



THE PARAMETERS OF SACCADIC EYE MOVEMENTS IN READING AND DOT SCANNING TASKS

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Introduction

Saccades are rapid voluntary eye movements that transfer gaze from one fixation point to another. [1] After processing the sensorial information saccades are generated by the *superior colliculus*, frontal eye fields and other brain structures. [2] Previous studies show that saccade generation can also be influenced by internal processes, for example, supplementary eye field is partially responsible for making acquired sequences of saccades. [1] This shows that saccade generation can also be performed automatically.

Reading is an automatic process has been described by both: vision scientists and psychologists. As a proof of the automaticity psychologists and vision scientists have described the Stroop effect.

Psychologists have also studied the ability to perform a parallel task to reading that is connected with the grammar of the text. And the results show that words are being perceived as a unity, and are not analyzed as a group of letters. [3]

There are two main models that describe the reading process and decision making of gaze transfer to next following position. The first of them is E-Z reader model supporting that a decision to make a saccade to the word n+1 is made after processing the lexical and semantic information of the word n. The SWIFT model supporting that parallel processing can be observed during reading. The saccades are generated automatically with occasional cognitive influence. [4]

The aim of the study is to determine, whether reading in Latvian with statistic significance can be described as an automatic process and to determine whether the average gaze transferring data of one person change during repeated tasks.

The tasks of the study are to:

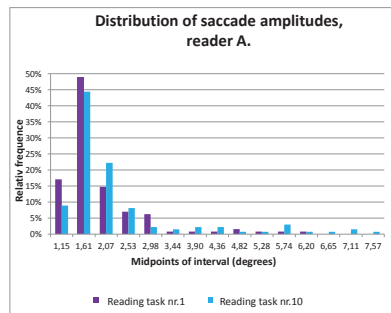
- Compare the distributions of saccade amplitudes in reading and free scanning of dots;
- Compare the statistical data of the dot's scanning and reading tasks;
- Analysis the dispersions of saccade amplitude distributions during repeated reading task;
- Compare average fixation amplitudes in repeated reading task.

Comparison between mean gaze amplitudes and dispersions in ten succeeding reading tasks

We have made 45 Fisher tests of each reader. Statistically essential differences between gaze amplitude dispersions were obtained in 64% of the tests for reader A and in 40% for reader B. In case of different dispersions t-tests of different dispersions were applied, in other cases t-tests of equal dispersions were used. During analysis of mean amplitudes we have obtained, that in case of reader A there are statistically differences between mean amplitudes in 11% of cases (total number 45), and in 16% of cases for reader B.

We have shown, that during successive reading number of saccadic regressions is diminishing. It means that cognitive load during the tasks is decreasing, however relative stability of gaze transfer is maintained. This maintenance of mean amplitude of saccades is confirming automatic reading. At the same time individual differences between reader habits must be taken in mind.

Number of task	Reader, A		Reader, B	
	Mean amplitude	SD	Mean amplitude	SD
1	1,71	0,87	1,72	0,64
2	1,96	1,26	1,77	0,69
3	1,87	1,11	1,67	0,57
4	1,89	1,14	1,79	0,71
5	1,82	0,90	1,89	0,67
6	1,93	1,41	1,86	0,73
7	1,82	1,06	1,74	0,67
8	1,93	1,07	1,79	0,63
9	1,93	0,95	1,77	0,78
10	2,09	1,39	1,86	0,79
Mean in all tasks	1,90		1,79	



Participants

Nine volunteers (20 to 25 years) participated in the experiments. All had normal vision without correction. All of the participants were native Latvian speakers.

Apparatus

Gaze parameters were recorded by the iViewX Hi-Speed 240 IR device.

