Suitable Length of Text Line on the Bases of Eye Blink for Reducing Maximum Focus Losses

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ABSTRACT
The usage of web shows the importance of usability and readability of the web applications or sources provide by the web. Web application fails to encounter the user's requirements in effective manner, because the designers are unaware from some of the important factors effecting readability, reading from the screen. In this regard, this study is the continuation of the previous work that has been done for the improvement of readability, to handle the readability issues on the basis of Eye Blink for male participants only. To achieve general recommendations for suitable length of text line for all type of users, female participants are considered in this study. Basically during reading from the screen focus losses at two positions, when eye blink middle of text line and when text line ends. This study specifying suitable length of text line on the basis of Eye Blink, assuming three typographical variables i.e. font style, font color, font size, and with white background, will improve the overall readability or reading from the screen. This study also shows two important things the degree of understandability and the degree of attractive appearance of different combination for female participants only.

General Terms
Suggesting suitable length of text line for textual materials that enhances readability, during reading from computer screen.

Keywords
Readability, Text Line length, understandability, appearance, Eye Blink.

1. INTRODUCTION
In present era of information technology, plethora of information are available, in this fast and busy life people want and wish to get the desire information as easy as possible. The usage of computer and internet increases day by day, today online reading from computer systems become more common. According to Google data centre June 2006, about 900 million computer users exist in the world [29]. According to Internet World States, internet users in the world distributions in the world 2011 are 2,095,006,005, which are approximately 2100 million or 2 billions [30]. It means a large population use internet to get the desire information easily, cheaply, and accurately. Though information readily available, and Internet is the source which provides information with comfort and almost with no cost, but these content is not up to the mark. As huge part of information is consists of textual data, it is difficult and tedious to spend a lot of time in front of a computer because user facing a lot of problems during reading from computer screen, known as readability problems. During reading from the computer screen, usability of the web contents must be consider with significance and should not be ignored. Typography plays a major role in the web contents usability, many studies exist regarding typography, standards has been deduce after different studies for soft copy and hard copy. Web usability is an approach to make web sites easy to use for an end-user, non specialized web user, without any specialized training, and without having any pre knowledge. Keep it in mind that huge amount of information are access through World Wide Web and Web browsers. There is an urgent need to increase our knowledge about the usability or readability factors influence reading from computer screen. Few problems create inefficiency and keep users away from online reading for long time. One of the main problem that act as a huddle in reading from computer screen is Eye Strain, focus loss during reading, brain fog, and headache. These entire problem are interrelated, the focus is to reduce the focus loss during reading and hence eye strain become less or to get large time to get tired. During reading from the screen users become tired after some time and get bored. It may involve many reasons but this study and the previous study specifies suitable Length of Text Line with special relationship to Eye Blink on the basis of font style, font size, font color and background color. The study reduces the problem caused by reading and increase readability that will ultimately lead to efficiency and comfort. This study is the succession of previous work, which is done for male candidate to complete the full experiment this study is performing for female candidates.

The structure of the paper is as follow. First the document describes the focus area and importance. Second section describes how to deal with the problem and approach that reduce or solve the problem. Third section introduces related work. Next section includes methods and procedures, analysis, facts and figure about experiment, lastly conclude the whole work.

2. HOW TO DEAL THE PROBLEM
Online reading or Reading from computer screen creates a lot of problems which lead inefficiency and degradation. Reading from the computer screen from nearer distance requires more focus and attention that led the reader or user to rapid fatigue and concentration loss position. During reading from the screen it is generally observed that the user feel problem related to eye e.g. Eyestrain, which causes them less productive work by preventing them from online reading. Eyestrain does not permanently damage eyes or vision loss. However, it can be very uncomfortable and lead to productivity loss, in the form of getting tired quickly and

