USABILITY COMPARISM OF FISHEYE EFFECT ON TREE AND LINEAR MENUS ON WEB BASED INTERFACES

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ABSTRACT
Usability testing has evolved from the rigorous methods of experimental psychology, to the wide variety of methods used today. In this study, the usability of four web page layouts was compared using the SUS model questionnaire. The web pages comprise of tree menu and linear menu of which a fisheye effect was applied to each of the two menu types to make four menus, (tree menu, fisheye tree menu, linear menu, fisheye linear menu). Ranking scores of the four menus were also taken from the participants. The mean time difference between menus of the same design (linear, fisheye linear and tree, fisheye tree menu) was identified although not to a significant effect. It was also identified that fisheye linear menu and fisheye tree menu were preferred by most participants as against linear menu and tree menu. An ANOVA between linear menu, fisheye linear menu, tree menu and fisheye tree menu shows no significant difference. It was concluded that some participants commented on fisheye linear menu and fisheye tree menu that they are nice and looked attractive although the selection time was not faster than the linear and tree menu

Keywords: linear menu, tree menu fisheye menu, web pages, SUS model.

INTRODUCTION

Usability is an important factor for all software quality models. It is the key factor in the development of successful interactive software applications (Foley & Van Dam, 1982; Sukinah et al., 2014). Foley & Van Dam, (1982) defined usability as a property of the syntactic and semantic analysis of a user interface. Mosier (1986) also described usability as a product attribute, which defines the concept by naming product or system characteristics. Usability entails how effectively a software or website is designed, and how satisfied the users of the website or software are. Usability combines factors, like ease of learning, intuitive design, efficiency of use, satisfaction and the rate and severity of errors (Bigby, 2018).

Most users of computer software and internet are familiar with navigating through different types of menus such as linear menu, pie menu, tree menu, fisheye menu and so on, as used to represent the files and directories on their computers (Ye, S. 2019). Selecting items from menus is a well-studied area and menu design has become quite standard with well grouped menu items in consistent locations using common names, but with the introduction of the Web and web applications, it is becoming increasingly common to use menus for selecting data items, as opposed to selecting operations. For example, menus

are used to select from a long list of fonts, to select one state out of thirty six states, to select one country out of two hundred states, or to select a web site from a list of favorite (Whitenton, K. 2017).
There have been tremendous studies on evaluating the efficiency and usability of these menus. However, despite the opinions and numerous studies on this subject, there are still unanswered questions regarding which type of menu design might perform better and be preferred by users. This therefore suggests that there is still some lack of knowledge in this important aspect of web site construction (Murano & Khan, 2015).

LITERATURE REVIEW

computer menu is defined as a set of options displayed on the screen, where the selection and execution of one, or more of the options results in a change in the state of the interface (Kenneth & Nancy, 1997). Margaret (2007) defines computer navigation menu as a set of options presented to the user of a computer application to help the user find information or execute a program function. Budiu (2016) described menus as list of options in a graphical user interface (GUI). They can be either visible ("menu bars") or expandable (where list of options are exposed when a menu handle is clicked or tapped). The menu handle can be a label, an icon, or both. Internet Explorer menu bar and File menu as indicated in the example below is an example of expandable menus. The File menu is an expandable menu hidden under the handle "File." The menu option selected may further be expandable to display a submenu.

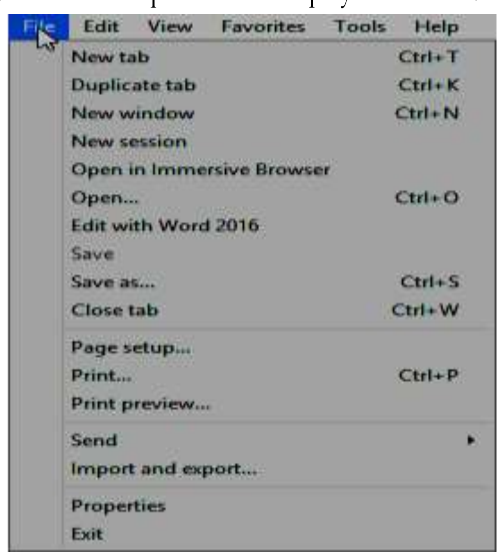

Figure 1: internet explorer menu bar (left) and file menu (right)

