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Eye Dominance and Reading Speed

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Purpose: The aim of this study was to investigate eye dominance and reading performance based on eye movements and reading speed. **Methods:** The eye dominance of 30 subjects was determined using the sighting test (hole formed by hands). The subjects were asked to read the numerical reading material aloud in English from left to right and from right to left at random. The number of saccades, regressions, and inter-fixations per minute was calculated using Visual-Oculography (VOG) and the reading speed was recorded as number of characters per minute using stopwatch. **Results:** No significant differences in reading speed among right and left eye dominant subjects as they read from left to right and right to left directions ($p>0.05$). However, left eye dominant subjects were found to read significantly faster compared to right eye dominant subjects in both directions of reading ($p<0.05$). In term of eye movement patterns, no significant differences in saccades, regressions, and inter-fixations per minute were found between subjects with right eye dominance and left eye dominance for both reading directions ($p>0.05$). **Conclusions:** Reading performance in term of eye movement and speed was not affected by eye dominance, but subjects with left eye dominance read faster than subjects with right eye dominance.

Key words: Eye dominance, eye movement, reading speed

Introduction

Eye or ocular dominance is the superiority of one eye whose visual function is predominating over the other[1] or the tendency to prefervisual input from one eye over the other[2-3]. Ocular dominance has been related to eye movement[4-5] or binocular rivalry[6-7],and was reported to be important in the control of reading[8].Approximately two thirds of the population is right-eye dominant and one third left-eye dominant; however in a small portion of the population neither eye is dominant[9-10].

Reading is a combination of visual detection, eye movements, and comprehension[11]. A number of fine tuned eye movements are involved during reading such as saccades, return-sweep saccades, regressions, and fixations[11]. Saccades are the fastest eye movement, occur when eyes move from one fixation to another during reading[11]. Regressions typically reflect some text confusion or comprehension problem and a recheck process[11]. Fixations occur when eye stops or pauses during reading[11]. About 10% ~ 15% of the saccades during reading in English are regressions[12]. Regressions tend to happen due to the reader making too long saccade; which short saccade to the left might make reading to proceed efficiently, problem in processing the currently fixated word (short within-word regressive saccade), and difficulty in understanding the text (longer regressions). Reading speed is a number of words that can be read at a certain time and was measured in words per minutes. By comparing the measurement of speed readers and normal readers based on reading comprehension, the speed readers are actually not reading every word but only skimming the text[13]. Several factors such as character size, font, contrast, letters spacing, and linguistic might influence reading performance. Reading rate increases as the letter size increases[14-15]. The maximum reading speed for the normal subjects are 5% faster with the Times font compared with the Courier font[16]. Reading performance is better with black on white text than any other color com-

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bination[17]. Luminance contrast is more important in determining reading speed than color itself. Reading speed increases with letter spacing and reaches the maximum as it is near to the standard letter spacing[15]. There is difference in reading performance between first language and second language text.

Dominant eye is functionally activated prior to the non-dominant eye following a horizontal saccade during reading[18]. Inputs from the dominant eye might be more sensitive, responsive and/or might capture attention more readily, leading to a more noticeable or important percept. For the normal population, the sighting-dominant eye does not have any special role for visual or oculomotor processes except for being the 'preferred' eye in some viewing situations[19]. No consistent effects of eye dominance or single eye superiority was found by Gates and Bond[20] in acuity, in relation to reading achievement, word pronunciation, reversal errors, or visual perception of various items. Gates and Bond performed the handedness, eye dominance, and visual acuity test in 4 groups of children which included retarded children, normal children, first grade pupils studied repeatedly during the year, and first grade pupils studied during the first half of the year. However, research done by Maples[21] revealed interesting results in the relationship between eye dominance and reading performance. Maples used Iowa Test of Basic Skills(Iowa) and the Visual Motor of Integration Test(VMI) and Wold Sentence Copy Test(Wold) in order to compare eye dominance with performance on reading[21]. The Iowa is a standardized academic test which was adopted by the Tahlequah Public School system as their standard measure of school achievement[21]. The VMI is a paper and pencil test which consists of series of 24 symbols which are reproduced by child[21]. The Wold was also a visual-motor test where the child was asked to copy a standard sentence[21]. The score was a number of correct symbols per minute[21]. By using Iowa test, no significant difference in total reading performance was found for the factor of eye[21]. But, for VMI and Wold test, right eyed subjects did significantly better than did the left eyed subjects[21].