preventing user not to use computer for long time. The piece of eye that take part in reading is called macula, which is 10% of the retina center and responsible for reading [25]. The Problems during reading from the computer screen can include: a feeling of being unable to focus on the screen that is focus losses again and again, confusion, attention deficit, brain fog, irritability, headache, eye Strain or neck pain, dizziness or faintness, queasiness or vomiting, and an uncomfortable feeling down through the chest. [1]. People or computer user most of the time avoid online reading because it is time consuming as compared to the reading from the paper. Reading from the screen is 25% slower than reading from the paper, because they loss their focus from the position they reading [17]. During reading from computer screen human losses concentration or accommodation at two positions, first when the line (text line) breaks and second when eye blink when reading or line still continue. In reading eyes naturally blink in order to relax muscles from contractions form which loss the focus or concentration from the position from where he/she is reading. Starting reading again, the muscles goes to contraction form to get focus. In same way when the line breaks, sweep from the end of the line to the beginning of the next line loss focus and the eye muscles goes from contraction to rest and then from rest to concentration. If this process happens as many times the eye become tired and will cause problems. This process involve two types of eye muscles internal muscles that are sphincter of the pupil, ciliary body and eye lens, external muscles such as medial rectus, superior rectus, superior oblique, inferior rectus, inferior oblique and lateral rectus.

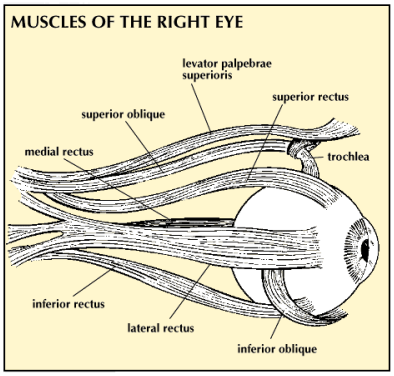

Figure 1 Show the muscles involve in Eye Moment [28]

The mentioned problems can be overcome to some extent by decreasing the process of focus loss and focus gain which will protect eye from rapid fatigue. Deducing or adjusting the length of text line to an adequate size will convert two focus losses to one, it means that when human eye blink the line should be end which will lead to convert maximum focus losses to minimum focus losses that will protect eye strain and indirectly all other relevant problems. The efficiency and readability will increase. The most important factors that affect length of text line are Font Size, Font Style, and Spacing between lines, Text color and Background Color.

Blinking also protect eye from irritants. Eyelashes are hairs attached to the upper and lower eyelids that create a line of defense against dust and other elements to the eye. The eyelashes catch most of these irritants before they reach the eyeball [26].

3. RELATED WORK

With such a large volume of material accessible from the World Wide Web or through web browser, there is an urgent need to increase our knowledge of factors influencing reading from screen.Web usability is an approach to make web sites easy to use for an end-user, without any specialized training. For this purpose a lot of work has been done till now since 1880. Before the evolution of computer system these experiment been done on printed media, but afterwards the efforts transformed towards online reading or reading from computer screen. All these experiments are summarizing in the following section.

Line Length: (WEBER, 1881) he suggested that an ideal line length was 4 inches equal to 100 millimeters. He stated further that the maximum never should exceed 6 inches or 150 mm. The same year Javel (1881) reported that line lengths should be no longer than 3.6 inches or 90 mm [7]. (COHN, 1883) suggested that 3.6 inches or 90 mm was the best length of text line, and that 4 inches or 102 mm was the longest tolerable line length for printed media [3]. (TINKER & PATERSON, 1929) found that line lengths between 3 inches and 3.5 inches or from 75 to 90 mm yielded the fastest reading performance Using 10-point black type on white paper. These recommendations were for Printed materials [4]. (SPENCER, 1968) proposed that the characters should not be exceeded from 70 characters per line, this recommendations also for printed materials or for hard copy [5]. (JACKSON & MCCLELLAND, 1979) analyze and measure the reading rate for effective reading performance on the bases of users or readers comprehension. These authors multiplied reading rate by the comprehension score to produce their index. However, they do acknowledge that multiplication may not be the optimal formula, as sacrificing comprehension for very fast reading may exaggerate reading ability [6]. (DUCHNICKY & KOLERS, 1983) found an affect reading rate for reading from screen and suggested appropriate Line length for text line, and specified that line length should be about 75 characters per line. The study has been done on the base of studying different display technologies [8]. (MASSON, 1985) The effect of line length on reading rate may be dependent upon the overall reading speed, means how fast a reader can read, as speeding up reading may result in different patterns of eye movements. Masson has reviewed research on the characteristics of naturally fast readers and found that “super readers" make fewer fixations during reading from the printed materials and also from the computer screen [9]. (RAYNER & POLLATSEK, 1989) They deduce that Tinker's work identified an optimal line length of 52 characters per line. The trade-off between two opposing factors that are: If line lengths are too long, the return sweeps to the beginning of the next line are difficult. If the lines are too short, readers cannot make use of much information in each fixation [10]. (DYSON & KIPPING, 1998) Kipping et al suggest in their study that 4-inch line length of text line produced the slowest reading rate and the 7.3 inch line length produced the fastest. These experiments are done with using 12-point type font size [11]. (YOUNGMAN & SCHARFF 1999) according to Youngman and Scharff 8 inch line length of text line elicited the fastest speed as compare to the line of 4 inches or 6 inches text line lengths. They used 12-point type for font size [12]. (DYSON & HASELGROVE, 2001) A medium line length of 55 characters per line appears to

