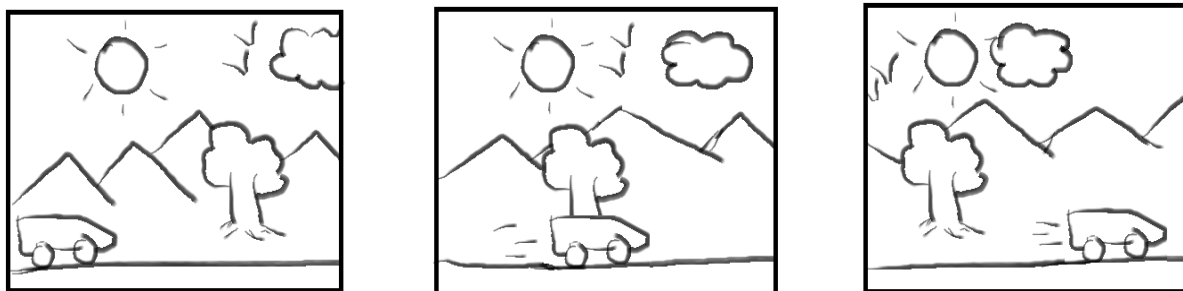


Figure 2-1 Parallax effect caused by motion of different backgrounds.

The popularity of the use of parallax scrolling in websites is increasing. Parallax scrolling is popular and is used in websites for the design aspects of the websites. Mainly it is used to give an effect to the website when it is scrolled to the content of the given website. Parallax scrolling also provides opportunities to the website designers to design a website that will appeal to the users to surf through the context of the website and make it entertaining. The use of parallax scrolling can also improve the experience of the user while using the website due to its animated effects and perception of 3D (Frederick et al., 2015).

Parallax scrolling is specially used in websites that are used for storytelling and infographics (Ku, 2015). Many studies have found that parallax scrolling is best suitable for hedonic purposes than for goal-oriented or utilitarian purposes (Frederick et al., 2015; Ku, 2015). The reason for this is due to the visual appeal provided by the design of the website influences the hedonic attribute of a human behavioral and emotional state of mind. This means visually engaging tasks provide usability and satisfaction (Hassenzahl, 2001). Hence parallax scrolling is more useful for the hedonic attribute of the product.

2.2 User experience in parallax scrolling

When any user uses any product either they like that or dislike that. They have certain experiences from that encounter, like good, bad, or fine (ok). It is the same as surfing through a website. They experience certain feelings as they go through the website either it is goal-oriented or serendipitous tasks. It makes a whole lot of difference when you add a certain element to the website. The element may be design style or effects that make the user interested in using that product. The experience is the result of the interaction between the product and the user which is connected to the design research (Forlizzi & Battarbee, 2004). There are different meanings related to the term user experience with many aspects like sensual, emotional, aesthetic, usability, and many more but there is no definite theory for “user experience” in the field of design (Forlizzi & Battarbee, 2004; Hassenzahl & Tractinsky, 2006).

A good first impression only needs 50 milliseconds (Hassenzahl & Tractinsky, 2006)

which can greatly affect the experience of the user using any system. This also concern with the visual appearance of the website and its stability (Hassenzahl & Tractinsky, 2006). According to (Frederick et al., 2015) there are different elements that constitute the experience of the user while using the website. These elements like usability, aesthetics, emotions, efficiency, dependability, and novelty have a great influence on the user's experience (Mahardika et al., 2018). User's experience can also be related to different emotions of the users fun, joy, enjoyment, and many other emotions(Frederick et al., 2015).

The study on effects of QoS degradation on parallax scrolling in web services, (Adachi & Ito, 2015) the researchers evaluated the Quality of Experience(QoE) in terms of web usability and used satisfaction, the effectiveness, and the efficiency as the parameter for QoE. In the study, they found that even if the quality of service is degraded, the parallax effect for web services can be maintained with proper web page design. This indicates that the parallax effect on a website might progress towards user comfort. According to (Frederick et al., 2015) in the study done to determine the effect of parallax scrolling on user experience, it was found out that parallax scrolling significantly improves the fun and enjoyment for the user to use the website. But it was also observed that it did not improve the overall user experience when compared between websites with or without parallax scrolling.

2.3 Usability and effectiveness of parallax scrolling

The usability is concern with quality characteristics that tells how the user interface is easy to use and during the design process it also refers to the approach for increasing ease-of-use. There are different characteristics associated with the term usability. These are also the component of usability. These components are learnability, memorability, efficiency, accuracy and user satisfaction (Nielsen, 2012). While designing a website, usability aspect should be included to develop a proper website with the easy to use user interface.

In the study done by (Frederick, 2013), the author did research on the effects of parallax scrolling on user experience and preference web design. In the study, the usability of the website with parallax scrolling and the website without parallax scrolling was tested. The result regarding the usability found in that study was that there was no significant

difference between the website with parallax scrolling and the website without parallax scrolling. From the statistics of the test done on the study, there was no evidence that a website with parallax scrolling has better usability than a website without parallax scrolling (Frederick, 2013).

2.4 Parallax scrolling and Universal design

Universal design from the word implies any design that can be used by all people universally is a universal design. According to Ron Mace, 1985 “Universal design is a type of design that’s usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” (Ostroff, 2011). Regardless of age, ability, or disability, the design which can be understood, accessed and used to its full extent by the people without any special requirement is considered as the universal design ((NDA), 2020).

During a period of three years from 1994 to 1997, research was conducted by the Center for Universal Design with the title of “Studies to Further the Development of Universal Design” and one of the tasks of that research was to create universal design guidelines. As the result 7 principles of Universal Design were developed. Those seven principles are:

1. Equitable Use
2. Flexibility in Use
3. Simple and Intuitive Use
4. Perceptible Information
5. Tolerance for Error
6. Low Physical Effort
7. Size and Space for Approach and Use. (Story, 2001)

The same is for web applications in terms of universal design. The website should also be designed in the consideration of the guidelines and principles of the Universal Design. The design of a website should be drawn in such a way that it can be used by any person, understandable, and easily accessible.

Parallax scrolling is a technique that is used in a website to give the website an

animation effect making it interesting to use (Frederick et al., 2015). Hence it is just an effect designed in a website and the website that has a parallax effect should also be designed using the guidelines of the Universal Design.

2.5 Conclusion

This chapter reviewed the past studies done involving the parallax scrolling technique in a website. There are different studies done in the user experience and approach of the user towards the parallax scrolling in a website. With the user experience, the approach of the research was to study the usability, aesthetics, emotions, efficiency, accuracy, and novelty. In the studies, it was found that the user experience also depends upon the fun, joy, and enjoyment of the user and the user interface they are using. It was also found that there was no significant difference in the usability of a website with or without parallax scrolling.

The study done by (Frederick et al., 2015) was to find the user experience and their preference. That study concludes that there was no improvement in the overall experience of the user and their preference with the use of parallax scrolling compared to non-parallax scrolling. The same outcome was achieved in the study done by (Ku, 2015). From other similar studies it was found that even though there was no improvement in overall preference and user's experience, the researcher did not disclose the probability of further study of parallax study and the usefulness of the parallax scrolling in fun and enjoyment activities. This study tries to find the usability and universality of the parallax scrolling through experiment and quantitative analysis of the result.

In the next chapter, the methodology will be discussed in how this research approaches the study of the usability investigation on websites with and without parallax scrolling. Methods and techniques that will help for the investigation in this research study will be addressed in the following chapter.

3 Chapter 3: Methodology

This chapter includes the method and the techniques that are used in this project. There are different types of methodologies and techniques that can be used in any project according to the project goal and researcher's preferences. Research methodology is the step by step process of systematic tasks where the researcher works on the research in scientific way. It involves different activities like formulating hypothesis, process of testing the hypothesis, collecting data, analyzing the collected data and forming a conclusion based on the analysis (Singh, 2006). When a research is done, it is crucial to begin the research with structured method of research which can be used for investigation such as interviews, survey, etc. (Lazar, Feng, & Hochheiser, 2017; Sharma, 2019). Qualitative research method focuses on the non-statistical data collection and analysis which does not involve any experiments where numeric data are collected. The data collected by the non-experimental research methods are text, audio and video which does not provide the numeric value or numeric data for the statistical analysis (Mills & Birks, 2014). Just the opposite of the qualitative research method, quantitative research method or experimental research method usually involves numeric data and statistical analysis. It operates on different variables using evaluative measures so that it can be compared with some standard (Di Pofi, 2002). Quasi-experimental method is similar to the experimental method and statistical variable relation which test casual hypothesis but it does not support random assignment of variables unlike experimental (Sharma, 2019; White & Sabarwal, 2014). Design Science methodology is also one of the methodologies used for research purpose. In design science, there are two parts that focuses in respect to the design of the artifact. The two parts that are involved with design science are *Validation* of the artifact that is designed, which asks the research questions for what will happen and the second part is evaluation which asks the design research questions for what has happened (Wieringa, 2010).

Upon consideration and analysis, Design Science methodology focuses on the organizational approach where artifact is created and evaluated to solve the problem identified by an organization (Peppers, Tuunanen, Rothenberger, & Chatterjee, 2007). Quantitative research method is empirical with numeric data and statistical analysis whereas qualitative research method is empirical with non-numeric data and non-

experimental approach (Aspers, 2009). For this project, experimental methodology has been chosen as the method to collect the data that is necessary for the investigation of the usability and the universal design of the parallax scrolling. With the help of different hypothesis this project will help to research parallax scrolling, its usability to uses and how the uses of parallax effect can contribute in the universal design.

3.1 Experimental Research Methodology:

It is very important that methodology that is used for the research is appropriate for the good research project. Experimental research is one of the methods that is being used for a long time in education and psychology (Ross & Morrison, 2013). “ According to (Lazar et al., 2017) selection of the research method is largely dependent on the context of the study specially the main purpose of it, duration of study, targeted participants, funding and experience of the researchers.”

The design of the experiment is the process of gathering test hypotheses necessary for user interaction technique involving definition and decision on the variables that is to be used, tasks and procedure to be included, number of participants and many other factors (MacKenzie, 2012). Experimental research helps to identify the different causes of the situations and gives a way to find out the casual relations. Hypothesis is a single statement that is focused on the problem on hold that can be tested with the help of experimentation in order to find out validation of that hypothesis. Experiments are initiated with the hypothesis required of the research. Normally, there is a null hypothesis and an alternative hypothesis in an experiment at the least. There are two types of the variables states in the hypothesis used in the experimental research, dependent and independent variables. In the experiment, hypothesis are tested in order to find true and false of the purposed hypothesis (Lazar et al., 2017).

The following steps are taken in order to work throughout this research study.

- Finding the issues related to the area of the research.
- Create the research questions with the help of previous studies done on the study.
- Create the problem statement that could not be answered on the previous research study related to the area.
- Designing a wireframe of the website using Axure.

- Design prototype websites to perform the experiment considering conditions and variables.
- Evaluation of the designed prototype was done with the help of SortSite 6.
- Different questionnaire like per-experiment and post-experiment questionnaire along with the task to perform for testing was developed.
- Participants were selected for the experiment of the designed prototype.
- The real experiment was conducted and the data was collected.
- Data was analyzed using statistical analyzing tool SPSS.
- Discussion and conclusion was made.

3.2 Hypothesis:

Research hypothesis is important factor that allows the researchers to conclude its result of the research study. In a sense, we can say that it is the fundamental part of the research study that states the specific statement of the problem (Toledo, Flikkema, & Toledo-Pereyra, 2011). According to (Banerjee, Chitnis, Jadhav, Bhawalkar, & Chaudhury, 2009), proper and good hypothesis should be simple with one predictor and one outcome variable, specific without any ambiguity and stated in advanced.

Hypothesis must be expressed as statements and facts which can be tested with the help of experiment and it should show the relation two or more measurable variables (Mourougan & Sethuraman, 2017). A theory is aggregate of hypotheses which are created through series of studies whereas a hypothesis is small focused statement which provides a foundation for an experiment and testing (Lazar et al., 2017; Rosenthal & Rosnow, 2008).

There are different types of hypotheses (Banerjee et al., 2009). In this research study, null and alternate hypotheses will be used. From the word 'null' we can anticipate that this hypothesis purpose it does not have any effects of the given hypothesis or difference between experimental treatments. It shows that there is no relation between the predictor and outcome variables (Banerjee et al., 2009; Lazar et al., 2017). Alternate hypothesis come to light when null hypothesis is rejected. It shows the possible outcome that the study is trying to achieve. Null hypothesis and alternate hypothesis are mutually exclusive to each other (Lazar et al., 2017; Mourougan & Sethuraman,

2017). That means outcome is either null or the outcome expected by the researchers. So when the possibility of the null hypothesis is rejected then alternate hypothesis is accepted and thus helps in the conclusion of the research study.

In this study, there are three research hypotheses were formulated which is based on the tasks that is to be tested through experiment and factors that are to be measured. Here null hypothesis is denoted by H₀ and alternate hypothesis is denoted by H₁ (Mourougan & Sethuraman, 2017).

Hypothesis 1:

H₀: There will be no significant difference in efficiency for a user while using websites with and without parallax effect.

H₁: There will be significant difference in efficiency for a user to the amount of time taken to complete tasks while using websites with and without parallax effect.

Hypothesis 2:

H₀: There will be no significant difference in the accuracy in terms of errors for tasks done by a user while using websites with and without parallax effect.

H₁: Differences will be seen in the accuracy in terms of errors for tasks done by a user while using websites with and without parallax effect.

Hypothesis 3:

H₀: There will be no significant difference in the satisfaction to a user while using websites with and without parallax effect.

H₁: There will be a significant difference in the level of satisfaction to a user while using websites with and without parallax effect.

3.3 Research Variables

The term variables are often used in the field of research. The term itself refers to something whose values can be or are changed during the operation and thus are the factors that can be measured. The variable is fundamental in the research as they can be quantifiable and becomes operable during the experiment and research (Kaur, 2013).

There are different types of research variables in research (Kaur, 2013; Kilpatrick, 1978). The variables that were used in this study are dependent and independent variables. When the hypotheses are developed in a study, a good hypothesis defines dependent variables and independent variables explicitly, of the research and the area of the study (Lazar et al., 2017).

