Reading Strategies in Monolingual Adults and Children vs. Bilingual Heritage and L2 Speakers of Russian: Scanpath analysis

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The majority of research in bilingual reading focuses on *local quantitative* differences between bilingual and monolingual reading as measured by conventional word-by-word eye-movement measures (Cop, Drieghe & Duyck, 2015; Parshina, Laurinavichyute & Sekerina, 2020). The aim of the current study is to investigate differences in reading from another, yet unexplored perspective. We ask: Are there *global qualitative* differences in reading behavior among bilinguals and monolinguals? To answer this question, we adopt a novel to bilingual research scanpath approach that gives us an analytical handle on global stimulus-level gaze trajectories or *reading strategies* as assessed through sequences of eye fixations that extend beyond the word-level (von der Malsburg & Vasishth, 2011). First, we ask what kind of reading strategies Russian speakers employ while reading single sentences and whether speakers' status (i.e., monolingual/child/heritage/second language learner) influences which of those reading strategy are adopted. In addition, we investigated the influence of individual differences on the preference for specific reading strategies in bilingual readers.

Methods: The data set contains eye movements (Eyelink 1000+) from 120 participants, 30 in each of the following groups: monolingual Russian-speaking adults (ML), 8-year-old monolingual Russian-speaking children (CH), heritage speakers of Russian (HS), and L2 learners of Russian (L2) (Table 1 for bilingual groups). Participants read 30 sentences from the *Russian Sentence Corpus child version* (see page 3 for details; Korneev et al., 2017).

Analysis and results: For each sentence, scanpaths from all participants were compared using a similarity measures for scanpaths (von der Malsburg & Vasishth, 2011) and entered into a cluster analysis using mixture of Gaussian modeling. We identified 3 prototypical reading strategies (Figure 1) based on the scanpaths closest to cluster centroids: a) *fluent* reading characterized by straight left-to-right reading, short fixations, frequent word skipping and few regressions; b) *intermediate* reading with longer fixations, less skipping and higher regression probability than the fluent strategy; and c) *beginner* reading where readers fixated words longer, skipped words even less than in the intermediate strategy, and were likely to re-read large portions of the sentence multiple times (Table 2; all *p*s<.05 for comparisons between strategies).

To investigate factors influencing which strategy was adopted, we fit separate GLMMs for each reading strategy as an outcome and group (or individual difference factors) as a predictor. Results indicated that monolinguals consistently adopted the fluent reading strategy (*p*=<.001), while children most often relied on the intermediate strategy (*p* =<.001). HSs were unlikely to follow the fluent strategy (*p*=.006) but did not show preference for either the intermediate or beginner reading strategy (i.e., used both frequently). Among all groups, L2 learners had a higher probability of being in the beginner reading category (*p*<.001). Among individual differences, proficiency in Russian for HSs and comprehension scores for L2 learners were the only factors affecting the strategy choice. High-proficiency HSs (*p*<.001) and L2 learners with high comprehension scores (*p*=.018) were more likely to follow the fluent strategy, while low-proficiency HSs often relied on the beginner strategy (*p*<.001).

In sum, we established through scanpath analyses that different groups of readers employ qualitatively different reading strategies to copy with the difficulties of written language processing. These strategies are not evident at a word-level analysis. Specifically, the intermediate strategy indicates local processing delays in reading by children and HSs (word re-readings and longer fixations), while beginner strategy may additionally indicate global difficulties in semantic and morphosyntactic information integration (multiple sentence re-readings) for low-proficient bilinguals.

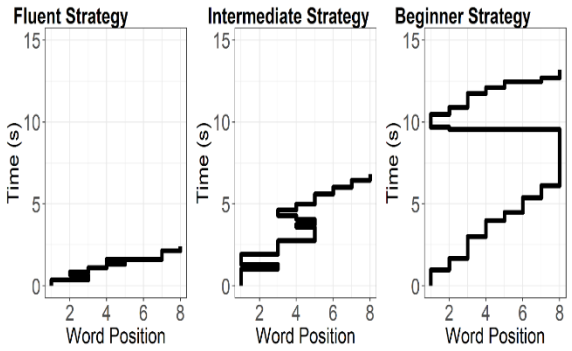

Figure 1. Example of prototypical reading strategies for the sentence "Nedaleko byl slozhen stog sena, ryadom stojali grabli" (A haystack was stacked nearby, a rake was next to it) as identified by scanpaths closest to the centroids of the clusters.