support effective reading at normal and fast speeds. The investigation was made on three effecting factors that are; comprehension, reading rate and scrolling patterns [13]. (BERNARD, FERNANDEZ & HULL, 2002) had participants read 12 point prose text with line lengths of 9.6 inches or 245 mm, 5.7 inches or 145 mm and 3.3 inches or 85 mm. Their adult subjects preferred the two shorter line lengths [14]. (BOB BAILEY, 2002) Users tend to read faster if the line lengths are longer up to 10 inches. If the line lengths are too short, means around 2.5 inches or less then it may impede rapid reading. Users prefer lines that are moderately long in length that is 4 to 5 inches [15]. (DAWN SHAIKH, 2005) reported a study that examined the longest line length of 95 characters per line or 10 inches resulted in the fastest reading speed [16].

(MUZAMMIL & MUSHTAQ, 2010) suggested different text line lengths for three variables on the bases of eye blink during reading from computer screen. The study concluded if the text for reading is provided in the given length it can reduce eye strain and enhance reading capabilities from the computer screen. The experimental setup was explained i.e. equipment, participants, material for experiment, the collection of data procedures, and then explain three main major factors that's must be consider during reading. Previous study presents eight different combinations from the combination of three given variables for experiment, i.e. Font color, style and size. Understandability, appearance, and line length on the bases of eye blink were three major factors that were considered. According to Muzammil et al combination "Verdana, 10, Black" and "Verdana, 10, Green" are best, when consider clarity and appearance. The experiment has been done for male participants only. They suggest length of text line shown in the following table [24].

	Length of Text Line (Three Measurable Units)		
	C/L Without Spaces	C/L With Spaces	C/L in Inches
Paragraph 1	77	93 (±5)	5.25
Paragraph 2	111	133 (±7)	9.13
Paragraph 3	116	141 (±7)	9.5
Paragraph 4	102	122 (±7)	10.74
Paragraph 5	74	87 (±5)	4.87
Paragraph 6	96	115 (±7)	8.13
Paragraph 7	114	134 (±7)	10
Paragraph 8	96	111 (±7)	10

Text Layout: (J. NIELSEN, 2000) Use colors with high contrast between the text and the background. Optimal legibility requires black text on white background and so-called positive text. White text on a black background and called it as negative text. Negative text is considered to be equally good, but has no proof [17]. RICHARD and HANNA provide systematic approach to prove Nielsen statement [18]. (BRADLEY WILSON) Times are the most popular body font that is 29%, then Palatino 13%, Garamond 8% and the rest fonts 50%. The font sizes that are normally used are, Average 9.99, Median 10, Largest 12 and Smallest 8.5 [19]. City of Seattle Web Presentation and Accessibility Standards Version 2.5 are; the minimum font size for basic page body text will be or appear equal to Verdana 10 points. All page body text will be black. All page body text will be presented in Verdana font [20]. (MUSHTAQ RAZA, 2007) Preliminary mean analysis of the fonts revealed that font type Time New Roman is the most readable, conveyed personality Business like and first preference of the participants as compared to Courier New, Arial and Bradley [21].

Eye Blink or Blink rate: The analysis of the eye movement in reading is blinks, when readers close their eyes. Blinking rate increases with increasing reading time, resulting in high data losses, especially for older adults or reading impaired subjects [22]. Spontaneous blink rate was significantly larger in women than in men (19 vs. 11 blinks per minute); older women blinked more frequently than younger women. Eyelid displacement was greater in young than in older subjects [23]. When eyes are focused on an object for an extended period of time, such as when reading, blinking rate decreases up to about 3-4 times per minute [28].

