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What Are You Reading Most: Attention in eLearning

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Abstract

Eye tracking is useful for investigating how people read and the attention that they give to certain items. We investigated how much participants read parts of educational text when they are required to answer questions relating to it. We found that there is no difference between the normalized number of fixations observed when participants answered multiple-choice questions correctly compared to when they answered incorrectly, however, there are differences for fill-in-the-blanks questions. Different presentation formats of the text and questions have an effect on the how thoroughly paragraphs containing answers to questions are read. For formats where only text is presented the first or last paragraphs are read the most thoroughly. For formats where the questions are shown with text, the fill-in-the-blanks questions were read more thoroughly than other parts on the page. This can be used to influence how students learn material in eLearning environments.

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Keywords: Eye gaze; eye tracking; adaptive eLearning; presentation format; Reading Behaviour

1. Introduction

Educational material is now commonly available online. This is especially true for tertiary education, where face-to-face education is now heavily supplemented with material that is available through online learning environments, such as Moodle and Blackboard. Tertiary institutions now offer online/off-campus degrees where students may have little or no face-to-face interaction with their instructors or other students. Eye tracking has long been used to investigate the reading process (see review by Rayner (1998)). Given that a primary form of educational material is text, this raises the question of how eye tracking can be used to make the learning process more effective when an instructor has little or no interaction with students.

This study investigates the relationships between reading intensity of paragraphs containing answers with correct responses to comprehension questions. In particular the hypothesis is that participant who answered questions correctly would spend longer in the paragraphs containing the answers. We also investigate which paragraphs of the

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text are given the most attention and then consider the difference that the types of questions have on the reading behaviour.

This paper begins with an overview of the literature on eText and eLearning environments and the use of eye tracking in these areas. The user study carried out is then described and the results are presented and discussed. We conclude with a discussion of how this research is beneficial to the development of adaptive eLearning environments that utilize eye tracking as the adaption mechanism.

2. Background

2.1. Electronic Text (eText)

Electronic text, eText, is the general term for digital presentation and storage of text. eText is read through some means of computer device, such as a computer screen, tablet, phone, eReader, etc. The advent of smartphones, tablet devices, and eReaders has meant that eText is becoming more prevalent. Initially a large amount of research went into comparing reading digital to paper based texts (see review by Dillon (1992)). Many studies are centred on the outcomes of reading, such as speed and comprehension. In general, the literature has shown that there is little evidence to support claims that one method of display is better than the other in terms of improving comprehension (Dillon and Gabbard, 1998). However, eText has advantages over paper presentation which include increased accessibility, easy storage and retrieval, ubiquity, and changeability. Changes can be simple, such as, font size, colour, or typeface or they can be more complex, such as verbalisations of the text, embedded definitions and links to background information (Anderson-Inman and Horney, 2007). The reader controls such changes; conversely, eText can be intelligently transformed by the system or the author to support learning and comprehension in several ways. Horney and Anderson-Inman (1999) produced a typology of resources for supported eText. These resources include presentational, navigational, translational, explanatory, illustrative, summarising, enrichment, instructional, notational, collaborative, and evaluation. The typology is a list of ways in which eText can be supported; they vary vastly in method and purpose. Perhaps for this reason there is no consensus on which supports, if any, should be provided and in what combinations (Anderson-Inman and Horney, 2007).

2.2. Eye Movements and Reading Comprehension

Eye tracking has long been used as an effective way to monitor the reading process. This is because the eyes move in a unique way during reading. This is characterized by frequent stopping to taking in visual information, termed a fixation, and fast ballistic movements to proceeding fixations, terms saccades. These movements occur because only a special part of the retina called the fovea sees in fine detail. The foveal region of the eye is about 0.2mm in diameter and around the point of fixation visual acuity extends only about 2° (Rayner, 1998).