The reading performance among right eye dominance and left eye dominance subjects during reading from left to right and from right to left directions were investigated in this study. The relationship between eye dominance and reading speed in subjects with right eye dominance and left eye dominance when read from left to right and right to left directions were analyzed.

Methods

This cross sectional experimental study was conducted in UiTM Optometry Clinic, Faculty of Health Sciences at UiTM Puncak Alam Campus. Thirty subjects (6 males, 24 females) participated in this study; fifteen subjects with right eye dominance and fifteen subjects with left eye dominance. The inclusion criteria was ability to read the text at 40 cm working distance, aged below 40 years old, in good health condition and not under any medication that might cause loss of attention throughout the measurement procedure.

To determine eye dominance, subject was asked to sight the examiner nose through the hole formed by two hands[21]. Subject was asked to extend both hands to arm's length, and put both hands together to make a small triangle between thumbs and the first knuckle on each hand. The triangle should be roughly 2-3 cm on each side. With both eyes open, subject was asked to look through the triangle and center the examiner's nose in the triangle. Examiner was standing at a distance of 1-1.5 m directly in front of the subject. Then, subject was asked to close the left eye. If the object remained in view, subject was right eye dominant. If the object was not within the triangle, the subject was left eye dominant.

The reading material (Appendix I) in numerical format was read in English. It contained randomly arranged numerical from number one to number nine. The total numbers was 289(17×17 numbers). The numbers were typed using Times New Roman font style with N12 font size. The reading material was printed with black numbers on white background of A4 sheet paper. Subject was reminded to read as naturally as possible. The time for the subject to complete the reading material from left to right and left to right was recorded respectively. The stopwatch was used to record the time taken by the subjects while reading the numerical reading material from left to right or from right to left directions. The reading speed was recorded as numbers per minute (npm). Video Oculo-graphy (VOG) Sensomotoric Instrument Version 5 was used to automatically record the eye movement pattern of the subject while the subject was reading the text. The numbers of saccadic, regression and inter-fixation were analyzed too.

Results

Based on the normality test, the parametric test could be used to analyze the data. No significant differences in reading speed among right and left eye dominant subjects as they read from left to right and right to left directions (Table 1). However, left eye dominant subjects were found to read significantly faster compared to right eye dominant subjects in both directions of reading (Table 2). The comparison of the total counts per minute in saccades, regressions, and inter-fixations was summarized in Table 3.

Discussion

In our study, eye dominance does not display differences in reading speed for two different direction of presentation (from right to left or left to right). However, subjects with left eye dominance were found to read significantly faster in both presentations of reading materials. Results from this study are supported by two previous studies[19-20]. Mapp *et al*.[19] suggested that the sighting-dominant eye did not have any special role for visual or oculomotor processes for the normal population. Eye dominance only affected the eye that would be preferred for performing a monocular task, but had no effect in performing binocular task. On the other hand, no consistent effects of eye dominance or single eye superiority was found by Gates & Bond[20] in term of acuity, relation of reading achievement, word pronunciation, reversal errors, or visual perception of various items. However, our findings are inconsistent with Maples[19]. In his study, Maples showed that for both visual motor tests which were VMI and Wold, the right

Table 1. Comparisons of reading speed between reading from left to right and reading from right to left in subjects with different eye dominance

Variables	Reading from left to right direction (numbers per minute)	Reading from right to left direction (numbers per minute)	t-stats	P value
Subject with right eye dominant	138.67 (22.65)	138.72 (13.71)	−0.01	0.99
Subject with left eye dominant	163.39 (38.51)	161.09 (35.52)	0.41	0.69

Table 2. Comparisons of reading speed between subjects with right eye dominance and left eye dominance

Variable	Subject with right eye dominant	Subject with left eye dominant	t-stats	P-value
Reading from left to right direction (numbers per minute)	138.67 (22.65)	163.39(38.51)	−2.14	0.04
Reading from right to left direction (numbers per minute)	138.72 (13.71)	161.09 (35.52)	−2.28	0.03