Menu panels usually consists of a list of options, the options may consist of words or icons, the word or icon is not an arbitrary symbol but conveys some information about the consequences of selecting that option. The total set of options is usually distributed over many different menu panels that allow the system to prompt the user with options that are likely to be useful. However, layering the options across many menu panels also requires the user to be able to navigate among panels in order to find options that are not available on the current panel. (kenneth & cooks, 1997)
Menus are common in Graphical User Interfaces (GUIs) such as Windows. Menus are also employed in some speech recognition programs. In a graphical drop down menu, clicking on an item (text, word,

button or icon) causes a list of new items to appear below that item. An example can be seen by clicking on one of the text words such as "File" or "Edit" in the horizontal list at the top of the screen in a Windows application. Clicking on an item in the menu executes the indicated function or generates another menu. In a variant of the drop down menu called a fly out, the list appears to the side of the clicked item. A pop-up menu appears above the clicked item when the main list is at the bottom of the window or screen. A menu may occasionally appear with apparent spontaneity at a random location in a window. This type of menu, also known as a pop-up menu, is usually meant to forestall a potential problem or prevent a user from making a mistake. A pop-up menu with only two choices, such as Yes/No, is called a dialog box. Pop-up menus should not be confused with pop-up ads that are used in some commercial websites (magaret, 2007).

Menus are used for exploring and selecting commands in interactive applications. They are widespread in current applications and used by a large variety of users. As a consequence, menus motivate many studies in Human Computer Interaction (HCI). Facing the large variety of designed menu techniques, it is difficult to have a clear understanding of the design possibilities, to understand the advances as well as to compare existing menu techniques. (Bailly et al., 2009).

In a study by Kalbach and Bosenick (2003), an evaluation was carried out for the development of the Audi Cars web site. They tested linear menus on the left and right sides of the web pages of the Audi web site. They found that there was no significant difference in terms of task times between the two menu types. However they did not test out any other metrics, which could have led to some interesting information.

In contrast, a study by Pietro and Tracey (2015) indicates that measuring other metrics can give other interesting and useful information. In the study, four linear menu positions (top, bottom, left and right of a page) were evaluated in the context of an online store. The results showed in agreement with Kalbach and Bosenick (2003) that tasks times did not seem to be affected.

However, in the Pietro and Tracey (2015) study, errors and mouse clicks were recorded along with final participant subjective opinions. The results showed that the top horizontal and left vertical positioned menus incurred fewer errors and fewer mouse clicks. Further, participants' levels of satisfaction were in line with the efficiency aspects observed in the study.

Bederson (2000) conducted a pilot study to compare user preference of fisheye menus with traditional pull-down menus that use scrolling arrows, scrollbars, and hierarchies. Users preferred the fisheye menus for browsing tasks, and hierarchical menus for goal-directed tasks.

Bederson used eye tracking to analyze users' interaction with the menus. The study involved menu selections from both alphabetical and categorical menu structures and selection of both known items and items that must be identified by browsing the menu. In Bederson's implementation, fisheye menus are defined by the position of the mouse and three parameters calculated from the screen height and the number of menu items: minimum font size, maximum font size, and focus-region length. The focus region is centered on the mouse, and all menu items in the focus region are displayed at the maximum font size. The transition from focus region to context is achieved by reducing the font size by one pixel for each menu item until the minimum font size is reached. The remaining menu items, all in the minimum font size, comprise the context

(Kasper & Morten, 2007) Conducted an investigation on whether fisheye menus are useful, and tried to untangle the impact on usability of the following properties of fisheye menus: the use of distortion, the index of letters for coarse navigation, and the focus-lock mode for accurate movement. He used twelve participants for the experiment comparing fisheye menus with three alternative menu designs across known-item and browsing tasks as well as across alphabetical and categorical menu structures. The results show that for finding known items, conventional hierarchical menus are the most accurate and by far the fastest. In addition, participants rate the hierarchical menu more satisfying than the fisheye and multi-focus menus, but did not consistently prefer any one menu.

