Key eye movement measures in Russian-Chinese and Chinese-Russian bilingual reading

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INTRODUCTION

There is a wealth of research devoted to measuring the eye movements during L1 and L2 reading, however, to this day there has been little research in the domain of Russian-Chinese and Chinese-Russian bilingual reading. Undoubtedly, there are a few key differences between the languages and their writing systems that make studying this language pair a topic of particular interest.

The most striking of them is the fact that two languages employ two different writing systems dissimilar in terms of mapping principle and informational density. An alphabetic system is used to write down Russian texts, and a logographic system is used to write down Chinese texts. However, Russian alphabet is different in its orthography to the English one and that could help reduce effects of early exposure to an alphabetic writing system (Latin-based Pinyin) on reading performance in Chinese bilinguals.

The goal of this study is to provide a description of eye movement measures of late artificial bilinguals at different language proficiency levels. For that, I set up an eye-tracking experiment aimed at eliciting information on basic characteristics of eye movements (mean fixation duration, mean progressive saccade length, mean regressive saccade length, frequency of regressive saccades) during L2 reading.

METHOD AND PROCEDURE

Participants

Thirty-one unbalanced Russian-Chinese and twenty-eight unbalanced Chinese-Russian bilinguals from Tomsk State University took part in the experiment. All of the participants were naïve as to the purpose of the experiment, and had normal or corrected-to-normal vision.

Pre-test

During the pre-test stage participants filled out a Language Experience and Proficiency Questionnaire (LEAP-Q), and took a foreign language proficiency test comprised of texts of four difficulties (A2-C1). Each test consisted of 26 multiple choice questions, and participants could get a maximum of 68 points.

Procedure

The participants read 25 texts in Russian and 25 texts in Chinese (one text in each block was assigned to a test trial). The texts were selected from HSK (Chinese Standard Exam) and TORFL (Test of Russian as a Foreign Language) test materials. Thirteen texts were considered to be of low difficulty (B1), twelve texts were considered to be of high difficulty (B2). First, participants read all texts in one language, then, after a short break, they read all texts in another language. The order of blocks was counterbalanced within groups. Within language blocks the texts were randomised in such a way that no 4 texts of the same difficulty appeared in a row. The participants were encouraged to take breaks every three trials. Each block was preceded with a calibration procedure. There were two yes/no questions after each trial to prevent participants from engaging in mindless reading.