When reading English, fixation duration ranges anywhere between 60-500 milliseconds but are generally about 250 milliseconds (Liversedge and Findlay, 2000). Saccades are between 1 and 15 characters with an average of 7-9 characters (Rayner, 1998). The majority of saccades are to transport the eye forward in the text when reading English; however, a proficient reader exhibits backward saccades to previously read words or lines about 10-15% of the time (Rayner, 1998). Backward saccades are termed regressions. Some regressions occur due to comprehension difficulties, as the reader tends to send their eyes back to the part of the text that caused the difficulty (Rayner, 1998). Comprehension of text can have significant effects on eye movements. Eye movements have been shown to reflect global text difficulty as well as inconsistencies within text (Rayner et al., 2006). More difficult text causes more fixations, more regressions, and longer fixation duration time.

2.3. Eye Tracking in Adaptive eLearning

Eye gaze patterns can be used to detect what kind of task the participant is performing (Iqbal and Bailey, 2004) or whether a person is reading or not (Campbell and Maglio, 2001) as well as if they are reading or skimming (Buscher et al., 2008). The use of eye tracking in adaptive learning systems (ALS) has been approached in a number of ways. An example of this is iDict, a reading aid designed to help readers of a foreign language (Hyrskykari et al., 2000).

iDict uses eye gaze to predict when a reader is having comprehension difficulties. If the user hesitates whilst reading a word then a translation of the word is provided with a dictionary meaning. Another example is The Reading Assistant (Sibert et al., 2000) that uses eye gaze to predict failure to recognize a word. The Reading Assistant then provides auditory pronunciation of the word to aid in reading. These applications work on the assumption that the user pauses on a problematic word, and then the system provides feedback about that word. They do not look at overall text comprehension or provide feedback about the overall comprehension of that text.

Separate from direct applications of eye tracking in ALSs are the investigations of eye movements within learning systems such as analysing how multiple choice questions are answered (Nugrahaningsih et al., 2013) or using eye movements to predict student performance of physics concepts when presented as text or images (Chen et al., 2014).

3. Method

A user study was conducted to collect participants' eye gaze as they read a tutorial and completed a quiz. The tutorial and quiz are coursework from a first year Computer Science course delivered at the Australian National University (ANU). The tutorial and quiz is composed of 9 screens of textual content, each covering a specific area about the main topic of the tutorial (Web Search). Each screen is 400 words long and has an average Flesch Kincaid Grade readability level of 11.5. This indicates that participants need a 12th grade education level to comfortably read the text. As the content is targeted at first year university students this is an acceptable readability level. For each screen there were two comprehension questions; one of the questions was multiple-choice and the other was cloze (fill-in-the-blanks). These two types of questions were used because they can be used to assess different forms of comprehension (Fletcher, 2006). Additionally, these questions are easily auto marked which takes into consideration use in MOOCs (Massive Open Online Courses), which is a prospective application area of this research.

The tutorial and quiz was presented to participants in four formats, labelled A, B, C and D, to measure the effect of presentation format on participants' eye gaze and answering behaviour. A between-subjects design was used; participants were shown one of the presentation formats only. For format A, the tutorial text slide (T) is first shown to participants followed by a slide with both questions and the tutorial text (Q&T). Since there are 9 topics there are 18 slides in total displayed in the study. For format B, the questions and tutorial text slide (Q&T) is shown to participants. Since there are 9 topics there are 9 slides in total displayed in the study. For format C, the tutorial slide (T) is first shown to participants followed by the questions slide (Q) but no access to the text. Since there are 9 topics there are 18 slides in total displayed in the study. Finally for format D, the slide with only the questions (Q) is displayed to participants followed by the tutorial text slide (T) and then again presenting them with the questions slide (Q). Since there are 9 topics there are 27 slides in total displayed in the study.