4. METHODS AND PROCEDURES

4.1 Considered Variables

Many factors were identified that effect reading from computer screen and degrade efficiency. The focus here on two type of standards that is standards for printed materials and web standards. The study involves; Typographical Variables that is Fonts size 10 points (web standard), 12 points (print media standard), Font face Verdana (web standard), Time New Roman (print media standard) and Color Combination (Foreground and Background) that is Black/White & Green/White for female users between 20 to 40 years old.

4.2 Equipment for Experiment

The experiment has been done on Laptop, i.e. the text for the test was provided and the required data was collected on a system having specifications:

Intel(R) Core(TM) 2 Duo CPU T5750 @ 2.00GHz, 1995 MHz Laptop of model Dell Studio 1535.

4.3 Participants

For experiment and collection of data Thirty Two (32) female volunteer were considered. They were aged from 21 to 36, that is 18 female participants are age ranged between 21 and 25, 9 participants are age between 26 and 30, and 5 female volunteered participants are age ranged between 31 and 36. Overall average age is 25. The participants were having correct vision, and there is no disability. All the participants are related to education. There are 16 or 50% participants were graduate students, 7 or 22% were postgraduate students, 6 or 19% professionals, and 2 or 9% were chosen randomly.

4.4 Experimental Setup

The data has been collected in early days in the month of August. The temperature were around 30 degree centigrade (30^{o}), weather were dry in those days i.e. no rain from few days. All the data are taken in under normal room light and the users are sat 24 to 28 inches away from the screen, means that follow the safety precautions that should be following during using computer. The text provide for experiment in "Internet Explorer" web browser.

4.5 Experimental Material

A web page is designed with 8 different paragraphs with different typographical properties. The design page is presented to the users or participants. Each paragraph is the combination of different parameters, means that each paragraph has one parameter different than all other paragraph. Each graph is around 5 to 6 lines long and the

length of each line is around 10.5 inches per line. This textual material is provided in Internet Explorer Web browser. The considered variables in the experiment are the two different standards, i.e. Print media standards and Web standards.

The composition of each paragraph is given in the following passage.

Short hands: Style, Size, Color
Paragraph 1: Time New Roman, 10, Black
Paragraph 2: Time New Roman, 12, Black
Paragraph 3: Verdana, 10, Black
Paragraph 4: Verdana, 12, Black
Paragraph 5: Time New Roman, 10, Green
Paragraph 6: Time New Roman, 12, Green
Paragraph 7: Verdana, 10, Green
Paragraph 8: Verdana, 12, Green

4.6 Data Collection Procedure

The data has been collected in the following manner.

Step 1: The user is positioned and instructs how to read the passages in order to collect correct data.

Step 2: The video has been taken from the user or reader but they are unaware from it because of; to get natural blink during reading.

Step 3: After the video been taken, the user is than briefly explained with the process, means the purpose of research and why the passages is read by them in a said constraint.

Step 4: A questioner has been conduct in order to collect information about the different combinations.

Questioner: A questioner contains of 16 questions, 8 about "to find out the degree of understandability or clarity of words in the paragraph based on fonts' style and size". And 8 about "to find out the degree of pleasant appearance or good-looks of the paragraph based on fonts' style and size".

Step 5: A thorough discussion has been made on each Question, and the conclusion was deduce.

Step 6: Each video analyzed carefully in order to find out the suitable length of Text Line on the bases of Eye blink for each combination, through which the maximum focus losses is replaced by fewer one.

Step 7: The values are put in EXCEL tool and the Result are deduced in the form of Charts and Tables.

5. RESULTS ANALYSIS AND DISCUSSIONS

5.1 Clarity and Understandability

The user is asked to rate the paragraph, on the basis of "the degree of understandability/clarity of words in the paragraph based on fonts' style and size".

Average perception of users about each paragraph

Paragraph 1 is too small, looking to much condense, and difficult to read.

Paragraph 2 is a bit easier to read than the first combination but the words are looking attached to each other. The words are looking shaky, that is unstable.

Paragraph 3 is Clearer, Understandable and very much easier to read as compare to the previous ones.

Paragraph 4 is also clear and easy to read but it is observe that the user lost correct line when the finish one and starting new line it may be because the lines are looking very close. During discussion it is observed that the readers get bored during reading such large font size textual materials.

Paragraph 5 is too much difficult to read because there is not high contrast between background and Text color, the words are too small and looking very condensed plus the green color font is looking very sharp with white background.