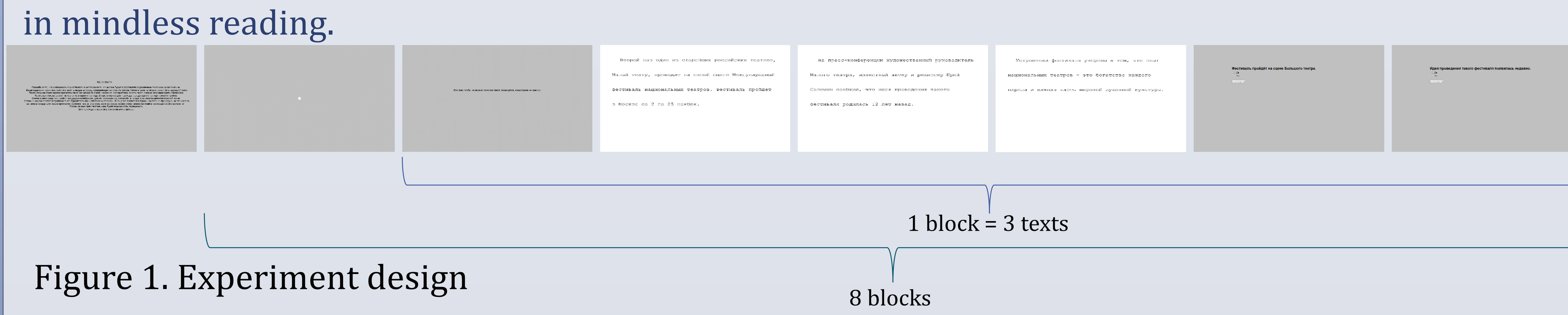

Figure 1. Experiment design

Apparatus

The eye movement data was recorded with an SMI RED 500 remote eye tracking system with a sampling rate of 500 Hz. A chinrest was used to reduce head movements. All texts were presented at a viewing distance of 65 cm on a white background. The Chinese texts were presented in black 20 point SimSun, each character subtended 0.81 degree of visual angle. The Russian texts were presented in black 24 point Courier New font, each character subtended 0.64 degree of visual angle.

RESULTS

The key eye movement measures are presented in the table 1.

Native language/ Stimulus language	Average fixation duration (ms)	Average progressive saccade length (character spaces)	Average regressive saccade length (character spaces)	Regressive saccade percentage	Comprehension rate (%)
Russian/Russian	187,36 (SD = 64,46)	7,07 (SD = 3,38)	3,91 (SD = 2,92)	22	2 correct – 76.4 1 correct – 22.1
Russian/Chinese	338 (SD = 204.7)	0.85 (SD = 1,03)	1.14 (SD = 1.11)	27	2 correct – 56.3 1 correct – 40
Chinese/Chinese	189,7 (SD = 73,25)	3 (SD = 2,43)	2,3 (SD = 2,1)	24	2 correct – 86 1 correct – 13.9
Chinese/Russian	246,9 (SD = 112,16)	4,99 (SD = 3,23)	3,27 (SD = 2,62)	29	2 correct – 65.2 1 correct – 28.9

Table 1. Key eye-movement measures

Linear mixed-effects model ('lmer' function in 'lme4' package for R) was used for the analyses. Two random effects were entered into the bilingual models: the participants and the texts being read. The main fixed factors for the models were pre-test score and text difficulty, two additional fixed effects included in the design of the experiment (number of correct responses to the text being read and the order of languages) were also taken into consideration. A separate model was created for each of the eye movement measures: average fixation duration, progressive saccade length, regressive saccade length, frequency of progressive saccades.

Reading Chinese texts

There was a statistically significant effect of pre-test score (χ^2 = 5,49, df = 1, p < 0,05), text difficulty (χ^2 = 15,94, df = 1, p < 0,001) and number of correct answers (χ^2 = 7,58, df = 2, p < 0,05) on the average fixation duration. The language order factor was found to be not significant (χ^2 = 2,85, df =1, p < 0,1). Every pre-test point decreased the average fixation duration by 2.45 ms (b = -0,006, t = -2,34, se = 0,002). The increase in text difficultty yielded a 17.1 ms increase in the average fixation duration (b = 0,043, t = 3,99, se = 0,01). One correct response increased the average fixation duration by 27.7 ms (b = 0,069, t = 2,17, se = 0,031), two correct responses increased the average fixation duration by 33.7 ms (b = 0,083, t = 2,63, se = 0,031).