3.3.1 Independent Variables:

The factors that are independent of the user's behavior while performing tasks or on the experiment done on research can be termed as independent variable. These factors can be the cause of the change in the dependent variable of the research and are usually the factors that researchers are trying to study in a research (Lazar et al., 2017). This means independent variables are anterior which comes before the dependent variable (Kaur, 2013). Independent variables are the conditions which are controlled by the researcher so that outcome can be achieved during the experimentation. In the field of HCI, independent variables are related to the technologies and the area in which it is used and its users (Lazar et al., 2017). Independent variables are causes and it produces effects on outcomes. If there are 3 or more independent variables then the number of effects produced by those variables will be too much and very difficult to find the interpretable meaning. So the independent variables should be limited to one or two (MacKenzie, 2012).

In this study there are three hypotheses that are developed in order to perform the experiment that could help in the testing the designed prototype. So, the independent variable is the designed prototype websites and it has two factor i.e. serendipitous tasks and goal driven. Two versions of website were designed, one with parallax effect and other one without parallax effect. Both the websites are tasked with the serendipitous activity and some goal driven tasks and experience, opinion and performance of the participants are collected with the help of designed experiment. Similar tasks were designed for both the websites which are performed by the participants and the dependent variables were measured according to the website they visit i.e. website with parallax effect and website without parallax effect.

3.3.2 Dependent Variable:

The variables which are dependent on the participant's behavior during an experiment could be considered as dependent variables. If the independent variable is considered as the 'cause' then the dependent variable is the 'effect' of that cause (Lazar et al., 2017). As the word suggests 'dependent', the dependent variable is dependent upon the human. The action and the tasks performed by the participants in an experiment are the reasons for the effects of the cause which means dependent variables are the effect and the independent variables are the cause (Lazar et al., 2017; MacKenzie, 2012). The dependent variables are the factors that are used for the measurement aspect of human behavior to create an outcome while experimenting on the designed prototype (MacKenzie, 2012; Rosenthal & Rosnow, 2008).

The dependent variables are the factors that are being measured in an experiment and are divided into different groups. The factors that are measured as the dependent variables are accuracy, efficiency, user satisfaction, ease of learning and others (Lazar et al., 2017). For this study, three dependent variables were measured to analyze the usability of the parallax scrolling.

- **Total time to complete tasks:**

This is the dependent measure that was used in order to measure the efficiency of the task done by the participants. This variable depends upon how fast a participant complete a group of tasks performed in both the prototype. So simply it is the time taken to complete the designed tasks by the participants.

- **Total error:**

This dependent measure was used to measure the accuracy of the tasks performed by participants. It measured the total number of errors that occurred during the experiment of prototype websites by participants. When participants unintentionally click while performing tasks, when participants click on the wrong content even if tasks are clear and when participants performing task number 1 (see [Tasks Design](#)) from any tasks group make a counting mistake; in these three situations, the errors are counted.

- **Satisfaction of the user:**

With this variable, the experience and the preference of the participants were measured by rating their experience from 1 to 5 after experimenting with the designed website prototypes. It was done with help of a questionnaire provided to the participants after the experiment was performed in order to collect the data.

3.4 Research Design:

The research design is the process of designing a framework that helps researchers to create a way to investigate the research questions through its implementation (Durrheim, 2006). According to (Lazar et al., 2017; MacKenzie, 2012) experiment design has been used in HCI to develop a task model, evaluate the design solutions and provide a response to other issues related to the technology and its acceptance with the users.

(Lazar et al., 2017; Rosenthal & Rosnow, 2008) pointed out that research design methods are categorized into three groups of studies and they are true experiment, quasi-experiment and non-experiment. In this study, true experiment design has been used as the experiment design. It has following characteristics:

- In this study, three testable hypotheses have been introduced.
- Two experimental prototype websites have been developed for the experiment.
- Dependent variables were measured with the help of quantified data.
- Results were analyzed with the help of statistical significant test (paired t-test).
- Any kind of bias was not practiced during the experiment.
- Two types of tasks were assigned (task A and task B) to the participants to perform in the experiment for both websites (serendipitous and Goal driven).

The flow chat is provided by (Lazar et al., 2017) in order to understand the flow of the true experiment.

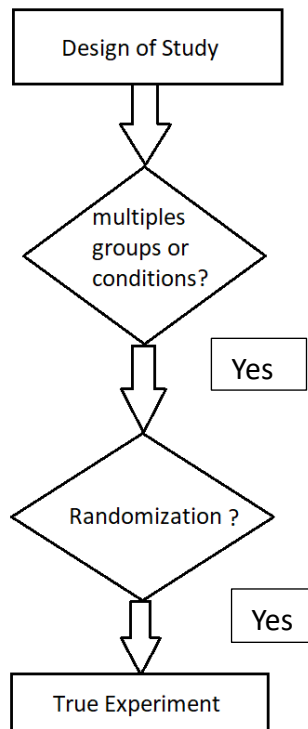


Figure 3-1: True Experiment

3.5 Factorial Design Concept

It is one of the most widely used design concepts which are followed when an experiment has to examine more than a single independent variable. In this design, the experiment conditions are divided into subsets as per the independent variable which allows investigators to examine the effect of independent variables and interaction between multiple variables (Lazar et al., 2017).

There are two websites in this study that have been used for the experiment. In the experiment, there is a single type of task that is going to be performed by the participants to examine the study. Hence it indicates that there are two types of independent variables i.e. websites with and without parallax effect and type of tasks. According to (Lazar et al., 2017) the total number of the conditions that are required for the experiment can be equated as

$$\text{Number of conditions} = 1 * 2 = 2$$

Further is described with the help of the table below:

Types of Tasks	Prototype website 1	Prototype website 2
Group tasks	Website with parallax effect	Website without parallax effect

Table 3-1: factorial design of independent variables

These two conditions or treatments have been used by participants in the experiment for example participant 1 had to perform a single group task in both the websites, with and without parallax effect.

3.6 Within-Subject Design

It is an experimental design that is used and suited when the number of targeted participants or participant pool is small (Lazar et al., 2017). It is also called within-group or dependent group repeated measures design because every single participant of the experiment takes part in all the conditions or treatment and researchers compare related measures (Bhandari, 2021). In this study, each participant is going to perform different tasks in both the designed prototype websites, hence, the approach of this within-subject design is chosen. There are different advantages associated with the within-subject design approach (Bhandari, 2021; Lazar et al., 2017). Some of them are as follows:

- Experiment can be performed with a smaller sample or pool of participants making the experiment cost-effective.
- It effectively isolates individual differences and helps to monitor the participant's effectiveness over the conditions.
- It provides more strong tests and is statistically powerful as it eliminates individual variation and gives more information from a single participant.

Despite the advantages of the within-subject design, there are some disadvantages and limitations. The main disadvantage of the within-subject design is that it is hard to control the learning effect. With the repetition of the same types of tasks for different conditions, the participants can learn the process of doing tasks and get to perform it better the next time they repeat the tasks. This creates a negative impact on the learning effect (Lazar et al., 2017). To prevent this limitation of within-subject design

randomization or counterbalance (Bhandari, 2021) is used in this study. According to (Lazar et al., 2017) another disadvantage of the within-subject design is fatigue. In a within-subject design, there are multiple conditions that a participant had to go over during the experiment which makes the time longer to complete one or more tasks under different conditions. During the experiment and completing the tasks, participants may experience boredom and tiredness. (Bhandari, 2021) pointed out these disadvantages as carryover effects which are categorized into three which are practice effect which is the same as learning effect, order effect which is the same as fatigue felt by the participant of experiment and sequence the effect which is effect on the outcome due to the interaction between conditions according to their sequence.

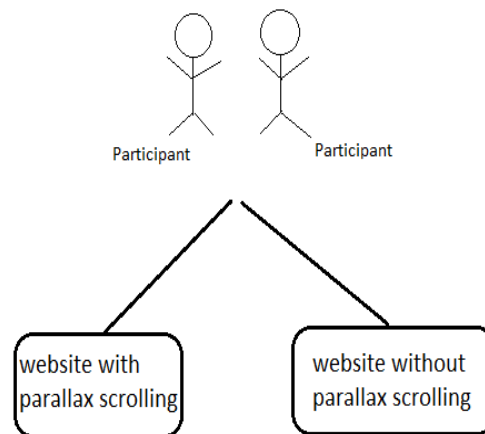


Figure 3-2: Within-subject design

Randomization is the process of assigning treatment or conditions to the participants of the experiment (Lazar et al., 2017). Randomization is introduced to the experiment to counterbalance the limitation of within-subject design i.e. learning effect. When the different possible sequence of treatment is assigned to participants it is randomization and when a limited number of sequences of treatment is presented to participants then it is called counterbalance (Bhandari, 2021). In this study, counterbalance had been used (Mayers, 2013).

4 Chapter 4: Prototype Development

The development of a prototype is one of the steps in the research study that helps in the investigation of research problems indicated in the study. According to (Lim, Stolterman, & Tenenberg, 2008) the prototype is a tool that helps in the visualization of the design concept depicted by the investigator which serves as the means for evaluation (for example usability testing) and is part of the whole design process. In the study done by (Lim et al., 2008), they used paper prototypes and computer screen-based prototype before producing the actual products. It is the way to design the idea and use it for experimental testing.

Before developing the prototype, other different procedures such as research statements, research questions, were performed in the study. Through the help of research statements, research questions, hypotheses, research methodology, prototype design and prototype development process were carried out. At first, a paper wireframe was designed to see the rough architecture followed by the electronic-based wireframe architecture was developed with the help of an electronic wireframe design tool called Axure RP 10. After that two prototype websites were designed with the help of different website developing technologies. One website was designed with the inclusion of the parallax effect and the other was without the parallax effect. The website with the parallax effect has subtle animation to it and the other website has no animation effect at all.

4.1 Prototype Design Procedure

In this study, prototypes were designed in order to investigate the different issues related to the parallax effect used in the website. Mainly, the usability and universal design issues related to the parallax scrolling technique in websites. The aim of the prototype development is to investigate the usability aspect of the parallax scrolling technique in a website and the universality of the use of parallax scrolling to the website.

Different steps were involved while developing the prototype website. Those steps are as follows:

- **Design research:** The first step was to research different types of websites that were using the parallax effect on their websites. The effectiveness of the parallax effect on the websites and the insights of the user's perspective were thoroughly noted.
- **Sketch the design:** A paper-based design was sketched as the outline of the prototype website. These sketches were based on the use of parallax scrolling on the website for the effect. Then the paper-based design was translated electronic wireframe for the prototype development.

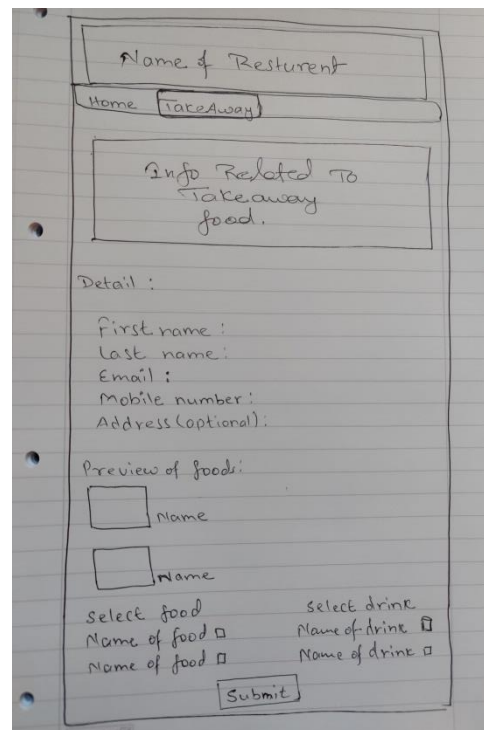
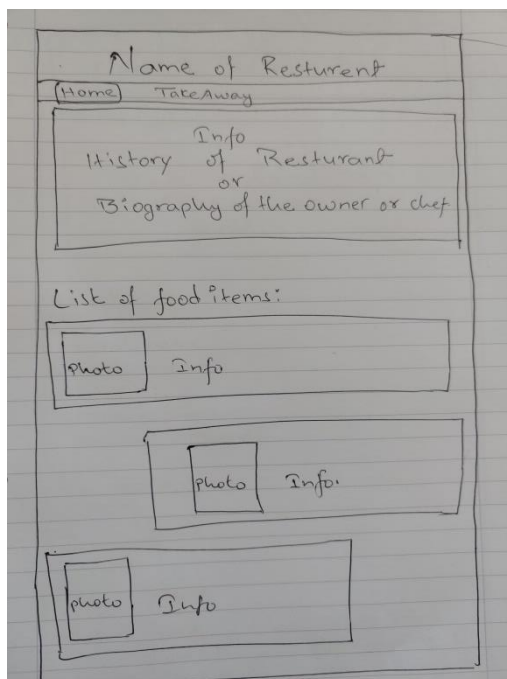