The tutorial text was accessible via the online learning environment used at ANU, called Wattle (a Moodle variant). The study was displayed on a 1280x1024 pixel Dell monitor. Eye gaze data was recorded at 60Hz using Seeing Machines FaceLAB 5 infrared cameras mounted at the base of the monitor. The study involved a 9-point calibration prior to data collection for each participant. As the data recorded is a series of gaze points, EyeWorks Analyze was used to pre-process the data to give fixation points. The parameters used for this were a minimum duration of 60 milliseconds and a threshold of 5 pixels.

A total of 33 participants took part in the study. All participants were enrolled in the first year Computer Science course. The marks for the quiz counted towards their course marks giving them the goal of achieving high grades on the quiz. The choice of participants is based on the target user group of the eventual online learning environment, which ais university students. The break down of participants is as follows:

Format A: There were 9 participants (2 female, 7 male) in this group with an average age of 21.3 years (standard deviation 4.7 years, range 17-31 years). English was not their first language for 4 of the participants.

Format B: There were 8 participants (1 female, 7 male) in this group with an average age of 21.8 years (standard deviation 7.9 years), age range 18-41 years. English was not the first language for 3 of the participants.

Format C: There were 9 participants (2 female, 7 male) in this group with an average age of 22.8 years (standard deviation 6.4 years, range 18-37 years). English was not the first language for 5 of the participants.

Format D: There were 7 participants (1 female, 6 male) in this with an average age of 20.1 years (standard deviation

2.8 years, range 17-24 years). English was not the first language for 3 of the participants.

3.1. Data Pre-processing

The raw eye gaze data consists of x,y-coordinates recorded at equal time samples (60Hz). Fixation and saccade identification was performed, from which other eye movement measures can be derived. In this analysis the normalized number of fixations (NNF) for the paragraphs within the text is used. Although the words per screen of text are controlled to be 400 words, the number of words in each paragraph was not controlled in the same way. The NNF is calculated by summing the number of fixations observed for a paragraph and dividing that by the number of words in the paragraph. The reason for this normalization is that if a paragraph has many more words in it than another, then participants will obviously spend longer reading it. The hypothesis is that there is a relationship between the attention participants give to the answer paragraphs and the answers they provide.

4. Results

We first investigate if there are relationships between attention given to the paragraphs that contain answers to the comprehension questions and whether the questions were answered correctly or not. We then investigate which paragraphs of the text are given the most attention. Finally, we consider the difference that the types of questions have on the NNFs within paragraphs.

4.1. Attention to Paragraphs containing Answers

Eye movements can provide, to an extent, a measure of the attention that a reader gives to certain parts of a piece of text (Liversedge & Findlay, 2000). The questions were designed so that the answers could be found in one or more specific paragraphs in the text displayed on the slide. We hypothesise that these are the paragraphs that the participants read the most and therefore to which they pay the most attention. To investigate this hypothesis, we investigate how much attention (in terms of NNF) participants gave to these paragraphs and if there is a relationship to how well they answered the respective comprehension questions. There is generally an uneven distribution of fixations on words whilst reading English (Rayner, 1998). The NNF values for normal reading behaviour are therefore expected to be less than 1. In fact, Carpenter and Just (1983) found that readers fixate on average 67.8% of words. The closer a value is to 0 indicates skimming of the text. Values above 1 correspond to more fixations than there are words in the paragraph and are indicative of re-reading of some of the text. The NNFs for the paragraphs containing the answers to the multiple-choice questions alongside the average for NNFs for all paragraphs are shown in Table 1.

Table 1. Average normalised number of fixations in paragraphs containing the answers for the multiple-choice questions.

Format	Page types	Wrong Answer	Right Answer	Answer Paragraphs Average	All Paragraphs Average
A	T Only	0.63	0.70	0.69	0.69
A	Q&T Only	0.25	0.28	0.27	0.47
B	Q&T	0.78	0.61	0.64	0.80
C	T Only	0.77	0.71	0.72	0.70
D	T Only	0.54	0.47	0.48	0.50

There is no statistical difference between the NNFs for when participants answered the multiple-choice questions correctly compared to when they answered incorrectly. There are multiple reasons for why this could be the case; for example, if a participant spends a long time reading the paragraph with the answer in it, this does not guarantee that they understand the text, and hence that they will get the answer correct.