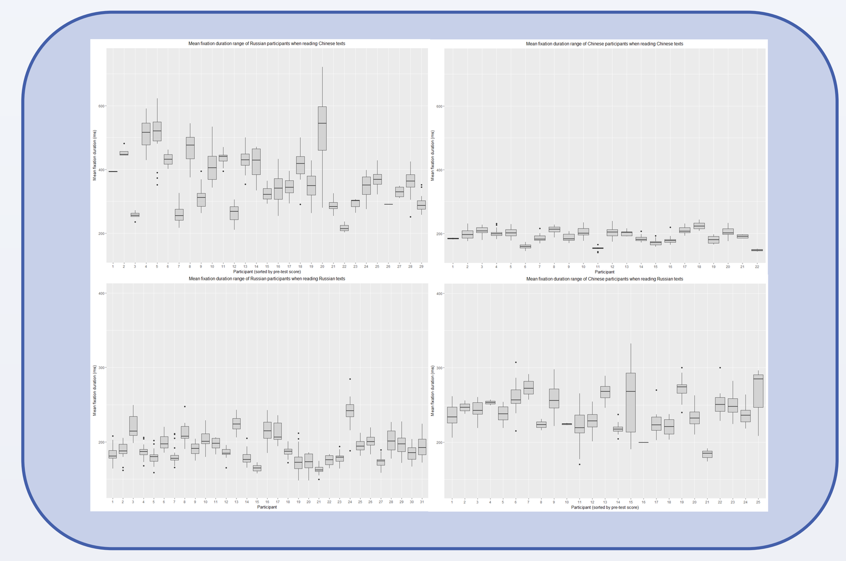

Figure 2. Average fixation duration across participants

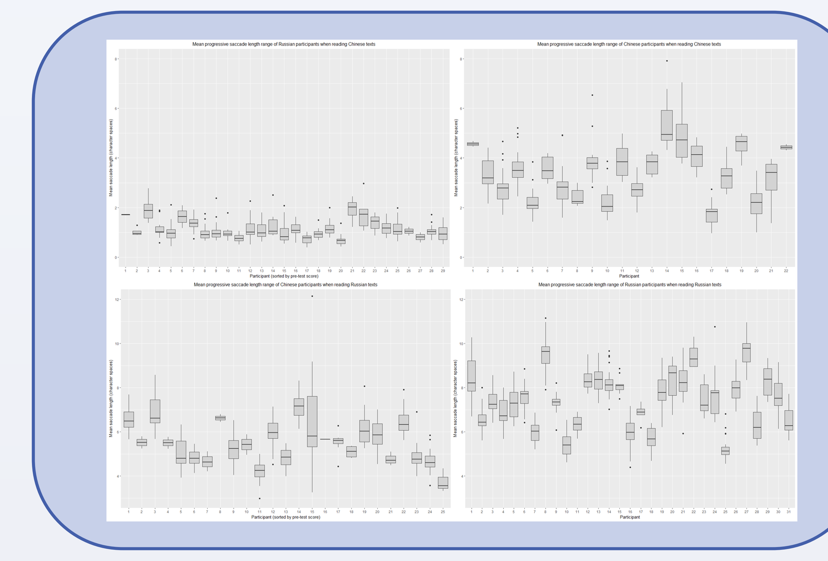

Figure 3. Average progressive saccade length across participants

There was no main effect of pre-test score, text difficulty, number of correct responses and language order on average progressive saccade length, regressive saccade length and frequency of progressive saccades.

The effects of pre-test score on the measures were as follows: progressive saccade length (χ^2 = 1,82, df = 1, p = 0,18), regressive saccade length (χ^2 = 0,8, df = 1, p = 0,37), progressive saccade frequency (χ^2 = 1,25, df = 1, p = 0,26).

The effects of text difficulty were as follows: progressive saccade length (χ^2 = 0,37, df = 1, p = 0,54), regressive saccade length (χ^2 = 1,31, df = 1, p = 0,25), progressive saccade frequency (χ^2 = 0,07, df = 1, p = 0,79).