Figure 4-1: Paper-based design architecture for the prototype

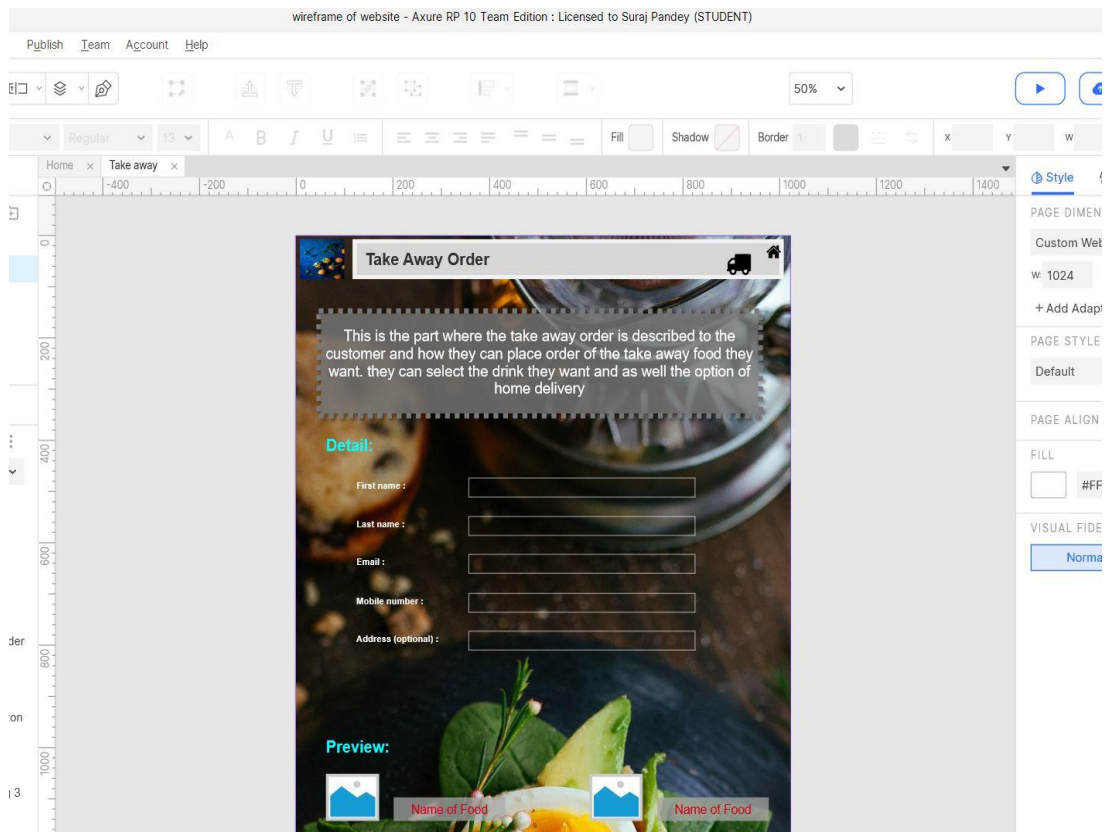
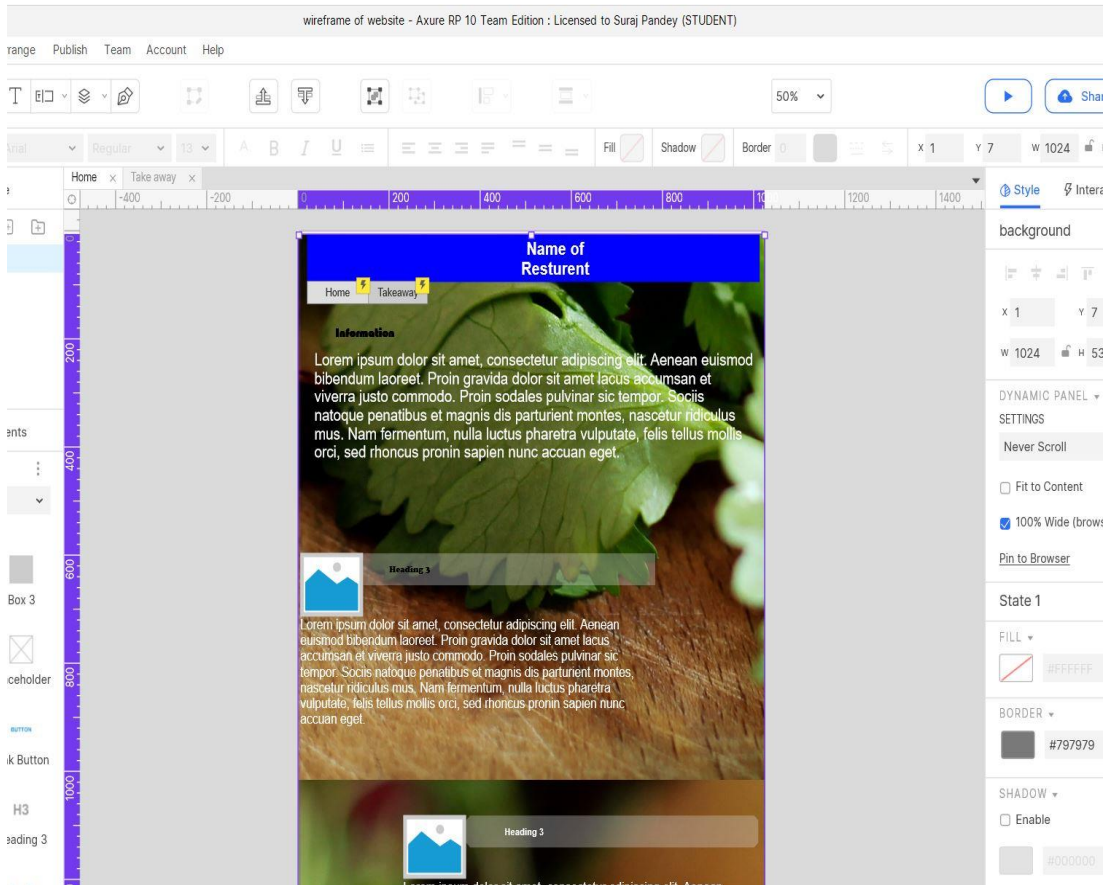


Figure 4-2: Electronic wireframe of the prototype website with the Home page and Takeaway page

- **Prototype development:** With the help of sketched design and different software, two prototype websites were developed.
- **Test prototype:** The design prototype is tested with the help of SortSite 6 to evaluate the usability of the developed prototype.
- **Final integration:** Issues that were found after the evaluation of the prototype with the help of an automated tool were resolved and the prototype was made ready for the experiment.

4.2 Technologies used in the Prototype Development

Different technologies were used in order to develop prototype websites which includes hardware and software. The hardware that was used in development of the experimental prototype websites is Lenovo legion 5 with AMD Ryzen 5 4600H with Radeon graphics, 16 GB of RAM, with the speed of 3.00 GHz. The laptop is equipped with Windows 10 Home edition as its operating system.

The software that were used to develop the two prototype websites were HTML and CSS. Visual studio code, a text editor was used to design the experimental website prototypes. The prototype was designed only with HTML as the base structure of a webpage and CSS was used as the styling for the webpages and to give the animation effect to the webpages which constitute the parallax effect for parallax scrolling.

4.3 Parallax Technique used in Prototype

What differs a normal website from an animated one is the effects that are used in the website. In this study as well there are two types of websites, one website prototype without parallax scrolling and one with the subtle parallax scrolling technique. The website prototype with parallax scrolling has two different layers one as the foreground and one as the background. The foreground layer has the actual content of the website and the background layer has an image that moves in the opposite direction of the foreground, resulting in the animation effect or parallax effect while scrolling the webpage. The parallax effect to the website was obtained with the help of CSS code on the styling page.

The code used in the prototype that helps to differentiate the website in terms of

parallax scrolling with non-parallax scrolling is present in the cascading style sheet and the lines of code to made the website to have parallax effect is

```
.container .parallax {  
.....  
.....  
Background-attachment: fixed;  
Transform: scale3d(1.09, 1.09, 1.09)  
.....}
```

4.4 Prototype Website:

In this study, as mentioned earlier, there are two websites with identical content and design but the only difference is that one website has parallax scrolling and the other does not have parallax scrolling. One has a subtle effect of motion between two layers and the other is plain and simple. Therefore prototype can be discussed as one with the key element of difference as the parallax effect. There are two pages on the prototype website. One is the *Home* page and the other is the *Takeaway* page. The website is about a restaurant that provides different food items to the customer with the takeaway service. On the home page, there are different food items with the picture and respective information about the entitled food. There is some information about the restaurant itself. The next page is about the takeaway service of the restaurant and the information related to it. It has a form related to the information about the customer like name, email, phone number and address. The takeaway page also shows a preview of the foods that were on the home page so that the customer feels easy to select the food of their liking and some drinks. This is also an option for home delivery. If a customer wants home delivery of the food then they can choose that option. And at last, there is a submit button that helps users to submit a selection of food and drink to be ready by the restaurant. Two pictures used in the prototype with the named coco.jpg and cake.jpg are downloaded from unsplash¹ website. Other pictures are private clicks

¹ [Unsplash](https://unsplash.com/)

and can be found in separate folder. The screenshot of the website with home page and takeaway page can be seen in the following pictures:

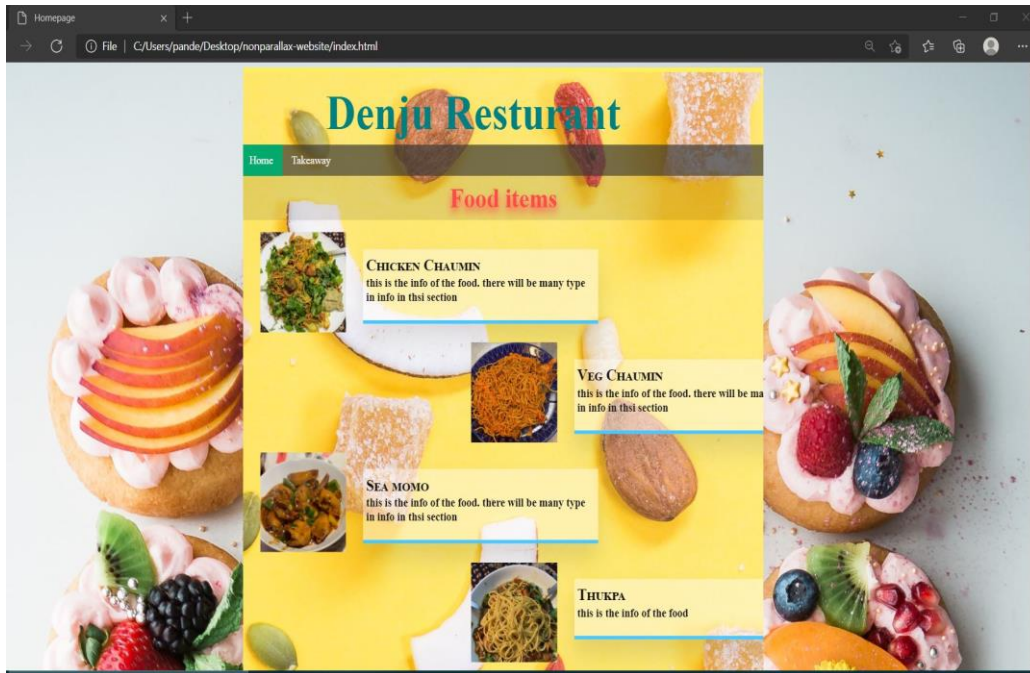


Figure 4-3: Screenshot of Home page of the prototype.

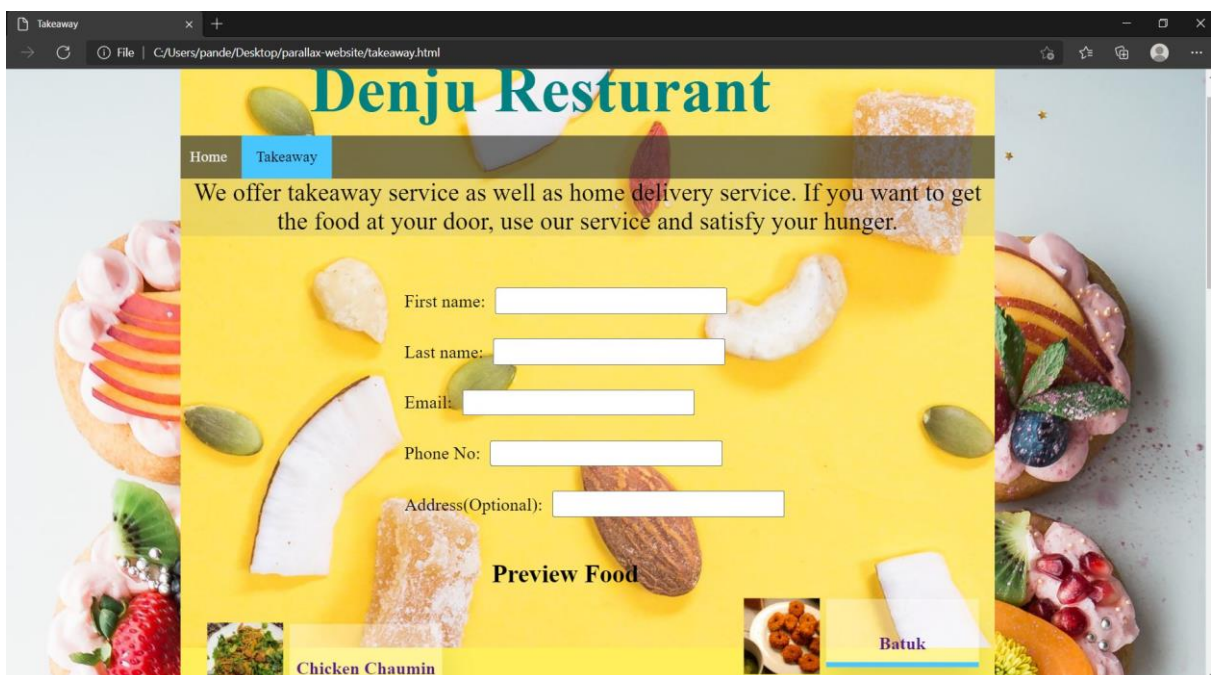


Figure 4-4: Screenshot of the Takeaway page of the prototype

4.5 Prototype Evaluation:

When the prototype is ready, it is very important to evaluate that prototype before actually using it in the experiment. It is important to access that the functions of the prototype are working properly as they are intended to in the experiment. Both the prototypes are designed keeping seven principles of the Universal design and web content accessibility guideline in mind (Institute for Disability Research, 2020; Story, 2001). The prototypes are designed so that it is flexible, accessible and easy to understand by the user with the implementation of the parallax effect. The prototype was evaluated with the help of the automated testing tool.

With the help of automated usability evaluation, it is very easy to identify various types of errors compared to the non-automated process. The cost of evaluation with the expertise and cost of usability itself can be reduced with the help of automated evaluation tools. When evaluated with the non-automated method, the evaluation only can be done after the prototype has been built and the changes cost even more. Hence using the automated evaluation tool helps in the efficient built and cost-effective changes on it (Ivory & Hearst, 2000). Using an automated usability testing tool, the usability issues can be identified quickly as these applications can read through codes quickly and provide the suggestion to fix the code or even fix them (Lazar et al., 2017). Because of all these advantages, an automated evaluation tool was used to test the usability and other aspects of the prototypes that will be used in the experiment. The automated tool also provides the report regarding the issues related to the guidelines which helps the designer to correct and revise the flaws and fix the issues related to them.

The automated testing tool used in this study was SortSite 6 with the trial version. It is a one-click tool that helps in testing the website. This tool helps to evaluate the following checkpoints in the website (PowerMapper, 2021) :

Accessibility: check WCAG 2.1 and section 508 guidelines.

Broken links: check for broken links and spelling mistakes.

Compatibility: check the codes working on browsers.

Search Engine optimization: check search engine webmaster guidelines.

Web standards: validates HTML and CSS.

Usability: check usability.gov guidelines.

The automated testing tool SortSite has different options for evaluation, it can check the entire site, current folder, current page and page and links. This tool provides a summary of the evaluation with different categories, issues, pages of the website and what was tested. The application gives the detail about the issues with the priority, mainly about the errors, accessibility, compatibility, search, standards and usability of the tested website.