There is a notable difference in the NNFs for the formats. Formats A *(T)* and C can be considered a baseline for the NNF observed in the answer zones. This is because in these scenarios the participants do not know what the questions are and therefore read the content without goals. Thus a NNF value of 0.7 can be considered standard;

70% of words fixated in the text agrees with the reported average value of 67.8% of words being fixated on during reading (Carpenter and Just, 1983). However, when considering A *(Q&T)* there are less than 0.3 normalized fixations, which is significantly different to format A *(T)* ($p=0<0.001$, two-sided, unpaired t-test) and format C ($p=0<0.001$). This indicates that for format A *(Q&T)*, when participants are can see the questions with the text they skim the paragraphs containing the answers to the multiple-choice questions.

Similarly, there is a lower than expected NNF observed for format D, which is significantly different to formats A and C (both $p=0<0.001$). The participants presented with this format know the questions before reading the text. It was hypothesised that the participants would skim the text to find the answers to the questions, and hence would only read those paragraphs thoroughly. However, the results do not confirm this hypothesis for the multiple-choice questions.

Interestingly, when the questions are presented with the text, participants read the paragraphs containing the answers to those questions less than average. The participants are superficially skimming the answer paragraphs for verification that they have chosen the correct answer rather than thoroughly reading all of the text.

The NNFs for the paragraphs containing the answers to the cloze questions and the average NNFs for all paragraphs are shown in Table 2. For the cloze questions it is possible to get half marks on the question so there is an additional column in this table. Note that in some cases no participants answered the cloze questions wrong or achieved half marks; this is denoted by "-".

Table 2. Average normalised number of fixations in paragraphs containing the answers for the cloze questions.

Format	Page types	Wrong Answer	Half Marks	Right Answer	Answer Paragraphs Average	All Paragraphs Average
A	T Only	-	0.34	0.75	0.74	0.69
A	Q&T Only	-	0.97	0.38	0.47	0.47
B	Q&T	0.57	1.2 *only 1 sample	0.81	0.81	0.80
C	T Only	0.91	0.69	0.84	0.82	0.70
D	T Only	0.59	-	0.82	0.64	0.50

For format A *(T)*, there are higher NNFs in the paragraphs containing the answers when the participants get the cloze question correct compared to when they answered half right ($p=0.075<0.1$). In this format participants did not know the questions before reading the text, and the differences observed reflect the participants' normal reading behaviour. This result suggests that participants who did not initially skim the paragraph are those who answered the cloze question correctly. For format A *(Q&T)* the opposite effect is observed. There are higher NNFs for the paragraphs containing the answers when participants answered the cloze half correctly compared to when the answers completely correctly ($p=0.067<0.1$). Participants who knew the correct answers to the cloze questions did not give much attention to re-reading the paragraph containing the answer.

For format C, there are higher NNFs in the paragraphs containing the answers when the participants answered the cloze questions incorrectly compared to when they answered either half correctly ($p=0.045<0.05$) or completely correctly. In this format, participants did not know the questions before or whilst reading the text, consequently the behaviour that we observe is based on their normal reading behaviour. The difference between the NNF when the answer was incorrect compared to partially correct could be explained as above, where participants believed they understood the text or simply did not care and so partially skimmed over that paragraph.

For format B, there is only one sample where a half mark was achieved. Furthermore, there are only two cases where the cloze question was answered incorrectly. Subsequently, it is difficult to make comparisons on behaviour observed between answering the questions correctly or incorrectly. Instead we can see that the overall NNF is not different to that observed for formats A *(T part)* and C but is significantly higher than that from format A *(Q&T part)* ($p=0<0.001$).