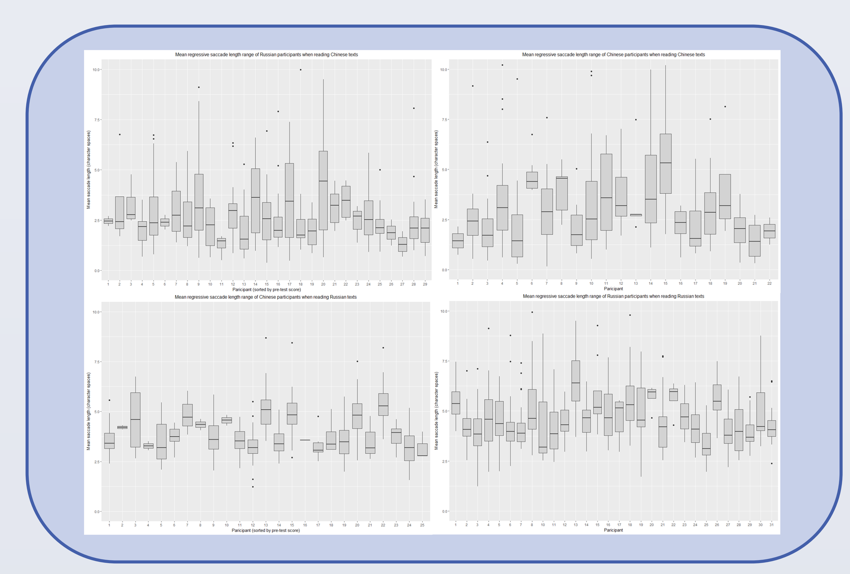

Figure 4. Average regressive saccade length across participants

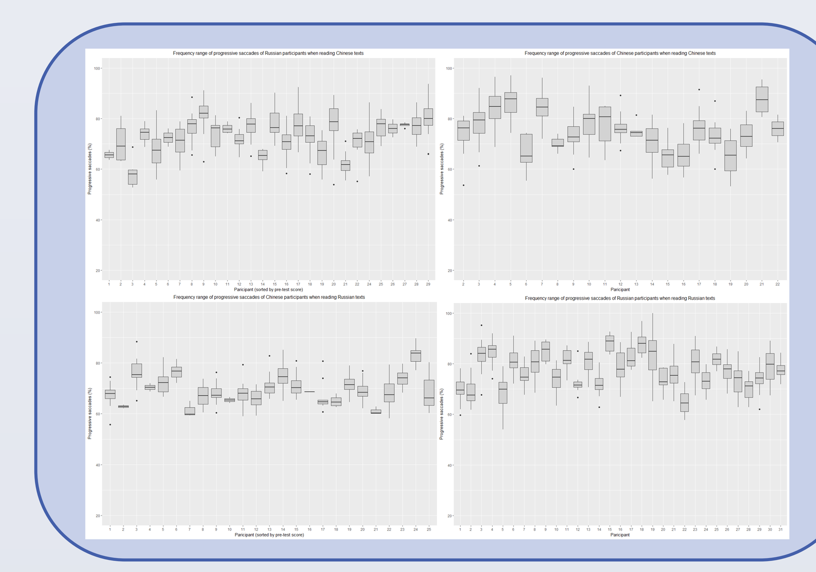

Figure 5. Frequency of progressive saccades across participants

Reading Russian texts

Pre-test score, text difficulty, number of correct responses and language order had no statistically significant effects on any of the eye movement measures.

The effects of pre-test score on the measures were as follows : average fixation duration (χ^2 = 0,87, df = 1, p = 0,35), progressive saccade length (χ^2 = 0,58, df = 1, p = 0,45), regressive saccade length (χ^2 = 0,06, df = 1, p = 0,81), progressive saccade frequency (χ^2 = 0,29, df = 1, p = 0,59).

The effects of text difficulty were as follows: average fixation duration (χ^2 = 0,092, df = 1, p = 0,761), progressive saccade length (χ^2 = 0,24, df = 1, p = 0,63), regressive saccade length (χ^2 = 3,82, df = 1, p < 0,1), progressive saccade frequency (χ^2 = 0,59, df = 1, p = 0,44).

CONCLUSIONS

Only one of the eye movement measures in one condition was found to be influenced by the participant's language proficiency level. Russian participants with a higher language proficiency level had shorter average fixations than their low-proficiency counterparts. Other measures showed no connection with one's language proficiency level. This comes as no surprise for the Chinese group, since almost every one of them had been to Russia for at least a year, and the difference in their language proficiency levels is rather small. It is surprising, however, to not find other signs of reading performance improvement in Russian bilinguals. This could be explained by the fact that there is a lot of between-reader variability even when reading texts in one's native language and more variability is expected when reading texts in L2.

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