The image that shows the testing of the website with the help of SortSite is given below:

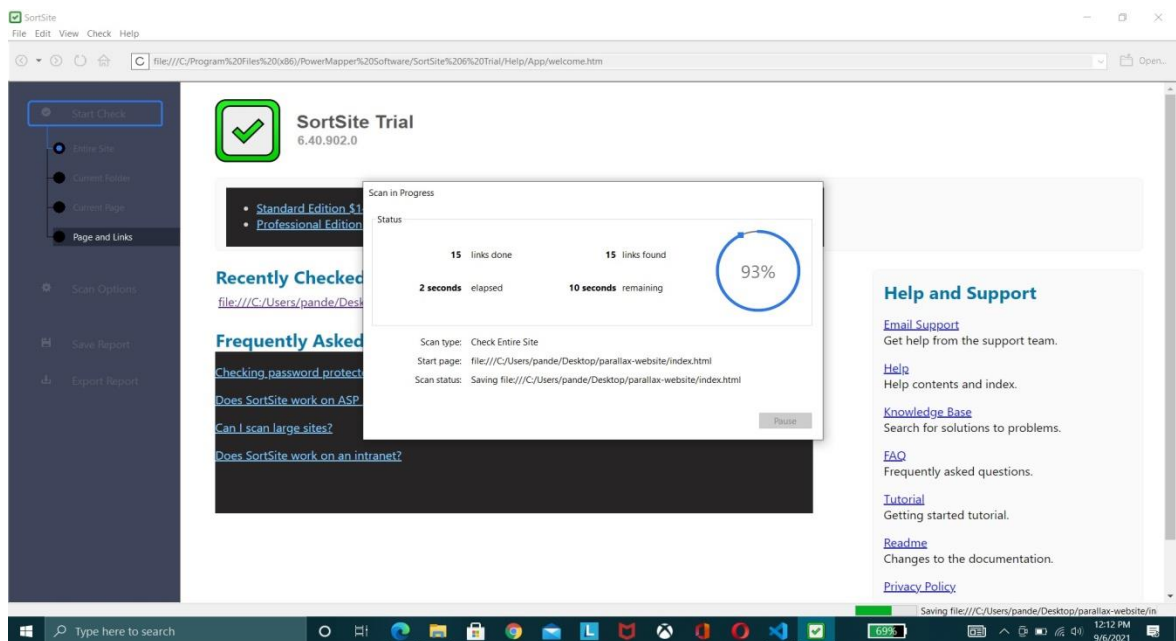


Figure 4-5: Testing of the website with SortSite application

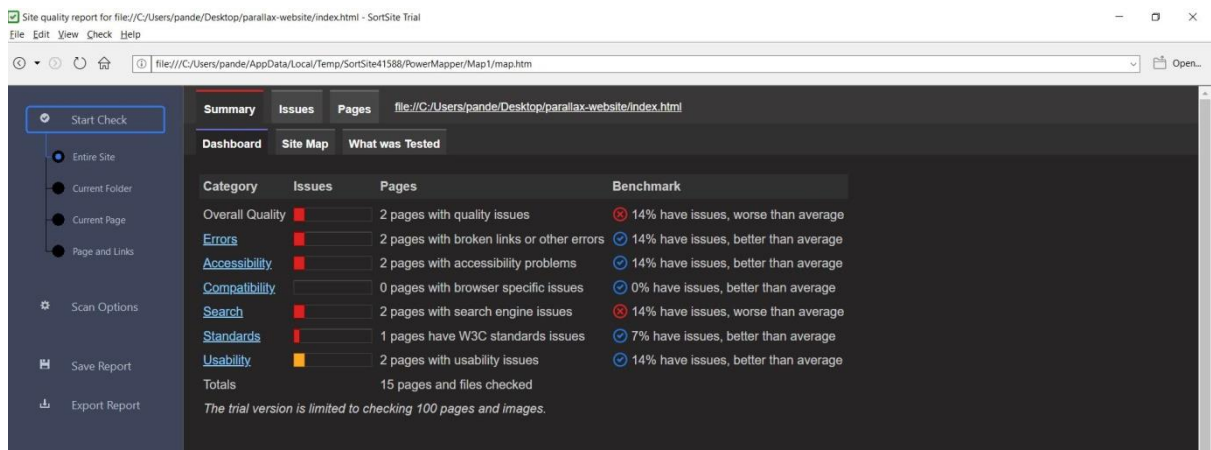


Figure 4-6: Report after testing the website

In figure 9, the report of the first evaluation can be seen. In the above picture, it can be seen that there are different issues pointed out in the report regarding errors, accessibility, search, standard, and usability.

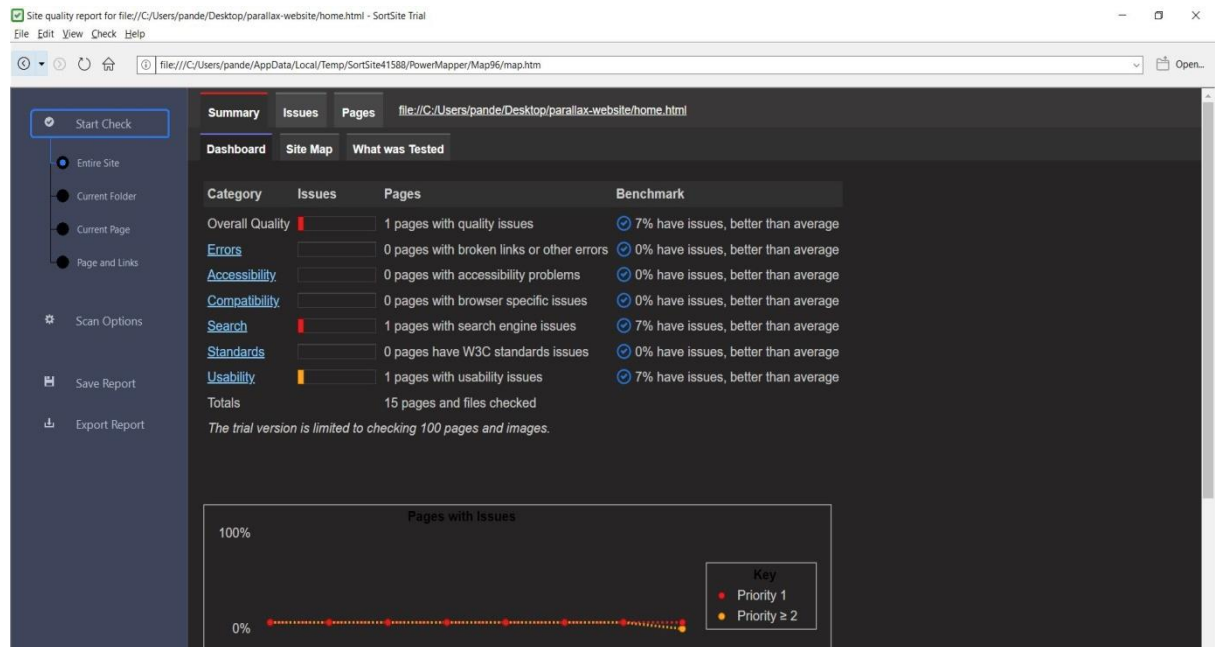


Figure 4-7: Report after the issues are fixed

In the above figure 10, it can be seen that most of the issues are fixed except for some of them. But the issues are minimized to a small percentage and according to the benchmark provided by the report, the overall quality of the evaluation is better than average. Hence, the prototype is ready for the experiment.

5 Chapter 5: Data Collection Method

One of the important parts of a research study is data collection where a certain amount of data is collected. With the help of that data, researchers can analyze the outcome of their study. This stage of the research study is also critical for the success of the intended study (Da Costa & Schneider, 2016). The data collection procedure is initiated when the prototype is developed and evaluated as well as after designing hypotheses and research questions are formed. When all the arrangements of the experimental research are met like research questions, hypotheses, prototype, then by following certain steps, the experiment session should be held. The procedure for the experiment sessions are (Lazar et al., 2017; Sharma, 2019):

1. At first, confirm the experimental prototypes are evaluated and working properly.
2. Insure the materials (devices and instruments) needed for the experiment are ready.
3. Introduce yourself to the participants and give a briefing about the experiment and the research purpose.
4. Take consent from the participant in a consent form.
5. Provide the pre-experiment questionnaire to collect some detail about the participant.
6. Conduct a simple briefing session regarding the tasks to be performed.
7. Tasks are performed by participants in a Real experiment.
8. Gather feedback from the participant with the help of a post-experiment questionnaire.
9. Conclude the experiment.

Stop-watch and screen recorder were used to measure the performance of a participant in the real experiment. Participant's opinions and feedbacks were gathered with the help of a post-experiment questionnaire in the form of scaling, more specifically Likert-scaling. The scale of 1 to 5 starting with strongly disagree to strongly agree as the end of the scale was used (Joshi, Kale, Chandel, & Pal, 2015). Counterbalance or randomization was used to minimize the impact of the learning effect. With the help of counterbalancing, conditions that are presented to participants can be rearranged in

different order. It is due to the limited number of treatments provided to the participants.

5.1 Tasks Design

In this study, there are two task groups namely task A and task B which are used in the experiment of the prototype websites. The tasks are not categorized as serendipitous or goal driven tasks in a particular task group but they are collectively present in both the task groups.

The tasks for the experiment were designed to measure the usability of the parallax scrolling. To design the tasks, a study from (Sherwin, 2019) was used as a reference. The prototype websites have two pages. The first page consists of the main content of the website and the second page consists of a form and preview of the contents that helps the participants to perform the tasks. Two groups of tasks were designed which contain activities similar to each other. The tasks are similar in nature but different in goal to achieve. Three tasks were designed for each task group that is performed in the real experiment. The two task groups were used for both websites and counterbalance technique was used to rearrange the order of tasks and conditions that participants have to perform (see [Randomization/counterbalance](#)) (Mayers, 2013). The designed tasks are presented in the table below:

Task Group A

No	Tasks detail
1	Go to home page and count the number of veg. food items.
2	Find the information about the Restaurant on the home page
3	Fill the form on the takeaway page and order 2 veg food items and one drink. Select the option of home delivery as well.

Table 5-1: Task Group A

Task Group B

No	Tasks detail
1	Go to home page and count the number of non-veg food items.

2	Find the email address of the restaurant on the home page.
3	Fill the form and order 2 non-veg items and 1 drink with the option of home delivery from the takeaway page.

Table 5-2: Task Group B

5.2 Materials and Systems Required for the Experiment

In this research study, the following materials and systems were used in the experiment in order to collect the data from the participants of the experiment.

- Lenovo legion 5 laptop with AMD Ryzen 5 4600H, Windows 10 OS, 16 GB RAM.
- Mobile Phone for Stopwatch.
- Microsoft Edge web browser.
- Screen recorder.
- Consent form.
- Pre-experiment questionnaire.
- Tasks document needed for the experiment.
- Post-experiment questionnaire.

5.3 Participants

Participants are the individuals that are participating in certain events. In this case, participants are people who are willing to participate in the experiment of the research study. A total of 6 participants were included in the experiment were either university students continuing their master’s degree or skilled workers. The experiment was done in the controlled condition meaning, the experiment was done in the room of student housing. All the participants were provided with a quiet and comfortable environment while performing the experiment. While performing the experiment, only participants and the experimenter were allowed in the room.

5.4 Ethical Concern

While performing an experiment, the ethical aspect of the research study must be addressed. To do so in this study a consent form was designed to notify participants about the ethical aspect of this study. Following are the ethical consideration that was made in this study with the reference of (Creswell, 2014) and (Sharma, 2019).

- The detail of the participants like name, phone number, address, email did not use in the research study.
- Participant's ID as the field name indicated with numeric value was used to record the data.
- Participants have the right to refuse to participate in the experiment.
- Participants have the right to know the purpose and goal of the study.
- Participants have the right to know the use of the collected data.
- Participants have the right to ask any questions before, during and at the end of the experiment.
- Anonymity of collected data was ensured to the participants.
- Participants were informed to keep the confidentiality of the study until it is completed.
- Even the prototype has the form to fill the detail about the user, participants do not have to enter actual detail, and those details are not collected.

5.5 Experiment Process

In this chapter, the process of experiment in this study is discussed. Mainly the experiment process is divided into three parts. Pre-Experiment followed by a brief explanation about the real experiment, Real experiment and Post-Experiment. The experiment was started when the participant agreed to take part in the experiment and the experimenter's introduction was given.

5.5.1 Pre-Experiment

When participants agreed to take part in the experiment, a web consent form was provided through social media or through email. Participants were told to read the form

carefully before submitting it. The detail about the purpose of the study, information about the research study, the procedure of the experiment and the confidential information that provides risk-free participation were listed on the consent form. After participants had agreed to the consent form and submitted it, they were presented with another web form of a pre-experiment questionnaire that help to gather information about the participants' background regarding the use of technology, use websites and the knowledge about parallax scrolling. The questionnaire was designed with reference to the following research papers (Fogg et al., 2001; Sharma, 2019)

After the pre-experiment is conducted, the participants were given a brief introduction to the procedure of the experiment and the tasks that they had to perform in the experiment. This was done to make sure that the participants were at ease and know what to do in the real experiment. The briefing of steps involved in the experiment was given so that there would be no need for the training session of the experiment before the real experiment proceeds.

5.5.2 Real Experiment

After participants filled the consent form and went through the pre-experiment questionnaire, they were on the next step that is the real experiment. Before the real experiment started, participants were given brief information about the procedure involved in the experiment which helped them to follow through tasks of the experiment and the instruments that are needed during the experiment was set up and ready like a mobile phone for a stopwatch and screen recorder to record the experiment performed by the participants. The experiment was carried out in the following order:

- Two prototypes with and without parallax scrolling were made ready.
- Total of six participants were involved in the experiment.
- Total of two task groups (task A and task B) were presented to the participants, both tasks to be done by each and every individual participant.
- Three dependent variables were measured in the process of the real experiment.

During the experiment, if any participant had any questions regarding the tasks they are performing, small hints were given by the experiment in order to complete the ongoing

experiment.

5.5.3 Post-Experiment

Post-Experiment is conducted when the real experiment is completed and the participants had gained some experience using the designed prototype. In this part of the experiment, participants were given a web form to fill up their opinion on the website design, preference in parallax or non-parallax scrolling technique, and tasks design. A set of questions were designed for the post-experiment as a questionnaire and were scaled by the participants on a Likert scale (Joshi et al., 2015). Participants select a scale from 1 to 5, where 1 is strongly agreed and 5 being strongly disagreed. The post-experiment questionnaires are designed in reference to the following scientific research paper (Brooke, 1996; Laubheimer, 2018; Sharma, 2019)

At the end of the experiment, the experimenter showed appreciation to participants for their participation with a big smile and thank you.