For format D, there are higher NNFs for the paragraphs containing the answers when the participants answered the cloze questions correctly compared to incorrectly, however this is not statistically significant. We hypothesize that only the regions that are deemed relevant to answering the questions are read thoroughly. Interestingly we see

that participants who answered the cloze question incorrectly are those who skimmed over the paragraphs containing the answers.

The difficulty of questions may differ in conceptual understanding and hence the outcome of answering those questions may be affected. The mean and standard deviations of the scores for the questions is shown in Table 3. The lowest mean quiz scores are found from participants who were presented with format C. This is an obvious result given that this is the format that has the highest reliance on short-term memory. A similar effect is seen for format D. There are quite low standard deviations of scores for questions. This indicates that the difficulty of the questions was relatively similar.

Table 3. Mean scores obtained for the multiple choice questions, cloze questions and overall mean for all questions.

Format	Mean Score for Multiple Choice Question	Mean Score Cloze Question	Mean Score for all questions
A	0.81±0.11	0.98±0.03	0.90±0.12
B	0.83±0.17	0.97±0.06	0.90±0.14
C	0.77±0.25	0.54±0.17	0.65±0.24
D	0.89±0.16	0.68±0.21	0.79±0.21

4.2. Paragraphs given the Most Attention

We now consider the NNFs for each of the paragraphs in the text. As mentioned earlier, the answers to the comprehension questions are located in one or more of the paragraphs in the text. We calculate the paragraphs that have the highest NNFs for each format (Table 4). There are asterisks (*) next to the entries where the paragraph with the highest NNF is an answer paragraph. A hash (#) next to an entry indicates that the paragraph is an end paragraph.

Table 4. Paragraphs that have the highest normalized number of fixations for each format.

	A (T)		A (Q&T)		B (Q&T)		C (T; Q)		D (Q; T; Q)	
Tutorial Page	Paragraph Number	Mean NNF	Paragraph Number	Mean NNF	Paragraph Number	Mean NNF	Paragraph Number	Mean NNF	Paragraph Number	Mean NNF
1	1	0.73	2	2.27	2	2.70	1	0.85	5*#	0.67
2	3#	0.91	2	1.23	2	1.55	3#	0.77	3#	0.52
3	6*#	0.43	2	0.78	1	2.04	6*#	0.45	6*#	0.87
4	4*#	0.40	2	4.36	2	3.02	1*	0.47	4*#	0.75
5	1*	0.47	2	1.42	2	2.46	1*	0.72	1*	0.56
6	1*	0.89	2	1.68	2	1.38	1*	1.16	1*	0.64
7	4#	0.40	2	1.39	2	1.77	4#	0.48	1*	0.38
8	1	0.56	2	2.07	2	1.84	1	0.63	1	0.45
9	1*	0.48	2	1.90	2	2.05	1*	0.56	3*#	0.70
Average		0.59		1.90		2.09		0.68		0.62

Firstly, what we observe is that for formats A *(Q&T)* and B the paragraphs with the highest NNFs are, in all but one case, the cloze questions. In the one case where the cloze question does not have the highest number of fixations it is the multiple-choice question. For formats A *(Q&T)* and B, the participants give the most attention to the questions themselves as opposed to the text. On average, the normalized numbers of fixations for these formats are both indicative of participants fixating on the words within the cloze questions twice which is considerably higher than the normal reading value of 0.7 that we found for the text in the above analysis.

Importantly, the results show that it is not always the case that the paragraphs containing the answers were read the most. This is not unexpected for formats A and C as the participants do not know the comprehension questions before or whilst reading the text. For formats where only text is presented to the participant the paragraphs with the highest number of fixations are always the first and last paragraphs. Not once does an internal paragraph have the highest NNF. Given that the majority of the time at least part of the answers to the comprehension questions is located in either the first or last paragraph this means that participants are reading that part of the text, but this seems at least partly due to the location of the paragraphs rather than their content.