Paragraph 6 is difficult to read because small, low contrast and looking unstable.

Paragraph 7 is ok and is clear than the paragraph 5 and 6, observing that the readers have positive approach towards this combination.

Paragraph 8 is ok but looking a bit larger and same problem as in paragraph 4.

Table 1 Measures for Understandability

Paragraphs	Excellent	Very Good	Good	Average	Bad	Very Bad	Average
Paragraph 1	-	1	17	12	1	1	11.2
Paragraph 2	5	15	10	2	-	-	15.1
Paragraph 3	19	7	4	2	-	-	17.1
Paragraph 4	6	13	8	5	-	-	14.8
Paragraph 5	-	-	3	19	14	6	7.3
Paragraph 6	3	9	14	4	-	-	13.5
Paragraph 7	17	7	5	3	-	-	16.6
Paragraph 8	7	11	6	8	-	-	14.5

Table 1: When the Questioner is evaluated then the user's data is converted into simple form as shown in table 1. For the conversion of qualitative measures into quantitative measure, Categories are assigned to some numeric values, that as Excellent = 0.6, V-Good = 0.5 … V-Bad = 0.1 and then each numeric value is multiplied by the number of users chose the respective option. That is;

$0.6 * X_1 + 0.5 * X_2 + 0.4 * X_3 + 0.3 * X_4 + 0.2 * X_5 + 0.1 * X_6 = \text{Average}$

Where X_x is the number of user select the respective category/choice. Automatically Graph has been generated. As shown in the following Figure 3

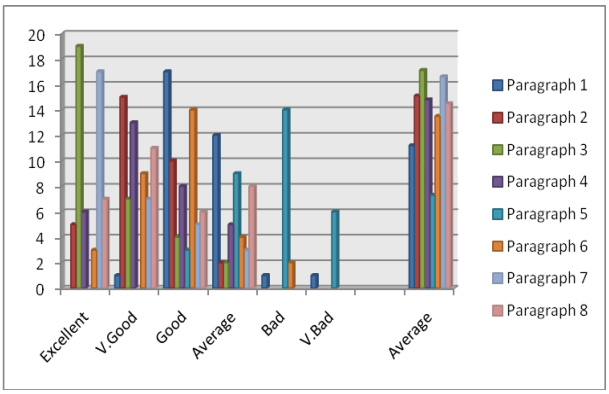

Figure 2 Graphical display of entries for Understandability

The Table and Chart shows the understandability and clarity for each combination, specified in each paragraph. The average in the table shows the clarity of each combination and in chart the BAR height shows the clarity of each paragraph. Each combination can be ranked as;

1. Paragraph 3: Verdana, 10, Black
2. Paragraph 7: Verdana, 10, Green
3. Paragraph 2: Time New Roman, 12, Black
4. Paragraph 4: Verdana, 12, Black
5. Paragraph 8: Verdana, 12, Green

6. Paragraph 6: Time New Roman, 12, Green
7. Paragraph 1: Time New Roman, 10, Black
8. Paragraph 5: Time New Roman, 10, Green

In simple words, combination in paragraph 3 should be use regarding understandability and clarity which is also the result of previous study.

5.2 Pleasant Appearance or good looks

The questioner contains fifty percent questions regarding appearance of each paragraph. The users were asked to rate the different combination on the basis of "the degree of pleasant appearance or good-looks of the paragraph based on fonts' style and size".

Average perception of Users about each paragraph

Paragraph 1 is looking very nice but not comfortable; the text is not easy to read.
Paragraph 2 is looking very much nice and nice to read. Observed that the user like the chemistry of the font. Most of the users like the font style.
Paragraph 3 is very much simple and very stable and much comfortable, enjoying reading.
Paragraph 4 is looking boring, very simple and extra large.
Paragraph 5 is appearing nice but too much uncomfortable, but as it is looking shaky, therefore reading this combination is more irritating.
Paragraph 6 is appearing to be very fine than the paragraphs 5, 7 and 8.
Paragraph 7 is looking fine and comfortable than others.
Paragraph 8 is ok but looking a bit larger and boring.