5.6 Quantitative Data Analysis

After the experiment was conducted, the data were collected from the performance of the participants. The collected data were the total time to complete the tasks, the total number of errors found during the experiment and subjective opinions of the participants rated from 1-5 with the help of the Likert scale (where 1 is strongly disagree and 5 is strongly agree). The data collected for this experiment were quantitative data. It is very important to select the appropriate method for statistical tests and analyze the result from that test (Lazar et al., 2017). Data from two websites, one with parallax scrolling and another without parallax scrolling were compared. For the comparison of the experimental data, it is good for the analysis if a significant test is selected. With the comparison of two or more groups, significant testing gives the confidence to accept or reject the hypothesis (Lazar et al., 2017).

There are different types of significant tests available. The most commonly used tests are the independent sample t-test, paired t-test, ANOVA test (Lazar et al., 2017). In this research study, paired t-test has been used for statistical testing and analysis.

The t-test is one of the commonly used quantitative analysis methods or to be a more precise significant testing method. The t-test is selected when the analysis is to be done

data from the two experiments has a paired control over the individual control, which means the same person is performing the experiment in two similar designs. The t-test is used when there is a somewhat normal distribution of data (Rosner, 1982). With the help of paired t-test, the accuracy, efficiency and user satisfaction on the two designs of the prototype with and without parallax scrolling can be measured and analyzed to see the significance in two cases in respect to the accuracy, efficiency and user satisfaction. The significant value or the p-value should be less than 0.05 to show the significant difference between the cases. If the p-value is greater than 0.05 then the null hypothesis is accepted which tells there is no significant differences between the cases. Here are steps that were followed to do the paired t-test and analysis of the produced result of the test:

1. Normal distribution test: test done to see whether data are normally distributed or not.
2. Paired t-test: test done to analyze the significance between two conditions, parallax scrolling and non-parallax scrolling.
3. Analysis of result: summary of the test and the analysis of result from the test and rejection or acceptance of the null hypothesis.

6 Chapter 6: Data Analysis and Result

When the experiment process was complete, the data was collected from the 6 participants of the experiment. The collected data was then analyzed with the help of a statistical analyzing tool which is IBM SPSS Statistics (SPSS, 2021). Microsoft Excel was also used to manage the data in the beginning and then analyzed by the statistical tool.

Paired t-test was used in this study for the analysis of the data collected from the participants, data of their performance and data from their opinion of the experiment. In paired t-test, the difference of dependent variable values is viewed with respect to the independent variable conditions which are obtained from a single group of participants. There must be two conditions or independent variable in which a single variable are measured in the across the same group in order to do a related or paired t-test. If the within-group condition or independent variables are more than two then repeated-measures ANOVA should be used, given the data is parametric and normally distributed (Mayers, 2013).

The data collected from the participant's general information is presented in the form of a bar graph with the help of Microsoft Excel. The data was collected from the performance and the opinion of the participant then tested with paired t-test and then analyzed with the help of the SPSS statistical analyzing tool (SPSS, 2021).

6.1 Demographic Information of Participants

In this study, 6 participants were included of which 67% of them are from the age group of 18-30 and the rests were of 30-40 and 40 above. No one was from the age group of 0-18. All of the participants were graduates. 50% of the participants were students and the remaining has professions other than designer and professor.

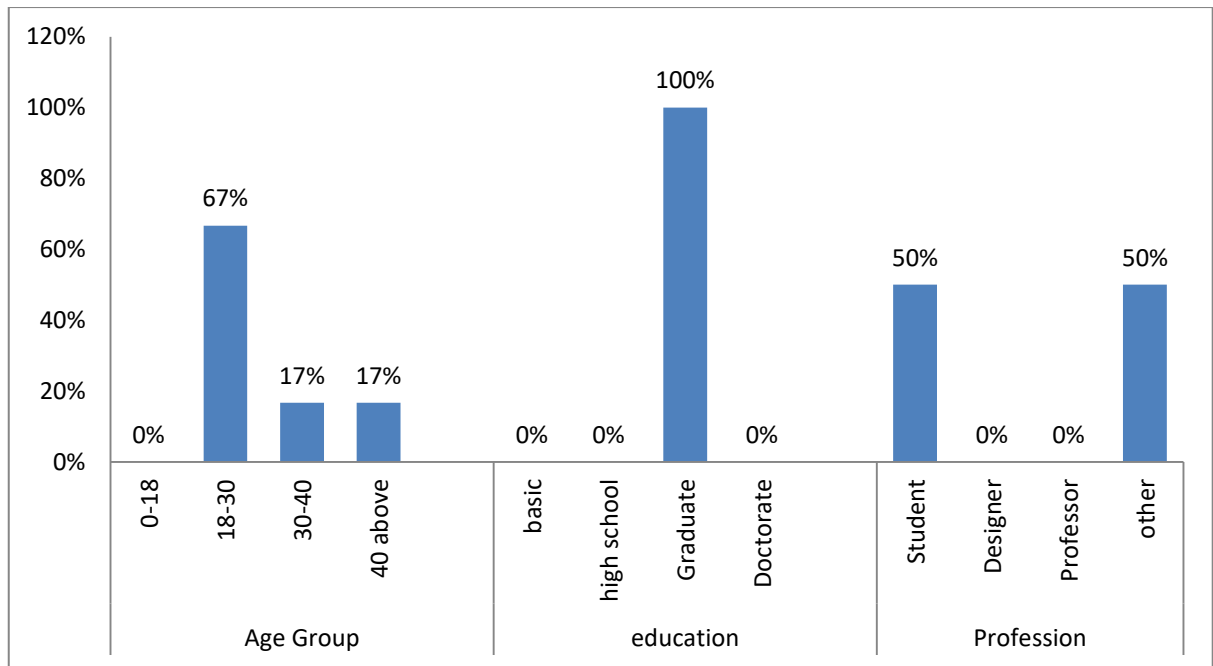


Figure 6-1: Percentage of participants according to age group, education and profession

From the data, 67% of participants have more than 5 years of experience of using the computer rest have 2-5 years of experience. The participant who uses the internet for email and web browsing are of 33.3% each and participant uses internet for research study and for fun are 17% each. 83% of participants have more than 5 years of experience of visiting website and rest has less than 2 years. Most of the participants, i.e. 67% uses laptops for visiting the website and rests use mobile phone for the same reason.

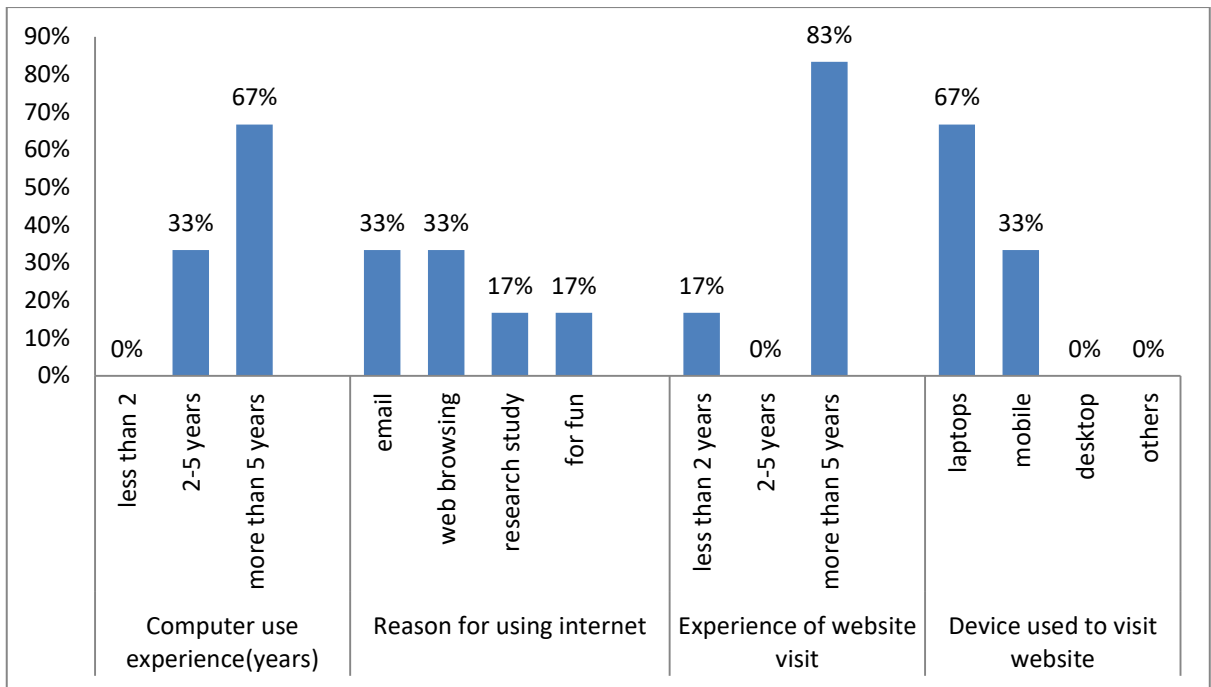


Figure 6-2: Percentage of participants in terms of computer use experience, reason for using internet, experience of website visit and device used to visit website.

Most participants (83%) scroll the webpage many times but some participant only scrolls sometimes. All of the participants have visited a website with animation or effect on it but 67% of the participants did not know about parallax scrolling. Most of the participants knew about the universal design.

None of the participants had any kind of impairment and they did not need any assistive technology to participate in the experiment.

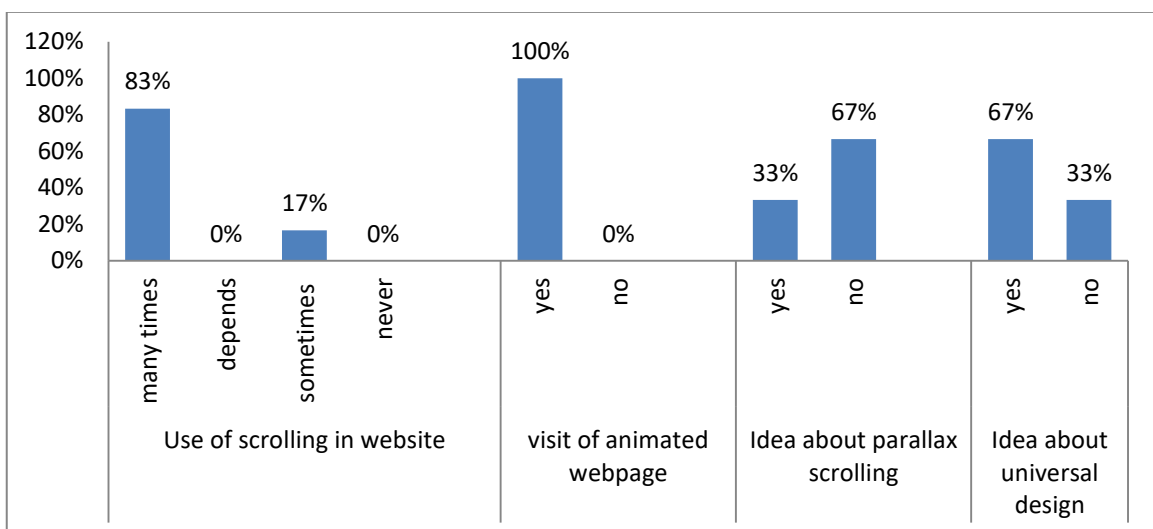


Figure 6-3: Percentage of participants in terms of use of scrolling in website, visit of animated webpage, an idea about parallax scrolling and idea about the universal design.

6.2 Performance of Participants on Experimental Condition

After the detail about participant’s demographic information analysis, the actual performance of the participant in two different experimental prototype website is analyzed in this section. The performance of the participant that was observed in the experiment was total time to complete given tasks and total number of errors. When the experiment was performed and the data was gathered, the data were analyzed with paired t-test in the statistical analysis tool SPSS(SPSS, 2021). The pre-requisites for the use of paired t-test to test and analyze data were verified beforehand and analysis was done when the result was ready.

6.2.1 Total time to complete tasks

Normal distribution test:

Before the actual test to be performed in the data, normality test should be performed. It is done to see whether the collected data are normally distributed or not.

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Time taken in Parallax scrolling	.219	6	.200*	.937	6	.634
Time taken in Non-parallax scrolling	.256	6	.200*	.875	6	.245

Table 6-1: Normality test of total task completion time

The above table shows the normality test done in the SPSS (Kolmogorov-Smirnov^a /Shapiro-Wilk test). From the test it was found that all the conditions were normally distributed as the significant value is greater than 0.05($p > 0.05$). The p value for parallax scrolling was found to be $p = 0.634$ and for non-parallax scrolling was $p = 0.245$.

Paired t-test:

From the normality distribution test, it was found that the data were normally distributed in both conditions. Now, the important test that is paired t-test can be conducted. With the test done and the result is obtained, the acceptance or rejection of

the null hypothesis can be done with the significant value from the t-test. If the p-value or significant value is greater than 0.05 i.e. $p > 0.05$ then, the null hypothesis can be accepted as it indicates that there is no significant difference between two condition for the tested dependent variable.