Table 3. Comparison of eye movement patterns between subjects with right eye dominance and left eye dominance

Variables	Subject with right eye dominant	Subject with left eye dominant	t-stats	p-value
Reading left to right direction (total counts per minute)				
Saccades	122.99(24.63)	138.31(31.39)	−1.49	0.15
Regressions	12.98 (3.32)	15.08(3.24)	−1.76	0.09
Inter-fixations	122.99(24.63)	138.92(30.76)	−1.57	0.13
Reading right to left direction (eye movements per minute)				
Saccades	123.25(17.92)	134.33(38.16)	−1.02	0.32
Regressions	13.35 (3.46)	13.76 (3.49)	−0.32	0.75
Inter-fixations	123.25(17.92)	135.61(37.29)	−1.16	0.26

eyed individuals performed significantly faster compared to left eyed individuals. Maples claimed that the poor performance of left handed, left eyed individual and cross-dominant individual might due to mechanical or ergonomic factors like paper or book placement, lighting, pencil grip and sitting arrangement in the classroom. For the factor of cerebral dominance, Maples claimed that it might play a minor or even insignificant role in lowered scores on both visual motor tests in those groups because the neurology of the eye was not like hand since no complete decussating of its nerve fibers were present. The efference from one eye is projected to both right and left hemispheres and the efference that originates from different hemispheres are supplied to the muscles of one eye. The brain is not lateralized for the eyes. The inconsistent of the results between present study and study done by Maples might be due to difference in target groups and the methodology of the study. Maples used visual-motor tests in measuring the reading speed and the total numbers of the subjects were 540 subjects, who were among the first through fifth grades students.

Even though subjects with left eye dominance read the reading materials significantly faster than subjects with right eye dominance, no significant difference was found in term of eye movement patterns between those two groups of eye dominance. However, Kallmark[11] reported that differences in speed of reading were reflected in the eye movement patterns. Slower reading speed was associated with statistically longer, higher number of saccades per word, shorter saccades per amplitudes and even more regressions. But, there is no statistically significant difference in eye movement patterns in our study between right eye dominant and left eye dominant subjects even though the speed of reading for left eye dominant subjects is significantly faster compared to right eye dominant subjects. One possible explanation of our eye movement findings is due to the reading materials that are consisted of numbers instead of text as well as single number display. Our study might also suggest that other factors might affect the reading speed instead of eye movement patterns.

Future research might look into different age groups, different contrast of the reading materials, different working distances, and different size of the font used in the text and others.

Conclusions

Reading speed is not affected by eye dominance, but subjects with left eye dominance read faster than subjects with right eye dominance.

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APPENDIX I

Reading Material

1	6	4	9	2	7	3	8	5	7	1	3	5	8	2	7	6
6	2	9	4	8	5	7	2	9	1	5	4	3	9	6	2	4
2	5	8	1	3	7	9	4	5	2	7	1	9	2	4	7	3
4	8	3	6	9	2	7	1	9	3	8	2	4	1	6	3	8
3	5	7	9	2	8	4	6	1	7	4	9	5	3	8	1	4
5	9	1	8	3	7	2	4	9	1	8	2	7	3	6	8	5
7	2	9	1	5	3	4	6	8	2	7	3	8	5	2	7	1
9	4	5	3	1	6	8	7	2	9	5	1	7	2	9	4	3
8	2	4	6	5	7	9	3	1	8	6	2	4	1	5	8	7
1	9	2	7	3	8	4	6	5	2	1	3	9	5	2	7	3
3	5	8	1	2	7	9	4	2	5	7	1	8	2	4	3	1
7	3	9	4	6	5	2	1	3	9	5	2	7	3	5	6	9
8	1	3	7	9	4	5	2	7	1	9	4	2	7	3	8	6
9	3	1	8	6	2	4	1	5	8	7	9	8	1	4	9	2
7	2	8	5	3	7	2	9	4	1	6	8	2	5	3	1	6
3	4	6	9	1	4	3	8	5	2	7	1	9	4	6	9	4
4	2	3	8	5	1	7	9	6	4	5	7	1	8	2	7	3