Table 2 Measures for Appearance

Paragraphs	Excellent	V.Good	Good	Average	Bad	Average
Paragraph 1	-	8	13	11	1	12.7
Paragraph 2	10	13	6	3	-	15.8
Paragraph 3	8	14	5	5	-	15.3
Paragraph 4	3	12	10	7	-	13.9
Paragraph 5	-	9	14	6	3	12.5
Paragraph 6	9	11	9	3	-	15.4
Paragraph 7	12	8	10	2	-	15.8
Paragraph 8	4	9	14	5	-	14

Note: No entries for very bad option (column is not included in the table above).

After evaluating the Questioner and converting user's data into tabular form for simplicity as shown in table 2. For the conversion of qualitative measures into quantitative measure, Categories are assigned to some numeric values, that as Excellent = 0.6, V-Good = 0.5 … V-Bad = 0.1 and then each numeric value is multiplied by the number of users chose the respective option. That is;

$0.6 * X_1 + 0.5 * X_2 + 0.4 * X_3 + 0.3 * X_4 + 0.2 * X_5 + 0.1 * X_6$ = Average

Where X_x is the number of user select the respective category/choice. Automatically Graph has been generated. As shown in the following Figure 4

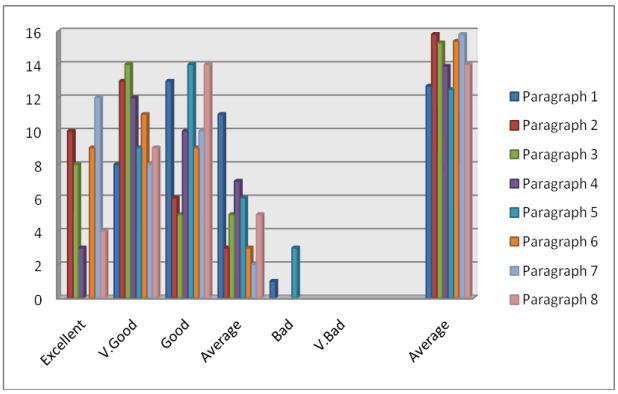

Figure 3 Graphical display of entries for Appearance

The Table and Chart shows the appearance and look for each combination, specify in each paragraph. The strength of appearance for each combination is shown in the form BAR height. Each combination can be ranked as;

1. Paragraph 7: Verdana, 10, Green

And Paragraph 2: Time New Roman, 12, Black

2. Paragraph 6: Time New Roman, 12, Green
3. Paragraph 3: Verdana, 10, Black
4. Paragraph 8: Verdana, 12, Green
5. Paragraph 4: Verdana, 12, Black
6. Paragraph 1: Time New Roman, 10, Black
7. Paragraph 5: Time New Roman, 10, Green

In simple words, combination in paragraph 7, paragraph 2 and paragraph 6 is best typographic combination regarding appearance and looks.

5.3 Length of Text Line on the Bases of Eye Blink

5.3.1 Data Analysis Procedure

During reading video has been taken from each user without informing them (after taking video the whole process and research purpose is explained to the user), in order to observe eye blink naturally when the users reading the textual materials. Calculate the length of Text line for each Blink for every paragraph and find out the Average of each user. Similarly the process of calculating length of text line is repeated for each user, and then finds out the grand average for all the users. The length has been specified. The length is measured in three different units that are Characters per Line without spaces, Characters per line with spaces and length in Inches per line.

Table 3 Length of Text Line on the Bases of Eye Blink (Three Different Measures)

Paragraphs	C/L Without Spaces	C/L With Spaces	C/L in Inches
Paragraph 1	71	86 (±5)	5.02
Paragraph 2	105	122 (±7)	9
Paragraph 3	110	129 (±7)	9.3
Paragraph 4	99	117 (±7)	10.5
Paragraph 5	72	81 (±5)	4.88
Paragraph 6	91	109 (±7)	8.03
Paragraph 7	108	124 (±7)	9.3
Paragraph 8	97	110 (±7)	10.02

The results has been obtained in three different measurable units that is Characters per Line without space count, Characters per Line with space count where (±5 or ±7) means the number of spaces vary in range of 10 spaces per line that is 93 (±5) means 88 to 98 and 133 (±7) means 126 to 140. The length per line in C/L without spaces and Length per line in inches give us exact measure than the C/L with spaces.

Figure 5 shows length of line as Character per Line without spaces (spaces are not counted) for each combination of parameters. The paragraph 3 (Verdana, 10, Black) accommodate 116 characters per blink which is greater than all other combinations and shows to be the most efficient typographical combination. The combination in paragraph 7 and paragraph 2 accommodate 114 and 111 characters per blink respectively and so on.