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Time taken in Parallax scrolling	145.83	6	48.72	19.89
	Time taken in Non-parallax scrolling	137.33	6	76.62	31.28

Table 6-2: Mean and standard deviation for total task completion time in parallax scrolling and non-parallax scrolling

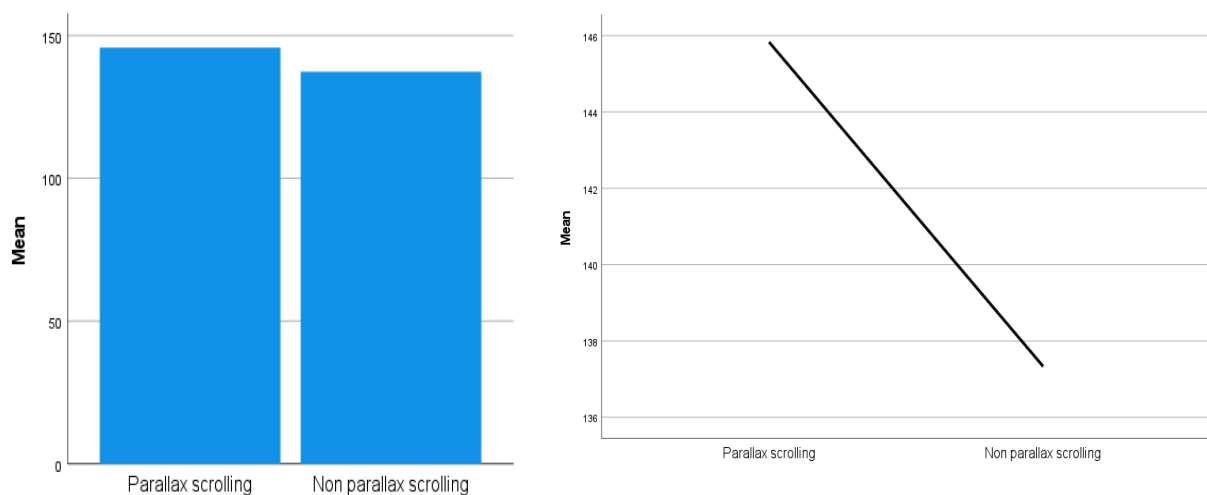


Figure 6-4: Bar graph and line graph for mean of total completion time in parallax and non-parallax scrolling

From the table above it was found that average time to complete the tasks were less in non-parallax (137 sec) than in parallax scrolling was 145.83 second with the standard deviation of 31.28 and 19.89 respectively. It can be visualize with the help of bar graph as well as line graph.

Paired Samples Test						
		Paired Differences				
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	
					Lower	
Pair 1	Parallax scrolling - Non parallax scrolling time taken	8.50000	75.45794	30.80557	-70.68825	
		Paired Differences	t	df	Significance	
		95% Confidence Interval of the Difference			One-Sided p	Two-Sided p
		Upper				
Pair 1	Parallax scrolling - Non parallax scrolling time taken	87.68825	.276	5	.397	.794

Table 6-3: Result of the Paired t-test for total time taken to complete tasks with the significant value

The above table shows the result of the paired t-test done in the data obtained from the participants to complete the given tasks. From the table it was found the t-value, degree of freedom and one-tailed p-value. Hence the statistical notation is $t(5)=0.276$, $p=0.397$. Here we have to choose one-tailed p-value because hypothesis of this study is one-tailed which means the conditions are has significance or not. Since the p-value ($p=0.397$) is greater than 0.05 i.e. $p>0.05$, there is no significant difference in time taken to complete tasks in parallax scrolling and non-parallax scrolling.

Analysis of result:

The result of paired t-test $t(5) = 0.276$, $p = 0.397$, $p>0.05$ suggests that the null hypothesis is accepted and alternative hypothesis is rejected. The null hypothesis (H0), there is no significant difference in efficiency between for a user while using websites with and without parallax effect is accepted. From the sampled statistics (mean score) it has been found that participant take less time to complete tasks in website without parallax scrolling (137 sec) than in the website with parallax scrolling (146 sec).

6.2.2 Total number of errors found while completing tasks

Normality test for the number of errors found while completing the tasks is given below.

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Number of errors seen in parallax scrolling	.310	6	.074	.805	6	.065
Number of errors seen in non-parallax scrolling	.254	6	.200*	.866	6	.212

Table 6-4: Normality distribution test for total number of errors found

From the table above, the normality test done in the SPSS (Kolmogorov-Smirnov^a /Shapiro-Wilk test) shows that the data are normally distributed among the conditions. As the significant value (p-value) is greater than 0.05 i.e. $p > 0.05$ it has been taken that the data are distributed normally. The p-value for number of errors in parallax scrolling and non-parallax scrolling is 0.065 and 0.212 respectively.

Paired t-test:

At first, mean and standard deviation of the number of errors in two prototypes while performing tasks is calculated.

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Number of errors seen in parallax scrolling	1.167	6	1.3292	.5426
	Number of errors seen in non-parallax scrolling	1.167	6	.7528	.3073

Table 6-5: Mean and standard deviation for total number of errors in parallax scrolling and non-parallax scrolling

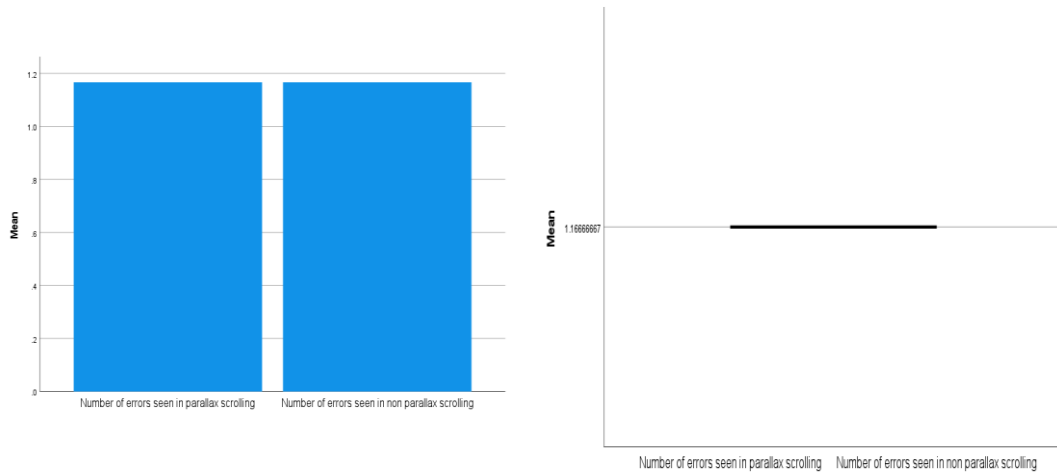


Figure 6-5: Bar graph and line graph for mean error found in parallax and non-parallax website.

From the statistics and the mean score it has been seen that both the conditions with and without parallax scrolling has same average score i.e. mean = 1.167. This means the average error found in both condition are same. It can also be seen in the bar graph and line graph.

Paired Samples Test							
		Paired Differences				95% Confidence Interval of the Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	
Pair 1	Number of errors seen in parallax scrolling - Number of errors seen in non-parallax scrolling	.0000	1.4142	.5774	-1.4841	1.4841	
		Paired Differences	t	df	Significance		
		95% Confidence Interval of the Difference			One-Sided p	Two-Sided p	
		Upper					
Pair 1	Number of errors seen in parallax scrolling - Number of errors seen in non-parallax scrolling	1.4841	.000	5	.500	1.000	

Table 6-6: Result of the Paired t-test for error while completing tasks with the significant value

From the above table it has been seen that significant value (p-value) is greater than 0.05 i.e. $p = 0.50$. This suggests that $p > 0.05$ and there is no significant difference in the number of errors found in the both parallax scrolling and non-parallax scrolling. The statistical notation can be written as $t(5) = 0, p = 0.5$.

Analysis of result

From the result of the paired t-test, it has been known that the p-value ($p = 0.5$) is greater than 0.05, which implies that there is no significant difference between number of errors that was found in website with parallax scrolling and website without parallax scrolling. This suggests that the null hypothesis (H_0) is accepted from hypothesis 2, meaning there is no significant difference in the accuracy of the tasks done by a user and total number of errors while using websites with and without parallax scrolling. In mean score also there is no difference in the number of error occur in both the websites, mean = 1.167.

6.3 Analysis of Opinion on Experimental Conditions

In the post experiment, the participants have given their opinion about the experiment and two prototype website. Those opinions were collected from set of questions designed based on the feeling of the participant after performing the experiment on website with parallax scrolling and website without parallax scrolling. Participants were asked to rate the question in Likert scale from 1-5 where 1 indicates strongly disagree and 5 indicates strongly agree (Joshi et al., 2015). These questions were analyzed with the help of paired t-test as there has been only two conditions, one with parallax scrolling and another without parallax scrolling and only one group of participants (Mayers, 2013). The gathered data were tested and analyzed with the help of statistical tool SPSS (SPSS, 2021).

6.3.1 Analysis on questions regarding experiment conditions

Question: I found it interesting while scrolling through the content of the website

Before conducting paired t-test, normality distribution test has been conducted. In the normality distribution test, it was found that data were normally distributed as the p-value was greater than 0.05 which in $p = 0.415$ and $p = 0.421$. The statistic table is present

in the [appendix c](#)

Paired t-test

At first, mean and standard deviation is measured with the help of sample statistic table which can be viewed in [appendix c](#). From the table it has been seen that participants are interested in the content of parallax scrolling with the mean score of 3.67 (mean=3.67; SD= 1.211) than in non-parallax scrolling which has mean score of 3.17 (mean=3.17; SD=1.169).

Paired Samples Test						
		Paired Differences				
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	
Pair 1	I found parallax interesting - I found non-parallax interesting	.500	1.517	.619	-1.092	
		Paired Differences	t	df	Significance	
		95% Confidence Interval of the Difference Upper			One-Sided p	Two-Sided p
Pair 1	I found parallax interesting - I found non-parallax interesting	2.092			.808	5

Table 6-7: Paired t-test result for question I found it interesting while scrolling.

From the table above, it has been found that there is significant difference in the interest of the participant while scrolling the content either in website with parallax scrolling or website without parallax scrolling because the p-value is greater than 0.05 i.e. $p = 0.228$. The statistic notation for this is $t(5) = 0.808, p = 0.228; p > 0.05$.

Analysis of result

Result from the paired t-test showed that the significant value is greater than the 0.05 ($p = 0.228$). This suggests that there was no significant difference in the opinion of

participant on interest on the content of the website with parallax scrolling and website without parallax scrolling while scrolling. The mean score suggests that content on the parallax scrolling (mean=3.67) was more interesting to the user than in the non-parallax scrolling (mean=3.17).

Question: I found it pleasant while scrolling through the content of the website

At first, normality distribution test was conducted. From the result it was found that the data are normally distributed because the significant value for parallax scrolling and non-parallax scrolling were 0.421 and 0.91 respectively which are greater than 0.05 i.e. $p > 0.05$. (Please see [appendix c](#) to see the statistical table)

Paired t-test

From the table of sample statistics (see [appendix c](#)), it was found that mean score for the opinion of participant who found parallax scrolling pleasant is higher (Mean=3.83, SD=1.169) than opinion on non-parallax scrolling (mean=3.33, SD=0.816). It suggests that participants found website with parallax scrolling more pleasant.

Paired Samples Test							
		Paired Differences				95% Confidence Interval of the Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower		
Pair 1	I found parallax pleasant - I found non-parallax pleasant	.500	1.643	.671	-1.224		
		Paired Differences	t	df	Significance		
		95% Confidence Interval of the Difference			One-Sided p	Two-Sided p	
		Upper					
Pair 1	I found parallax pleasant - I found non-parallax pleasant	2.224	.745	5	.245	.490	

Table 6-8: Paired t-test result for question I found it pleasant while scrolling.

The table above shows results of paired t-test done on the data collected from the participants for question of I found it pleasant while scrolling in the website. The significant value ($p=0.245$) is greater than 0.05 i.e. $p>0.05$. This indicates that there was no significant difference in the opinion of participants for the question I found it pleasant while scrolling through the content of the website. The statistical notation is $t(5) = 0.745, p=0.245$.

Analysis of result

After the paired t-testing was done, it has been found out that p-value was 0.245 which is greater than 0.05 ($p>0.05$). This suggests that there is no significant difference in the opinion of the participant in terms of 'I found it pleasant' for website with or without parallax scrolling. From the mean score it has been found out that website content with parallax scrolling was more pleasant (mean=3.83) compared to the non-parallax scrolling (mean=3.33).

Question: I felt confident while performing tasks in the website

Starting with the normality distribution test, it was found that the data were normally distributed among the conditions. As the significance value from the normality test has been found to be $p=0.167$ and $p=0.473$ which is greater than 0.05 i.e. $p>0.05$. (see statistics table in [appendix c](#))

Paired t-test

From the sample statistics (see in [appendix c](#)) it has been found that on average participant felt confident performing tasks on website with parallax scrolling (mean=4, SD=0.894) than in the non-parallax website (mean=3.67, SD=1.033).

Paired Samples Test				
	Paired Differences			
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference
				Lower

Pair 1	I felt confident in parallax - I felt confident in non-parallax	.333	.816	.333	-.524	
		Paired Differences			Significance	
		95% Confidence Interval of the Difference				
		Upper	t	df	One-Sided p	Two-Sided p
Pair 1	I felt confident in parallax - I felt confident in non-parallax	1.190	1.000	5	.182	.363

Table 6-9: Paired t-test result for question I found it pleasant while scrolling.

Above table presents the results from paired t-test and it showed that significant value ($p=0.182$) is greater than 0.05 i.e. $p>0.05$. This suggests that there is no significant difference in the opinion 'I felt confident' by participants for both websites with and without parallax scrolling. The statistical notation can be written as $t(5) = 1, p=0.182$.

Analysis of result

From the result of paired t-testing, it has been found out that p-value was 0.182 which is greater than 0.05 ($p>0.05$). This suggests that there is no significant difference in the opinion of the participant in terms of 'I felt confident' for website with or without parallax scrolling. From the mean score it has been found out that parallax scrolling website (mean=4) was more confident to use than non-parallax website (mean=3.67).

Question: After the experiment I prefer

The normality distribution test showed that data were normally distributed as the significant value ($p=0.110$ and $p=0.091$) from normality test is greater than 0.05 i.e. $p>0.05$ (See the [appendix c](#) for the normality test table).

Paired t-test

From the samples statistics (see [appendix c](#) for detail) it has been found that on average

the parallax scrolling (mean=4, SD=1.26) was more preferred than non-parallax (mean=3.33, SD=0.816) website.

Paired Samples Test							
		Paired Differences				95% Confidence Interval of the Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower		
Pair 1	I prefer parallax - I prefer non-parallax	.667	1.862	.760	-1.287		
		Paired Differences	t	df	Significance		
		95% Confidence Interval of the Difference			One-Sided p	Two-Sided p	
		Upper					
Pair 1	I prefer parallax - I prefer non-parallax	2.621	.877	5	.210	.421	

Table 6-10: Paired t-test result for question I prefer.

Above table presents the results from paired t-test and it showed that significant value ($p=0.21$) is greater than 0.05 i.e. $p>0.05$. This suggests that there is no significant difference in the opinion 'preference of website' by participants for both websites with and without parallax scrolling. The statistical notation can be written as $t(5) = 0.877$, $p=0.21$.

Analysis of result

The result of paired t-testing has shown that p-value was 0.21 which is greater than 0.05 ($p>0.05$). This suggests that there is no significant difference in the opinion of the participant in terms of 'I prefer' for website with or without parallax scrolling. From the mean score it has been found out that parallax scrolling website (mean=4) was more preferred than non-parallax website (mean=3.33).