Experimental design

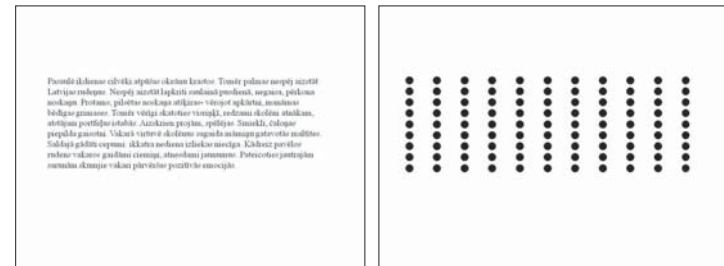
Reading text was artificially constructed of words that all were 6-8 symbols long and hence located approximately 2° from each other (when reading in Latvian, the saccades are on average 6-8 characters long). The text consisted of 9 lines with 8-10 words per line.

Dots for scanning task were made of 0.5° wide black circles, 2° apart each other

Data analysis

The Behavioral and Gaze Analysis (BeGaze) software was used. Software divided experimental participants' gazes in saccades and fixations between them. The number of saccades in each gaze analysis depends on gaze peak velocity threshold (between 25-30°/s, depending on the participants individual reading characteristics).

To analyze distribution of the saccade amplitudes, only the successive saccades were taken into count. Statistical analysis if the data was performed by Microsoft Excel. The Sturge's rule was used to determine the histogram interval in the analysis of the distribution of the saccade amplitudes. Fisher's and t-test were used to statistically compare the distributions.



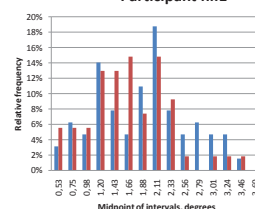
Subject	Scanning dots		Reading text	
	Average saccade amplitude (degrees)	SD	Average fixation duration (ms)	SD
1	354.8	167.1	270.2	113.4
2	316.5	161.2	209.0	91.4
3	228.0	86.7	201.4	72.8
4	290.7	157.7	161.8	96.3
5	249.9	174.3	178.0	92.4
6	322.2	207.8	225.6	104.4
7	292.1	136.4	229.9	184.4
8	335.5	194.3	230.9	81.5
9	319.5	199.7	213.7	102.0

Comparison of the distribution of the saccade amplitudes

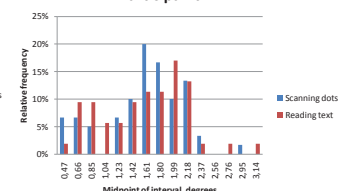
Results show that in dots' scanning task where the observer is required to make equally big saccades, the participants also make saccades that are smaller and larger- similarly to reading text. Fisher and t-test, comparing the two distributions do not always show that the distributions are equal. Result confirms that reading and dots' scanning tasks are individual cognitive processes and are being perceived individually by the observer depending on the previous experiences of the observer.

In dots' scanning task fixation amplitudes are on average 90ms longer than in reading task. The result shows that during the automatic scanning of the dots' the participants make longer saccades to get the semantic meaning of the stimuli.

Saccade amplitude distribution Participant nr.1



Saccade amplitude's distribution Participant nr. 2



Conclusions

In a task, where it is necessary to make successive horizontal saccades, the brain perceives it as a reading task and transfers gaze automatically and similarly to reading. Reading and dots' scanning task are individual cognitive processes. The dots' scanning task does not require any semantic processing of the data, but because of the automaticity of the process, the fixations are longer than in reading text: in the scanning task there is lack of lexical information and observer maintains a longer fixation, in order to get more information.

Repeatedly reading the same text, the main characteristics of the saccades change slightly, but it can be observed, that because the text is well known, more information is being processed in parallel and the process becomes more automatic.

References

1. R. John Leigh, David S Zee (2006) The Neurology of Eye Movements Fourth Edition. New York- Oxford University Press, p 108, 292.
2. K.J.Ciuffreda, B.Tannen, (1995) Eye Movement Basics for the Clinician, New York: Mosby, 266.p
3. Stephen K. Reed, Cognition (1996), Theory and Applications, Brooks/Cole Publishing Company,p 69-70.
4. Keith Rayner, (2009), Eye Movements in reading: Models and Data Journal of Eye Movement Research, 2(5):2, 1-10.