MATERIALS AND METHODS

There are various types of research methodology used in HCI paradigm, such as HCI participant based experimentation, usability metrics, security metrics, population sampling and so on, but this research work utilizes the participant based experimentation which is a popular approach for comparing two or more items or objects of concern.

Area of Study Description

The experiment was conducted at the HND laboratory of computer science department, federal polytechnic Bida, faculty of ICT, Bida Niger State. The lab contains 60 working computer systems all of which were networked and connected to a server. The laboratory was equipped with four (4) network printers and a wireless router

Participants

73 participants were selected. The participants chosen for this experiment were selected from a class of undergraduate students by means of politely asking for the participants to show interest in the experiment after explaining the aim of the experiment. We decided not to select users with certain characteristics because we believe they have undergone several practical and assignments on high computer usage experience, high confidence in using computers and experience of using the internet. Linked to these, we specifically asked and confirm from the participants if there is anyone without internet browsing and computer usage experience of which no one affirmed to that. These choices were made because we wanted the data collected from participants to not be affected in any way with bias in relation to someone not having adequate IT skills. Also the sample recruited had a mixture of male and female participants across the 16-30 age range.

Tools and Materials

The following materials were used in the research:

- 20 desktop PC running Windows 8, 4GB RAM, 500GB HDD, a dual core 2.4330GHz processor, a 64 bit operating system and a 24 inch monitor,
- Firefox internet browser.
- A wireless router
- The four sample web pages which were identical in content and style with the exception of the actual aspect being investigated, i.e. the navigation bar positioning (see Experimental Design section above for the actual positions used in the experiment).

Data Collection

The System Usability Scale (SUS) model was used to develop the Research questionnaire administered to all the participants at the end of each section of the experiment to state their view, opinion and experience on the interfaces. Participants also ranked the menus according to their preference, the result of which was stored in the database for further analyses.

Experimental Procedure

The purpose of the experiment was to get feedback on the efficiency, fastness and user preference of the two types of menus for selecting an item from a list. In order to conduct the experiment the procedure described below was followed. Before beginning the tasks, the participants were given orientation and demonstration on how to carry out the experiment using a projector and also asked to carefully read the information on the home screen. This contained information about confidentiality and use of the data collected. Finally, participants were asked to click the “start” button at the bottom of the welcome screen to begin with the experiment.

There were four items on the home screen and seven tasks for each of the items stated for the experiment. Each of these was designed to simulate a typical registration procedure where a user may be asked to fill in a bio data and some other information. The tasks were further designed to ensure that the participants had to use the navigation bar to select options peculiar to them on the sample web site. They were to also record the time they start and finish each item

The four items were as follows:

- Tree menu
- Fisheye Tree menu
- Linear menu
- Fisheye linear menu

The tasks were as follows:

- Task 1: select your gender
- Task 2: select your age range
- Task 3: select your employment status
- Task 4: select your marital status
- Task 5: select your nationality
- Task 6: select your state of origin
- Task 7: select your local government

Then, the participants were instructed to select or click the items applicable to them from each menu to fill the sample form which contains mainly their bio data and other personal information. Immediately after the experiment, the participants were thanked for participating in the experiment and were requested to answer a post-experiment questionnaire (a 10 point Likert scale with five (5) characteristics taken from the system usability scale (SUS)) (Slaughter, Harper, & Norman, 1914) (see appendix section for a summary of the areas covered by the post-experiment questionnaire).

The five characteristics are:
Strongly disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly agree = 5
Also, the participants were asked to rank the four menus in order of preference. They were also offered the option of typing any comment about the menu. Then finally, the participants were once again thanked for their time and participation.

Statistical Analysis

The data was compiled using Microsoft excel 2016 and analyzed **by statistical package for social sciences (SPSS) version 26.0.** Repeated measures one-way ANOVA was used since the initial examination suggested that there was enough normality in the data to use a parametric test. For statistical analysis an alpha level of 0.05 was used.