4.3. Comparison of Multiple-Choice and Cloze Questions

The differences in the NNFs recorded in the paragraphs containing the answers for each of the multiple-choice and the cloze questions are notable. For formats A *(Q&T)*, B and D there are a significantly higher normalized numbers of fixations recorded in the paragraphs containing the answers to the cloze questions compared to the multiple-choice questions ($p=0.025<0.05$, $p=0.005<0.01$, and $p=0.002<0.01$, respectively). Additionally, for formats A *(Q&T)* and B, the paragraphs with the highest NNF are, in all but one case, the cloze questions. The cloze questions attract more attention, and hence more fixations than the multiple-choice questions.

We conclude from this that to answer the cloze questions, participants needed to read the paragraphs containing the answer more thoroughly than for answering the multiple-choice questions. Several explanations could account for this difference; the cloze format questions require participants to answer with words or phrases which may be harder to do than picking between options in the multiple-choice questions. The important point in the context of designing educational material is that to promote reading of the textual content, and cloze questions promote this more than asking multiple-choice questions.

5. Use in Adaptive eLearning

In this study, normal reading of the text produced NNFs around 0.7; in other words 70% of words are fixated. This is expected as previous research has found that 67.8% of words are fixated during reading (Carpenter and Just, 1983). Higher values for this measure indicate the participants require more fixations to read text, either because they deem it important enough to re-read or because they are suffering from comprehension difficulties. Below this value, the participants are probably skimming the text and deem it less important to re-read. As shown in Table 4, the paragraphs at the beginning and end of each text have the highest NNFs. This normalized fixations measure can show other factors relating to the text as well, for example if higher than expected ratios are observed for parts of the text then it could be that the piece of text is difficult to read. This is also useful information for editors of learning material as they should make sure their content is well suited to their audience and most importantly, comprehensible. Information about reading behaviour can be used to make text easier to understand or more interesting to read, to try to decrease the likelihood that students will skim over important concepts.

An adaptive eLearning system using embedded eye tracking could detect whether the student has skimmed over key paragraphs of text and dynamically incorporate into future displays another exposition of that concept so that it is re-iterated to them. Alternatively, if the tracking system detects that the student has thoroughly read the area of text explaining the concept, yet they perform poorly on assessment of the concept, the learning system can give the student remedial help via explanations of the concept in simpler terms.

There are several implications for the design of effective eLearning material of the finding that participants read the first or last paragraphs of text the most thoroughly. First is that the authors of learning material can exploit this phenomenon to ensure that students read important concepts. That is, authors can include important concepts in the first and last paragraphs of learning material text so as to ensure that students are more likely to read that text. Secondly, if an author wants to conversely make students read all of the content then they should only include the key concepts in the central parts of the text. This will imply that students have to read the internal paragraphs in order to understand the text and also to answer the comprehension questions effectively.

6. Conclusion and Further Work

When analysing how much attention, as defined by the normalized of number of fixations, a participant gives to paragraphs containing the answers to the comprehension questions, we found that there is no difference between the attention observed when a participant answered a multiple-choice question correctly or incorrectly. The participants were students enrolled in the course that the tutorial and quiz was taken from so the marks for the quiz did count towards their course marks. The participants were therefore reading with the goal of achieving high marks on the quiz. However, we found that there was a difference in the NNF observed when a participant answered a cloze question correctly or incorrectly. The different formats of presentation have an effect on how participants identify paragraphs containing answers as well as how much attention is given to them.

Additionally, we assessed which paragraphs were given the most attention on each tutorial page. For formats where only text is shown to the participants, only the first or last paragraphs of the text had the highest NNF. For formats where questions and text are presented together, in all but one case the cloze question had the highest NNF. Furthermore, we found cloze questions induce more attention given to paragraphs containing the answer compared to multiple-choice questions. When designing text based learning material this can be used as a way of implicitly making students read the learning content.