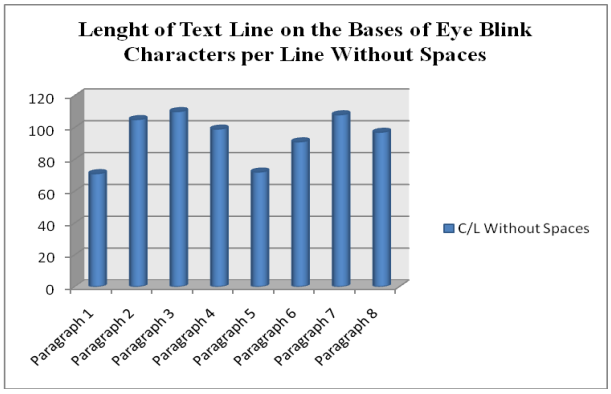

Figure 4

Figure 6 shows the number of characters per line with spaces for one natural eye blink. The length is same as in above Figure 6 but not precise and accurate like other units because the number of spaces varies up to ±5 or ±7 spaces per line and depends upon the words used.

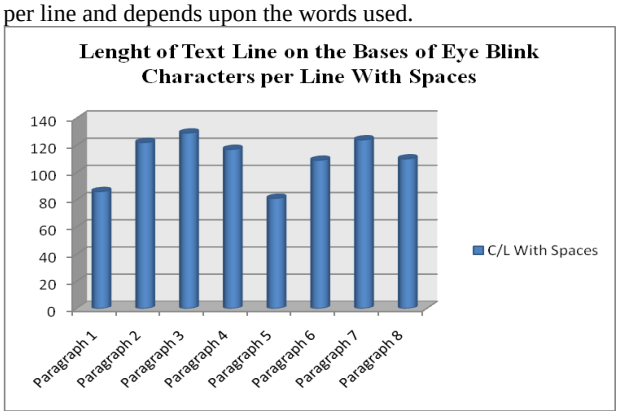

Figure 5

Figure 7 shows length of text line of each combination in inches. As the length of paragraph 4 is longest one but it does not means that it is more efficient than other paragraphs because the number of words are less than from paragraph 3, 7 & 2 because the size is bigger which increase the length of text line but accommodate less words.

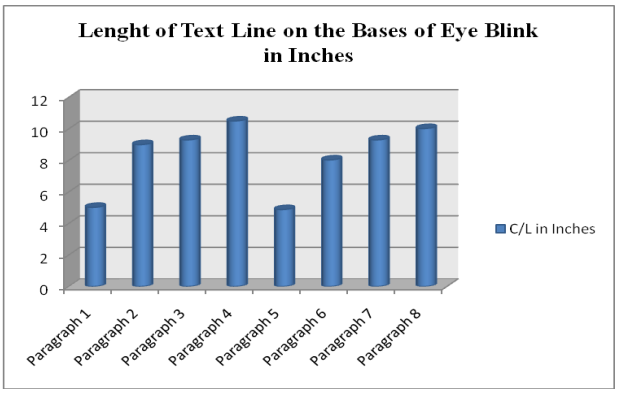

Figure 6

6. CONCLUSION

The main objective of this study is to suggest suitable length of text line for web page or online reading, while keeping Eye forefront. On the bases of eye blink suggest the suitable length of text line considering different typographical variables i.e. font style, font color, and font size with white background. This scrutinize illustrate three important things about various combination of standards. One; the length of text line on the bases of eye natural blink for female, second; understandability or clarity, third; the good attractive appearances of the combinations. The study suggested the Length of Text Line in three units of different standards combinations. Presenting these text materials for reading through internet or generally from computer screen in the suggested line length will deduce the problems of causing reading, by converting maximum focus losses to minimum ones. This study proves that "paragraph 3"; the combination "Verdana, 10, Black" shows overall promising results for efficient line length, understandings, and for attractiveness. The combinations in paragraph 2 and paragraph 7 are the competitive combinations showing good results in all three aspects. These recommendations serve materials that study online or from computer screen, for example Thesis, e books, research papers etc. in simple words, during designing materials for reading from computer screen, the recommendations should be considered for different combinations for maximum efficiency.

Now it is essential to compare the previous study [24] to this study in the same direction to achieve more accurate results.

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