RESULTS AND DISCUSSION

Demographic Information of the Subjects

The major descriptive statistics are discussed accordingly. Table 4.1 shows that most of the participants were male 55(75.3%) and female 18(24.7%). One hundred percent of the participants 73(100%) were students of which (86.3%) were higher national diplomas (HND) and (13.7%) were national diploma (ND). Since most of the participants were students, about 83.6% were below 30 years of age (21-30) and 16.4% are between (16-20) years.

Table 1: Demographic data of the subjects

Variables	*Categories*	frequency	Percentage (%)
Gender	Female	18	24.7
	Male	55	75.3
Age Range	(16 -20)	12	16.4
	(21-30)	61	83.6
Status	Student	73	100.0
Qualification	Higher National Dipl	63	86.3
	National Diploma	10	13.7

The Four Menu Design Types

The ten (10) questions answered by the participants for each of the menu design types were transformed to linear, fisheyelinear, tree and fisheyetree respectively. Mean, standard deviation (SD) and ANOVA of the data was then calculated. Result of the mean and standard deviation of linear menu, fisheye linear menu, Tree menu, fisheye tree menu in Table 4.6 did not show much difference (M=2.9068, SD=0.47150), (M=2.887, SD=0.47198), (M=2.9096, SD=0.47439), (M=2.9247, SD=0.47439) respectively. To confirm this claim, a Friedman test was conducted to determine whether there are differences between the mean of linear, fisheyelinear, tree, fisheyetree and confirmed by a Kendall's W Test. The test result indicates that there are no statistically significant differences between all the four menu design types X2 (3) = 0.123, P = 0.989.

Table 2: Mean and standard deviation of the four menu design types

Descriptive Statistics

Menu design types	N	Mean	Std. Deviation	Minimum	Maximum
Linear	73	2.9068	.47150	1.50	4.00
Fisheyelinear	73	2.8877	.47198	1.00	3.90
Tree	73	2.9096	.47439	1.50	4.00
FisheyeTree Menu	73	2.9247	.47749	1.60	3.90

Table 3: Friedman and Kendall's W. ANOVA Test for all the four menu design types

Friedman Test

Kendall's W Test

Ranks

	Mean Rank
linear	2.52
fisheyelinear	2.50
Tree	2.46
FisheyeTree	2.52

Ranks

	Mean Rank
linear	2.52
fisheyelinear	2.50
Tree	2.46
FisheyeTree	2.52

Test Statistics[a]