6.4 Analysis of Opinion on Prototype and Task Design

In this section, the opinion of participants regarding prototype and tasks design has been analyzed. There were 4 questions in the post experiment questionnaire that helped to get the opinion of the participants regarding task understandability, design of the prototype (websites), etc. Participants were asked to rate the question from the scale of 1-5 where 1 being strongly disagree and 5 being strongly agree. With the help of bar graph the average percentage value has been depicted with 100% for strongly agree, 75% for agree, 50% for neutral, 25% for disagree and 0% for strongly disagree.

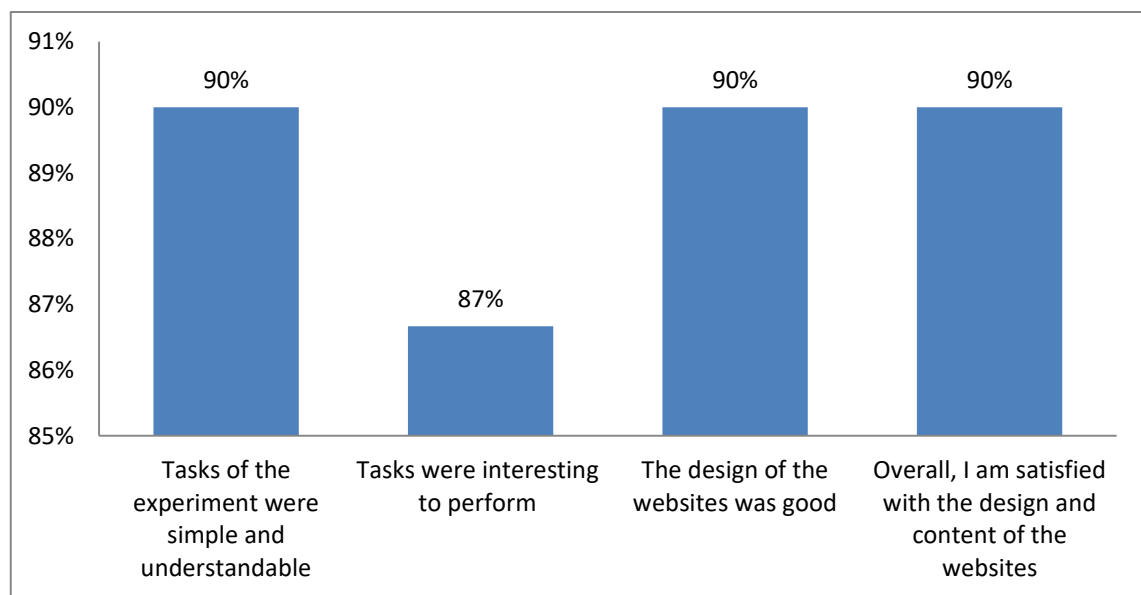


Figure 6-6: Opinion of participants regarding tasks design and prototype design in percentage

From the figure above, it has been found that participants have rated between agree (75%) and strongly agree (100%) for the design of the tasks and design of the prototype. This suggests that participants found tasks simple and easy to understand and interesting to perform in the experiment as well. From the rating that participants have provided, it seems that they found design of the prototype (websites) to be good and overall, participants were satisfied with the design and the content of the prototype (websites).

7 Chapter 7: Discussion

Discussion is one of the important parts of the research study. In this section, summary of the result from the analysis, comparison of result whether they support other studies done previously and the limitations of this study will be discussed.

7.1 Summary of Analysis of Result

With the help of experiment data were collected from the participants of the experiment and those data were analyzed in a statistical tool. The statistical analysis was done in the data to compare two different experimental conditions, one condition being website with parallax scrolling and another being website without parallax scrolling. For that, three different dependent variables; total time to complete tasks, total number of errors and user satisfaction were measured. The dependent variables were analyzed to examine whether there was significant difference in the performance of the participant and user satisfaction on two different experimental conditions of the website i.e. website with parallax scrolling and website without parallax scrolling. The analyses of the results are discussed below in terms of performance of participants and user satisfaction.

Discussion of result from participant's performance

In the experiment conducted, participants were given sets of tasks to perform and total time for the completion of the tasks and total number of errors found during experiment was collected. The analysis of the result done after the statistical test in participant's performance in terms of time of tasks completion and number of errors which are included in the two hypotheses are discussed below:

1. For the hypothesis 1, null hypothesis (H₀) is accepted because there was no significant difference in the total time of tasks completion in both the experimental conditions i.e. in parallax website and non-parallax website. Hence there was no significant difference in the efficiency of a user while using the website with and without parallax scrolling.
2. Similarly, null hypothesis (H₀) is accepted for hypothesis 2 as there was no significant difference in the total number of errors recorded in the both the websites while

completing tasks. Therefore, there was no significant difference in accuracy while using website with and without parallax scrolling.

From the analysis it seems that there is no significant difference in the time of tasks completion and number of errors while performing tasks on the website with parallax scrolling and website without parallax scrolling. Despite of that, from the analysis of mean score it has been found that participant took less time to complete tasks in the website with non-parallax scrolling and made equal number of errors in both website with and without parallax scrolling. From the finding of this study, it would suggest that the use of parallax scrolling in a website does not pose much of the impact in making a website universally designed.

Discussion of opinions of participants on experimental conditions

After the real experiment was conducted, participants were given post-experiment questionnaire which were based on the opinion of participants towards experiment conditions (parallax scrolling and non-parallax scrolling) tasks design and prototype design. There were four questions which were related to the experimental condition and user satisfaction factor of usability. Here, for the hypothesis 3, null hypothesis (H0) is accepted as statistically there was no significant difference for the user satisfaction and opinion of the participants regarding the experimental conditions

1. For opinion on 'interesting while scrolling website', there was no significant difference in interest of user either on website with parallax scrolling or without parallax scrolling.
2. For opinion on 'pleasant while scrolling website ', there was no significant different on website with or without parallax scrolling.
3. For opinion on 'felt confident while performing tasks', there was no significant difference on confident level of user, using both websites with or without parallax scrolling.
4. Similarly, for opinion on, 'preference of website', there was no difference of preference on website with or without parallax scrolling.

However, from the mean score of the result, it was found that website with parallax

scrolling has better mean score than website without parallax scrolling. On average participants chose website with parallax scrolling over the non-parallax scrolling. Although, from the finding of study, it seems there was not much of an impact on universal design by the use of parallax scrolling on website.

Discussion on participant's opinion on tasks design and prototype design

In post-experiment questionnaire, some questions were asked to participants regarding the design of the tasks and design of the prototype websites. There were 4 questions which relates to the task design and prototype design. Participants were asked to rate those questions based on their opinion from 1-5 (strongly disagree - strongly agree) (Joshi et al., 2015). Two of the questions were related to the task design and remaining two questions were related to the design of the prototype. The rating given by participant was between agree and strongly for all four questions in terms of tasks design and prototype design. This indicates that participants found tasks simple and easy enough to understand and interesting to perform as well as the design of prototypes to be good and participants were satisfied with the design and content of the prototypes.

7.2 Comparison with Previous Study

Different researches were done previously regarding the topic of parallax scrolling on the website. Some of researches are discussed in the literature review section. In literature review it was found that there are certain aspects where use of the parallax scrolling is more suitable in the website. It attracts the attention of the users but it is not fitting in every scenario and aspect of the website. A study conducted by (Frederick et al., 2015) to see the effect of parallax scrolling on user experience and preference in web design. In that study he found that parallax scrolling is appropriate for hedonic use in a website rather than in the goal-oriented purposes. Similar study on parallax scrolling done by (Ku, 2015) suggests that the parallax scrolling is especially useful for the websites which are based on storytelling and info-graphics instead of goal oriented websites. This notion was further supported by the study done by (Hassenzahl, 2001) stating that visually engaging tasks provide usability and satisfaction.

In the study conducted by (Frederick et al., 2015), it was also found that although

parallax scrolling on a website improves fun and enjoyment, overall there was no improvement in the user experience when compared with the website without parallax scrolling. In the same way it was found out that there was no evidence that website with parallax scrolling increases the usability with the use of parallax scrolling in a website.

With the findings and results from the studies previously done, it seems that there are lots of instances where improvement can be made in a website with parallax scrolling. From previous studies it can be pointed out that there are still some issues related to the usability as well as universal design in the context of use of parallax scrolling in a website. From the analysis of this study, it can be seen that the results support the finding of the previous researchers and their studies. This study shows that although on average users find parallax scrolling interesting, pleasant and prefer it in a website, there was not much of an impact on the usability of a website compared with website without parallax scrolling as well as in the universal design.

7.3 Limitations of the Study

When the study has been done, there are still some limitations that might lead directed towards the better and more accurate result statistically from the experiment done with participants. There are some gaps regarding the research and universal design even though the prototypes were developed using guidelines provided by WCAG 2.1 and universal design principles. These gaps are needed to be enhanced which could be better for the future research.

The main limitation of this research study is the number of the participants included in this study to conduct the experiment. With the greater number of participants, the quantitative result could be improved which in turn increases the accuracy and statistical significance in the result of the study. The experiment was conducted with participants who were graduates. There was no diverse group of participants that could help to obtain the result with the variance in participant's performance leading to the better result. The results would be even better if there participants with different disabilities and elderly were included in the experiment.

Mobile devices were not used in the real experiment; it was conducted only using laptop. If mobile devices were used in the experiment then there could be improvement

in the significance of the result.

The prototype was developed for screen with the aspect ratio of 16:9. Using it with the screen with bigger or smaller aspect ratio may cause the website to be disoriented or disarranged.

It would be better if there were more questions included in the post-experiment questionnaire in the context of user satisfaction and feelings of the users, it would be better of the analysis of the usability of parallax scrolling in a website. During the experiment, the observation of the participant's performance, count of errors and recording of the time was done simultaneously which might distract the participant to perform the tasks with proper focus.

There were only two tasks group with similar tasks (to reduce bias) to perform in the experiment for two websites. This might have given idea to participants on how to perform similar tasks in next prototype. This could be reduced if there were more tasks group with tasks variation in the experiment.

8 Chapter 8: Conclusion

The goal of this study was to investigate about usability and universal design approach of parallax scrolling in a website. This study and experiments took inspiration and is based in the concepts which are found in the studies of (Frederick et al., 2015; Sharma, 2019; Sherwin, 2019). The aim of this research was to find whether parallax scrolling used in a website has better usability than the website without parallax scrolling together with the universal design stand of parallax scrolling. In the beginning of study, the problems and issues concerning parallax scrolling were figured out with the help of different studies and research previously done in context of parallax scrolling.

Generalizing the issues and problems related to the parallax scrolling gave a direction toward which the study could move. Two prototype websites were designed, one with parallax scrolling and another without parallax scrolling. The designed prototype websites then were developed with the help of WCAG 2.0 guidelines and universal design principles. Both the prototype website had same layout and same content but the only difference was that one website had parallax scrolling and another did not.

After the development of the prototype, experiments were conducted in two websites for the evaluation of participant's performance by observing the time take to complete tasks and total number of error made during experiment and opinion of participants. Data were collected from the experiment and participants and then analyzed to find some significance in the result. Data testing and analysis was done with the help of statistical tool SPSS to compare the website with and without parallax scrolling. From the analyzed result it was found that there was no significant difference in the efficiency and accuracy in the performance of participants when compared with parallax and non-parallax scrolling in a website. In terms of participant's opinion, the findings in this study suggest that there were no significant difference in the opinion of participants as well. This means there was no significant difference in the user satisfaction regarding parallax scrolling and non-parallax scrolling used in a website. However, in average most of the participants prefer parallax scrolling over non-parallax scrolling.

Hence from the analysis of the result in this study, it was found that parallax scrolling does not increase the usability of a website. The analysis of the results of this study suggests that the usability of parallax scrolling in a website is no differing than website

without parallax scrolling. This answers the first research question about the usability of the parallax scrolling of website. This also suggests that parallax scrolling does not have any significance in a website in terms of universal design. From this analysis the answer for the second research question is achieved i.e. the use of parallax scrolling does not help in the universal design of the website.

There are still some areas that can be improved by eliminating the limitations of this study. So there is possibility of conducting future study and place for future work using this study as the base which can produce better result and more accurate statistical analysis.

8.1 Future Work

There are some points that could help to study in more detail and obtain more accurate result if applied in the future research of parallax scrolling regarding its usability and universal design. These points are as follows:

1. Involving as much as participant to obtain more accurate result from the performance of the participants in experiments. Due to time constrains not many participant were involved in this study. So, in the future studies try to involve more than 30 participants if possible.
2. Including elderly as well as people with disabilities in experiment to get clear data and result regarding universal design and usability analysis.
3. Adding more post experiment question on real feeling of participants which can improve the quality of collected data and accurate results.
4. Add more random tasks in the experiment to perform by participants to reduce the learning effect.
5. Individual study of different types of error found during experiment to find proper accuracy of tasks done in experiment.
6. Include mobile devices for the purpose of experiment as well. In this study only laptop was used for the real experiment.
7. Develop a responsive prototype that can be used in different devices with display of different aspect ratio.