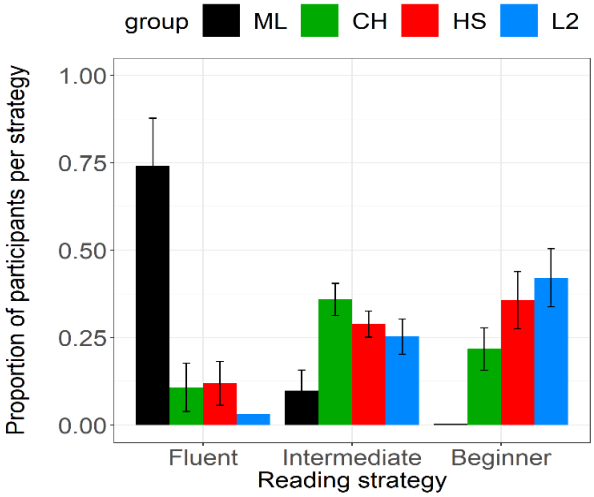

Figure 2. Proportions of participants using the three reading strategies. *ML* - monolingual, *CH* – child, *HS* – Heritage Speaker, *L2* – L2 learner

Table 1. *Demographic and performance characteristics of the two bilingual groups.*

	HS	**L2**
	Mean *(SD)*	Mean *(SD)*
Age (y.o)	17.5	21.2
Age of arrival to the USA (y.o)	4.3 *(5.4)*	0.13 *(0.75)*
Daily Russian exposure (%)	25.6 *(18.9)*	7.9 *(7.4)*
Self-estimated comprehension (1–5)	3.2 *(1.1)*	2.8 *(.87)*
Proficiency score (Rus)	12.3 *(6.0)*	8.3 *(2.7)*

Table 2. *Descriptive characteristics of reading strategies.*

	Reading strategy		
	Fluent	**Intermediate**	**Beginner**
Gaze duration	289.3 (81.8)	689.9 (338.2)	1053.5 (544.4)
Skipping rate (%)	17.1 (13.7)	8.7 (11.9)	5.8 (10.9)
Fixation count/word	1.3 (.390)	2.8 (1.1)	5.1 (2.1)
Regression rate (%)	12.9 (14.7)	25.4 (18.7)	38.2 (22.7)
Count of word readings	1.0 (.270)	1.4 (.492)	2.2 (.923)
Total time reading/sentence (s)	2.1 (.761)	6.4 (2.9)	13.8 (5.9)

References

Cop, U., Dirix, N., Drieghe, D., & Duyck, W. (2017). Presenting GECO: An eyetracking corpus of monolingual and bilingual sentence reading. *Behavior Research Methods, 49,* 602–615.

Korneev, A., Akhutina, T., & Matveeva, E. (2017). Silent reading in Russian junior schoolchildren: an eye tracking study. *Psychology, Journal of Higher School of Economics, 14,* 219–235.

von der Malsburg, T., & Vasishth, S. (2011). What is the scanpath signature of syntactic reanalysis? *Journal of Memory and Language, 65*(2), 109–127.

Parshina, O., Laurinavichyute, A. K., & Sekerina, I. A. (2020). Eye-movement benchmarks in Heritage Language reading. *Bilingualism: Language and Cognition*. doi: 10.1017/S136672892000019X

Table 3. *Descriptive characteristics of the child Russian Sentence Corpus.*

	Child Russian Sentence Corpus
# of sentences	30
# of words	227
Sentence length (words)	*M* = 8, range: 6–9
Word length (letters)	*M* = 5.6, *Mdn* = 6, range: 1–13
Word frequency (items per million)	*M* = 3088.2, *Mdn* = 2583.3, range: 7.4–7537.7

Examples of the sentences in the child RSC:

(1). Дорога вела в глухой лес, петляя по склонам.
‘Road led to thick forest turning around slopes.’

(2). Они заметили вагон красного цвета и переглянулись.
‘They noticed carriage in red color and exchanged looks.’

(3). В доме лесника охотники нашли крупу, сухари и спички.
‘In forester's house hunters found grain, crackers and matches.’

(4). Вася любил сгущенку, особенно с чаем.
‘Vasya liked sweet milk especially with tea.’

(5). В магазине Андрей купил молоко, сметану, творог.
‘In the store Andrey bought milk, sour cream, cottage cheese.’

(6). Недалеко был сложен стог сена, рядом стояли грабли.
‘A haystack was stacked nearby, a rake was next to it.’