N	73
Chi-Square	.123
df	3
Asymp. Sig.	.989

a. Friedman Test

Test Statistics

N	73
Kendall's W[a]	.001
Chi-Square	.123
df	3
Asymp. Sig.	.989

a. Kendall's Coefficient of Concordance

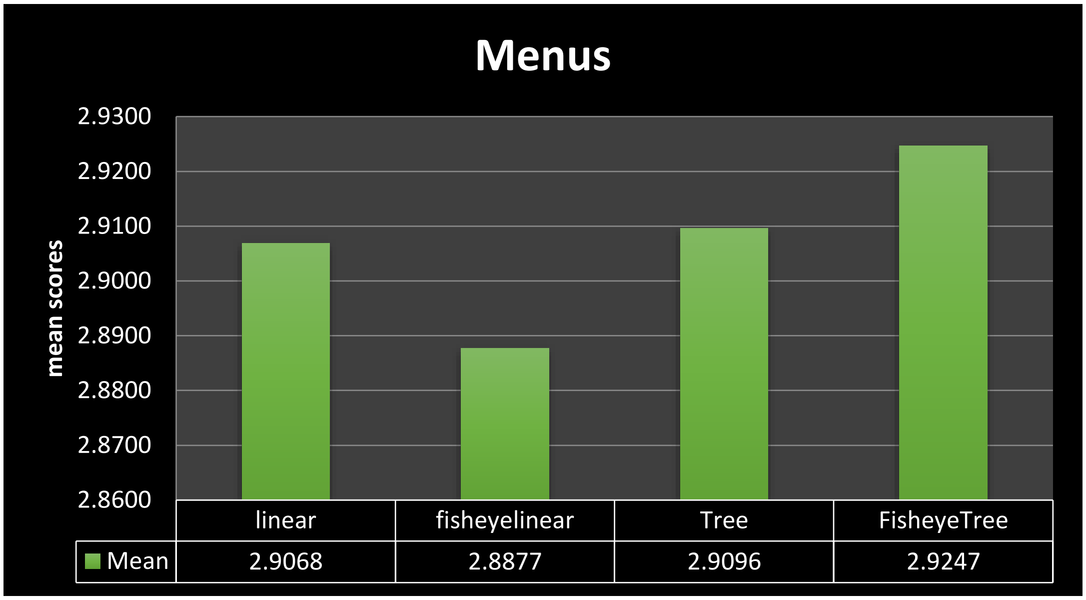

Figure 2: Mean of all the four menu design types

DISCUSSION

This study compared the performance of tree menu, fisheye tree menu, linear menu, fisheye linear menu on a web based interfaces. The data was initially explored by looking at the distributions and overall pattern. To be able to analyze the data generated, each of the variables was transformed to find the mean. Shapiro-Wilk was used to check whether the data was normally distributed before we do any statistical test since our data is less than one hundred (100). A parametric test (one-way between subjects ANOVA) was conducted since the initial examination suggested that there was enough normality in the data (the data was normally distributed). For statistical analysis an alpha level of 0.05 was used.

Overall Ranking

From the descriptive statistics in table 4.3 above, it indicates that the fisheye linear rank (M=3.47, SD=1.334) and fisheye tree rank menus (M=3.38, 1.287) have the highest mean ranks across the four test designs. Friedman **ANOVA** test was conducted to check the mean ranks; the results show that there is statistically significant difference in rank scores between the four test groups $X^2(3) = 22.450$, $P<0.001$. A follow up post-hoc test which was confirmed by Kendall's W test indicates that there is statistically significant difference on fisheye linear rank $x^2(1) = 11.529$, $p = 0.001$ and fisheye tree ranks $x^2(1) = 12.552$, $p<0.001$. While no significant difference was recorded for linear x2(1) =2.174, p = 0.140 and tree menus $x^2(1) = 0.123$, p=0.989 respectively.

Total Completion Time

An ANOVA for total completion time (appendix C) shows no statistically significance difference between the four test conditions $F(11, 61) = 1.318$, $p = 0.237$. Although by examining the time data in full (Table 4.5), it can be seen that the mean time difference between menus of the same design (linear, fisheye linear and tree, fisheye tree menu) was identified although not to a significant effect.

The four menu designs

The questionnaire data show that participants prefer the use of the menus that have fisheye effect i.e. fisheye linear menu and fisheye tree menu than the conventional linear and tree menus, particularly for the selection of items from a list of data sets. In accordance with these findings some participants commented that they appreciated the fisheye effect on both the linear and tree menu. For fisheye linear menu the comment goes like this "this menu is the best", "it's very satisfactory", "good", while fisheye tree menu has comments like "it's very ok and satisfactory", "the menu was nice", "it's very ok". Note however, that in this study we observed that the actual time taken to complete given tasks in linear and tree menus are faster than the fisheye linear menu and fisheye tree menu though, not a statistically significance. The usability of fisheye menus (linear and tree) rests on their ability to enable users to accomplish the objective of homing on a target items. Result of the mean and standard deviation of linear menu, fisheye linear menu, Tree menu, fisheye tree menu in Table 4.6 did not show much difference (M=2.9068, SD=0.47150), (M=2.887, SD=0.47198), (M=2.9096, SD=0.47439), (M=2.9247, SD=0.47439) respectively. To confirm this claim, a Friedman test was conducted to determine whether there are differences between the mean of linear, fisheyelinear, tree, fisheyetree and confirmed by a Kendall's W Test. The test result indicates that there are no statistically significant differences between all the four menu design types $X2 (3) = 0.123$, $P = 0.989$ and therefore will not be discussed further in this study.