A limitation of this study is that a relatively small sample size was used, though we found statistically significant results. It would be beneficial to run this experiment will a greater number of student participants so that the results can be more generalized. Furthermore, there are only two types of questions that are investigated in this analysis, being multiple choice and cloze questions. For very large on-line courses such as MOOCs, multiple choice and cloze questions are among the most useful, being most easily amenable to automated marking. Nevertheless, further research should include investigating the effect other question types have on participants' observed reading behaviours.

The implications of this research can be used in the design of adaptive eLearning environments to monitor the attention given to parts of the learning material and to dynamically alter the text shown to students based on their attention.

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References

1. Anderson-Inman, L, Horney, MA, Supported eText: Assistive Technology Through Text Transformations. Reading Research Quarterly 2007; **42**:153-160.
2. Buscher, G., Dengel, A., Elst, L. V. Eye Movements As Implicit Relevance Feedback. Chi '08 Extended Abstracts On Human Factors In Computing Systems. Florence, Italy: ACM 2008;2991-2996.
3. Campbell, CS, Maglio, PP, A Robust Algorithm For Reading Detection. Proceedings Of The 2001 Workshop On Perceptive User Interfaces, ACM. 2001;1-7.
4. Carpenter, P. A. & Just, M. A. What your eyes do while your mind is reading. Eye movements in reading: Perceptual and language processes, 1983;275-307.
5. Chen, S-C, She, H-C, Chuang, M-H, Wu, J-Y, Tsai, J-L, Jung, T-P, Eye Movements Predict Students' Computer-Based Assessment Performance Of Physics Concepts In Different Presentation Modalities. Computers & Education, 2014;**74**;61-72.
6. Dillon, A. Reading From Paper Versus Screens: A Critical Review Of The Empirical Literature. Ergonomics, 1992;**35**:1297-1326.
7. Dillon, A, Gabbard, R Hypermedia As An Educational Technology: A Review Of The Quantitative Research Literature On Learner Comprehension, Control, And Style. Review Of Educational Research, 1998;**68**:322-349.
8. Fletcher, JM, Measuring Reading Comprehension. Scientific Studies Of Reading, 2006;**10;**323-330.
9. Horney, MA, Anderson-Inman, L, Supported Text In Electronic Reading Environments. Reading & Writing Quarterly, 1999;**15:**127-168.
10. Hyona, J, Lorch Jr, RF, Rinck, M, Chapter 16 - Eye Movement Measures To Study Global Text Processing. In: The Mind's Eye. Amsterdam: North-Holland. 2003.
11. Hyrskykari, A, Majaranta, P, Aaltonen, A, Räihä, K-J, Design Issues Of Idict: A Gaze-Assisted Translation Aid. Proceedings Of The 2000 Symposium On Eye Tracking Research & Applications, ACM, 2000;9-14.
12. Iqbal, ST, Bailey, BP, Using Eye Gaze Patterns To Identify User Tasks. The Grace Hopper Celebration Of Women In Computing 2004.
13. Liversedge, SP, Findlay, JM Saccadic Eye Movements And Cognition. Trends In Cognitive Sciences, 200;**4:**6-14.
14. Nugrahaningsih, N, Porta, M, Ricotti, S, Gaze Behavior Analysis In Multiple-Answer Tests: An Eye Tracking Investigation. Information Technology Based Higher Education And Training (ITHET), 2013 International Conference On, 2013. IEEE, 2000;1-6.
15. Rayner, K. Eye Movements In Reading And Information Processing: 20 Years Of Research. Psychological Bulletin, 1988;**124(3)**:372-422.
16. Rayner, K, Chace, KH, Slattery, TJ, Ashby, J, 2006. Eye Movements As Reflections Of Comprehension Processes In Reading. Scientific Studies Of Reading, 1998;**10**:241-255.
17. Sibert, JL, Gokturk, M,Lavine, RA, The Reading Assistant: Eye Gaze Triggered Auditory Prompting For Reading Remediation. Proceedings Of The 13th Annual ACM Symposium On User Interface Software And Technology. San Diego, California, United States: ACM. 2000;101-107