References

- (NDA), N. D. A. (2020). What is Universal Design / Definition and overview. Retrieved from <http://universaldesign.ie/what-is-universal-design/definition-and-overview/>
- Adachi, Y., & Ito, Y. (2015). *Effect of QoS degradation on parallax effect in web services*. Paper presented at the 2015 IEEE 4th Global Conference on Consumer Electronics (GCCE).
- Aspers, P. (2009). Empirical phenomenology: A qualitative research approach (The Cologne Seminars). *Indo-pacific journal of phenomenology*, 9(2), 1-12.
- Banerjee, A., Chitnis, U., Jadhav, S., Bhawalkar, J., & Chaudhury, S. (2009). Hypothesis testing, type I and type II errors. *Industrial psychiatry journal*, 18(2), 127.
- Bhandari, P. (2021). What is a within-subjects design? Retrieved from <https://www.scribbr.com/methodology/within-subjects-design/>
- Brooke, J. (1996). SUS-A quick and dirty usability scale. *Usability evaluation in industry*, 189(194), 4-7.
- Creswell, J. W. (2014). *Qualitative, quantitative and mixed methods approaches*: Sage.
- Da Costa, C., & Schneider, Z. (2016). Quantitative data collection and study validity. *Nursing and Midwifery Research, 5th ed.; Schneider, Z., Whitehead, D., LoBiondo-Wood, G., Haber, J., Eds*, 181-196.
- Di Pofi, J. A. (2002). Organizational diagnostics: integrating qualitative and quantitative methodology. *Journal of organizational change management*.
- Durrheim, K. (2006). Research design. *Research in practice: Applied methods for the social sciences*, 2, 33-59.
- Fogg, B. J., Marshall, J., Laraki, O., Osipovich, A., Varma, C., Fang, N., . . . Swani, P. (2001). *What makes web sites credible? A report on a large quantitative study*. Paper presented at the Proceedings of the SIGCHI conference on Human factors in computing systems.
- Forlizzi, J., & Battarbee, K. (2004). *Understanding experience in interactive systems*. Paper presented at the Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques.
- Frederick, D. (2013). *The effects of parallax scrolling on user experience and preference in web design*. Purdue University,
- Frederick, D., Mohler, J., Vorvoreanu, M., & Glotzbach, R. (2015). The Effects of Parallax Scrolling on User Experience in Web Design. *Journal of Usability Studies*, 10(2).
- Fu, J. (2016). *Parallax Scrolling Interface research based on Fitts' law*. Paper presented at the 2016 IEEE Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC).
- Hassenzahl, M. (2001). The Effect of Perceived Hedonic Quality on Product Appealingness. *International Journal of Human-Computer Interaction*, 13(4), 481-499. doi:10.1207/S15327590IJHC1304_07
- Hassenzahl, M., & Tractinsky, N. (2006). User experience-a research agenda. *Behaviour & information technology*, 25(2), 91-97.
- Institute for Disability Research, P., and Practice. (2020, Sep 21, 2020). Web Content Accessibility Guidelines. Retrieved from <https://webaim.org/standards/wcag/>
- Ivory, M. Y., & Hearst, M. (2000). *The state of the art in automated usability evaluation of user interfaces*: Computer Science Division, University of California.
- Joshi, A., Kale, S., Chandel, S., & Pal, D. K. (2015). Likert scale: Explored and explained. *British Journal of Applied Science & Technology*, 7(4), 396.
- Kaur, S. P. (2013). Variables in research. *Indian Journal of Research and Reports in Medical Sciences*, 3(4), 36-38.
- Kilpatrick, J. (1978). Variables and methodologies in research on problem solving. *Mathematical problem solving*, 7-20.
- Ku, D. (2015). Parallax Scrolling: To scroll or not to scroll. In.

- Laubheimer, P. (2018). Beyond the NPS: Measuring Perceived Usability with the SUS, NASA-TLX, and the Single Ease Question After Tasks and Usability Tests. Retrieved from <https://www.nngroup.com/articles/measuring-perceived-usability/>
- Lazar, J., Feng, J. H., & Hochheiser, H. (2017). *Research methods in human-computer interaction*: Morgan Kaufmann.
- Lim, Y.-K., Stolterman, E., & Tenenbergs, J. (2008). The anatomy of prototypes: Prototypes as filters, prototypes as manifestations of design ideas. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 15(2), 1-27.
- Mace, R. (1997). What is universal design. *The Center for Universal Design at North Carolina State University*, 19, 2004.
- MacKenzie, I. S. (2012). Human-computer interaction: An empirical research perspective.
- Mahardika, W., Wibirama, S., Ferdiana, R., & Kusumawardani, S. S. (2018). A novel user experience study of parallax scrolling using eye tracking and user experience questionnaire. *International Journal on Advanced Science, Engineering and Information Technology*, 8(4), 1226-1233.
- Mayers, A. (2013). *Introduction to Statistics and SPSS in Psychology*: PEARSON EDUCATION LIMITED.
- Measuring digital development: Facts and figures 2019 [PDF File]. (2019). Retrieved from https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2019_r1.pdf
- Mills, J., & Birks, M. (2014). *Qualitative methodology: A practical guide*: Sage.
- Mourougan, S., & Sethuraman, K. (2017). Hypothesis development and testing. *IOSR Journal of Business and Management (IOSR-JBM)*, 9(5), 34-40.
- Murano, P., & Sharma, S. (2020). A Usability Evaluation of Web User Interface Scrolling Types.
- Nielsen, J. (2012, January 3, 2012). Introduction to Usability. Retrieved from <https://www.nngroup.com/articles/usability-101-introduction-to-usability/>
- Ostroff, E. (2011). Universal design: an evolving paradigm. *Universal design handbook*, 2, 34-42.
- Peppers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of management information systems*, 24(3), 45-77.
- PowerMapper. (2021). SortSite Desktop. Retrieved from <https://www.powermapper.com/products/sortsite/>
- Rosenthal, R., & Rosnow, R. L. (2008). *Essentials of behavioral research: Methods and data analysis*.
- Rosner, B. (1982). A generalization of the paired t-test. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, 31(1), 9-13.
- Ross, S. M., & Morrison, G. R. (2013). Experimental research methods. In *Handbook of research on educational communications and technology* (pp. 1007-1029): Routledge.
- Sharma, S. (2019). *Evaluation of Scrolling Techniques on the websites in the context of universal design*. OsloMet-Oslo Metropolitan University,
- Sherwin, K. (2019, January 20, 2019). What Parallax Lacks. Retrieved from <https://www.nngroup.com/articles/parallax-usability/>
- Singh, Y. K. (2006). *Fundamental of research methodology and statistics*: New Age International.
- SPSS, I. (2021). IBM SPSS Statistics. Retrieved from <https://www.ibm.com/products/spss-statistics>
- Story, M. F. (2001). Principles of universal design. *Universal design handbook*.
- Summers, J., & Hinojosa, A. (2020). Considerations for using parallax effects on websites. Retrieved from <https://medium.com/@summertimecoolj/considerations-for-using-parallax-effects-on-websites-3d7773a24724>
- Toledo, A. H., Flikkema, R., & Toledo-Pereyra, L. H. (2011). Developing the research hypothesis. *Journal of Investigative Surgery*, 24(5), 191-194.
- White, H., & Sabarwal, S. (2014). Quasi-experimental design and methods. *Methodological briefs: impact evaluation*, 8, 1-16.

Wieringa, R. (2010). *Design science methodology: principles and practice*. Paper presented at the Proceedings of the 32nd ACM/IEEE International Conference on Software Engineering- Volume 2.

9 Appendices

9.1 Appendix A

***Note:**

The Programming codes are included in separate appendix file called Code appendix.

9.1.1 Consent Form

Oslo Metropolitan University
Department of Computer Science
Faculty of Technology, Art and Design

Title of Research Experiment: An Usability and Universal Design investigation of parallax scrolling.

Researcher Name: Suraj Pandey

Department: Computer Science

Contact: pandey.suraj686@gmail.com

Supervisor Name: Dr. Pietro Murano

Department: Computer Science

General Information:

You are invited to participate in the masters research experiment where you will perform tasks from two groups and in two website one with parallax effect and another without parallax effect. The goal of this experiment is to investigate the usability and universal design of the parallax scrolling used in websites.

Experiment procedures

If you agree to participate in this experiment then you will be asked following questions:

Pre-experiment:

This is the first part before the real experiment where you will be asked with the questionnaire to fill with you demographic information that is required for the research study. You will not be asked to fill your personal information like name, phone number, address, etc.

Real experiment:

After agreeing to participate in the research experiment, you will be given two tasks

groups with tasks to be performed in the prototype websites on with parallax scrolling and another without parallax scrolling. The content of the websites are same the only different is in the scrolling technique. A briefing about the experiment will be given at the beginning of the real experiment.

Post-experiment:

This is the end part of the experiment. Here you will be asked to fill the post-experiment questionnaire which is based on performed tasks in experiment and experience of the experiment. The set of question that will be asked is based on your opinion on user experience, usability of the system, accessibility and user satisfaction. The total experiment session time will be approximately 15-20 minutes.

Confirmation and Consent (please tick the boxes):

- I confirm that I have read and understand the information regarding the research study and I have right to ask questions regarding the experiment at any time.
- I understand that I am free to refuse to participate in the experiment and free to withdraw from the research study any time. Refusal to participate or withdrawal of the consent will not affect anything or anyone.
- I confirm that I do not have any health related problem at the time of participation.
- I agree not to share any information regarding the research study with other until the research is complete.
- I understand that any data that is entered in the real experiment is not stored and will not be used for any purpose.
- I understand that the data collected from my participation will be anonymous and only be used in master thesis and possibly for published study.
- By checking all the boxes I am consenting to participate in the research and experiment.

9.2 Appendix B

9.2.1 Pre-experiment Questionnaire

Participant number: _____

Date: ____/____/____

Pre-experiment Questionnaire

Pre-experiment Information

These questionnaires are the beginning of the experiment. Here you will be asked some questions regarding your general information, use of computer, use of internet, understand and use of parallax scrolling in a website. The information gathered from this form will be kept secret and will be used for the research purpose only.

Please check one of the boxes per question.

1. Age Group: below 18 18-30 30-40 40 above

2. Education: Basic school High school Graduate
 Doctorate

3. Profession: Student Designer Professor Other

4. Computer Use Experience less than 2 year 2-5 years
 More than 5 years

5. Reason for using internet Email Web Browsing
 Research study For Fun

6. Your experience about the website visit less than 2 year 2-5 years
 More than 5 years

7. Device you use to visit website Laptop Mobile Desktop
 Others

8. How Often you scroll page on website Many times Depends
 Sometimes Never
9. Have you ever visited webpage with animation while scrolling: Yes No
10. Do you know about parallax scrolling? Yes No
11. Do You Know about Universal Design? Yes No
12. Do you have any kind of impairment and need any Assistive technology to participate in experiment? Yes No

If yes,

Impairment Type _____

Name of Assistive Technology_____

4. I found it pleasant while scrolling through the content of the website.

Website with parallax scrolling:

Strongly disagree				Strongly agree
1	2	3	4	5

Website without parallax scrolling:

Strongly disagree				Strongly agree
1	2	3	4	5

5. I felt confident while performing tasks in the website.

Website with parallax scrolling:

Strongly disagree				Strongly agree
1	2	3	4	5

Website without parallax scrolling:

Strongly disagree				Strongly agree
1	2	3	4	5

6. After the experiment I prefer

Website with parallax scrolling

Strongly disagree				Strongly agree
1	2	3	4	5

Website without parallax scrolling

Strongly disagree				Strongly agree
1	2	3	4	5

7. The design of the websites was good.

Strongly disagree				Strongly agree
1	2	3	4	5

8. Overall, I am satisfied with the design and content of the websites.

Strongly disagree Strongly agree

1 2 3 4 5

9.2.3 Randomization or Counterbalance of participants

Participants Number	Session 1		Session 2	
	Website	Task Group	Website	Task Group
1	P	A	N	B
2	N	B	P	A
3	P	B	N	A
4	P	A	N	B
5	N	B	P	A
6	P	B	N	A

P = Website with Parallax scrolling

N = Website without Parallax scrolling

Tasks group (A and B)

9.2.4 Participants performance Sheet

	Task Groups	Website	Total time of Completion	Total number of errors
1	A	P		
	B	N		
2	B	N		
	A	P		
3	B	P		
	A	N		
4	A	P		
	B	N		
5	B	N		
	A	P		
6	B	P		
	A	N		

9.3 Appendix C

9.3.1 Participants Data

9.3.1.1 Total Time of tasks Completion

Total task completion time (in seconds)		
Participant no.	Parallax scrolling	Non-parallax scrolling
1	160	120
2	150	221
3	225	117
4	105	58
5	150	240
6	85	68

9.3.1.2 Total number of errors done

Participant no	Number of errors	
	Parallax scrolling	Non-parallax scrolling
1	0	0
2	0	1
3	3	1
4	2	1
5	0	2
6	2	2

9.3.1.3 Participant Opinion Data on Experimental Conditions

Question: I found it interesting while scrolling through the content of the website

Participant number	Parallax scrolling	Non-parallax scrolling
1	4	3
2	5	2
3	2	3
4	3	4
5	3	2
6	5	5

Question: I found it pleasant while scrolling through the content of the website

Participant number	Parallax scrolling	Non-parallax scrolling
1	4	3
2	5	3
3	2	4
4	3	4
5	4	2
6	5	4

Question: I felt confident while performing tasks in the website.

Participant number	Parallax scrolling	Non-parallax scrolling
1	4	4
2	4	3
3	3	4

4	5	4
5	3	2
6	5	5

Question: After the experiment I prefer

Participant number	Parallax scrolling	Non-parallax scrolling
1	5	3
2	5	2
3	2	4
4	3	4
5	4	3
6	5	4

9.3.1.4 Participant opinion on task design and prototype design

Question: Tasks of the experiment were simple and understandable.

P_number	1	2	3	4	5	6
Response	4	5	4	5	4	5

Question: Tasks were interesting to perform

P_number	1	2	3	4	5	6
Response	4	5	5	4	3	5

Question: The design of the websites was good

P_number	1	2	3	4	5	6
Response	5	5	4	4	4	5

Question: Overall, I am satisfied with the design and content of the websites.

P_number	1	2	3	4	5	6
Response	5	5	4	4	4	5

9.3.2 Statistic Table

9.3.2.1 Participant opinion on experimental conditions

Question: I found it interesting while scrolling through the content of the website

Normality Distribution test

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
I found parallax interesting	.209	6	.200*	.907	6	.415
I found non-parallax interesting	.223	6	.200*	.908	6	.421

Sample statistics (Mean and SD)

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	I found parallax interesting	3.67	6	1.211	.494
	I found non-parallax interesting	3.17	6	1.169	.477

Question: I found it pleasant while scrolling through the content of the website

Normality Distribution test

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
I found parallax pleasant	.223	6	.200*	.908	6	.421
I found non-parallax pleasant	.293	6	.117	.822	6	.091

Sample Statistics (Mean and SD)

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	I found parallax pleasant	3.83	6	1.169	.477
	I found non-parallax pleasant	3.33	6	.816	.333

Question: I felt confident while performing tasks in the website

Normality Distribution test

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
I felt confident in parallax	.202	6	.200*	.853	6	.167
I felt confident in non-parallax	.293	6	.117	.915	6	.473

Sample Statistics (Mean and SD)

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	I felt confident in parallax	4.00	6	.894	.365
	I felt confident in non-parallax	3.67	6	1.033	.422

Question: After the experiment I prefer

Normality Distribution test

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
I prefer parallax	.285	6	.138	.831	6	.110
I prefer non-parallax	.293	6	.117	.822	6	.091

Sample Statistics (Mean and SD)

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	I prefer parallax	4.00	6	1.265	.516
	I prefer non-parallax	3.33	6	.816	.333