CONCLUSION

The results suggest overall that whether the menus have a fisheye effect or not does not statistically affect interaction time. Fisheye linear menu and fisheye tree menus performed similarly in terms of overall ranking, and preference while linear and tree menu performed similarly too in terms of task time. Therefore, the results of this experiment suggest that menus that have fisheye effect seem to elicit better preference by users in terms of time taken to complete the whole task in each menu, linear menu and tree menu performed faster. No statistical significant differences in terms of overall ranking were found between fisheye linear menu and fisheye tree menu and likewise linear menu and tree menu. The authors would therefore suggest that using menus with fisheye view would go a long way to helping in having web pages that are universally designed.

Furthermore, the significant differences in errors between the different menu types suggest that menus with fisheye effects would incur fewer errors. Although it is felt that this study helps to increase our knowledge regarding menu and navigation design, more work could still be done to make things more clear. Some examples include investigating further other menu design types and other menu configurations. The authors hope to be able to engage in further studies around these contexts. The research carried out and described in this experiment, has helped to gain more understanding about which menu type may be better.

RECOMMENDATION

The authors of this research work recommends that more work still needs to be done to obtain empirical results for other types of menus and also to investigate in more depth issues of sub-menus and nesting. This is recommended because clearly other researchers have had different results which may indicate that there are other issues at play still to be discovered.

It is also recommended that in future research, the impact of fisheye effect on mega menu and overview menu should be investigated. Also future experiments with more difficult tasks could lead to more understanding of the issues as this approach may show clearer results favoring a particular type of menu design. Furthermore we suggest that perhaps other psychological aspects and/or user experience could have effects that have not been identified yet.

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APPENDIX A: Results From Statistical Analysis

Normality test for the Rank values

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
linear	.075	73	.200*	.986	73	.616
fisheyelinear	.096	73	.092	.954	73	.129
Tree	.082	73	.200*	.987	73	.662
FisheyeTree	.094	73	.178	.978	73	.218

**. This is a lower bound of the true significance.*

a. Lilliefors Significance Correction

Friedman Test

Ranks

	Mean Rank
Linear Rank	2.04
FisheyeLinear Rank	2.87
Tree Rank	2.33
FishayeTree Rank	2.76

Kendall's W Test

Ranks

	Mean Rank
Linear Rank	2.04
FisheyeLinear Rank	2.87
Tree Rank	2.33
FishayeTree Rank	2.76

Test Statistics

N	73
Kendall's W[a]	.103
Chi-Square	22.450
df	3
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Test Statistics[a]

N	73
Chi-Square	22.450
df	3
Asymp. Sig.	.000

a. Friedman Test

One Way ANOVA For The Rank Values

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
*Subjects * Linear Rank*	Between Groups	(Combined)	4762.460	4	1190.615	2.928	.140
	Within Groups		27649.540	68	406.611		
	Total		32412.000	72			

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
*Subjects * FisheyeLinear Rank*	Between Groups	(Combined)	1395.756	4	348.939	.765	.001
	Within Groups		31016.244	68	456.121		
	Total		32412.000	72			

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
*Subjects * Tree Rank*	Between Groups	(Combined)	1342.075	4	335.519	.734	.989
	Within Groups		31069.925	68	456.911		
	Total		32412.000	72			

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
*Subjects * FishayeTree Rank*	Between Groups	(Combined)	5011.237	4	1252.809	3.109	.000
	Within Groups		27400.763	68	402.952		
	Total		32412.000	72			

Normality test for the Time Scores

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.

Linear Time	.220	73	.000	.824	73	.000
FisheyeLinear Time	.336	73	.000	.595	73	.000
Tree Time	.401	73	.000	.614	73	.000
FisheyeTree Time	.347	73	.000	.609	73	.000

a. Lilliefors Significance Correction

Friedman Test

Ranks

	Mean Rank
Linear time	2.52
Fisheyelinear time	2.50
Tree time	2.46
FisheyeTree time	2.52

Kendall's W Test

Ranks

	Mean Rank
Linear time	2.52
Fisheyelinear time	2.50
Tree time	2.46
FisheyeTree time	2.52

Test Statistics[a]

N	73
Chi-Square	.123
df	3
Asymp. Sig.	.237

a. Friedman Test

Test Statistics

N	73
Kendall's W[a]	.001
Chi-Square	.123
df	3
Asymp. Sig.	.237

a. Kendall's Coefficient of Concordance