Cross-linguistic comparison in reading sentences of uniform length: Visual-perceptual demands override readers' experience

Olga Parshina[1], Nina Zdorova[2,3], Victor Kuperman[4]

[1]Middlebury College, [2]HSE University, [3]Institute of Linguistics, Russian Academy of Sciences, [4]McMaster University

In this study, we present the findings of the cross-linguistic comparative eye-tracking reading experiment that aims to provide adjudication of conflicting predictions of two theoretical accounts of eye-movement spatial control in reading. The first, *dynamic adjustment* account (Liu et al., 2016) suggests that readers heavily rely on the input characteristics (e.g., word length) when planning lengths of saccades while reading; and that readers can rapidly adjust to the characteristics of the input "overriding" the general language settings or the reader's prior experience. The second, *discrete control* account (McConkie's et al., 1988), on the other hand, argues that readers develop a preference towards saccade lengths as a result of the reader's experience with the statistics of the written language. This study of Russian sentence reading follows Cutter et al.'s (2017) study in English and presents readers with sentences consisting of words of the same length. We hypothesized that if the readers' experience matters as per *discrete control account*, Russian readers would produce longer saccades and farther landing positions into the words than the ones produced by English readers since an average Russian word is longer than an English one. On the other hand, if the saccadic targeting is primarily driven by the immediate perceptual demands as per the *dynamic adjustment account,* the saccades of Russian and English readers would be of the same length, resulting in similar landing positions.

Method. The design of this study follows the study design conducted in English (Cutter et al., 2017). Russian monolingual speakers (N=24) read four sets of 30 sentences distributed across four Blocks while their eye-movements were recorded. Block 1 contained only sentences with 3-letter words (labeled U3), Block 2 consisted only of 4-letter words (U4), and Block 3 consisted only of 5-letter words (U5). The sentences in Block 4 consisted of a combination of 3-, 4-, and 5-letter words (non-uniform sentences, labeled NU); see examples in (1). All participants were exposed to all four Blocks, but the order of the Blocks was fixed progressing from 1st to 4th Block.

Results. Linear mixed-effects models were fitted to incoming saccade length and landing position as dependent variables. Fixed predictors consisted of word frequency (log-transformed) and a 6-level factor Condition including 3 uniform conditions (U3, U4, U5) and three, four, and five-letter words found in non-uniform sentences (NU3, NU4, and NU5, respectively). The random effect structure included by-participant and by-word random intercepts as well as by-participants random slopes for word frequency. Similar to findings in English study (Cutter et al., 2017), the results showed rapid adaptation of the saccade length in reading in Russian (Table 1). Specifically, saccade length increased in the beginning of the trials of each respective Block and remained consistent within this Block (Table 1). Crucially, we did not observe longer incoming saccades in Russian sentences compared to the length-matched English counterparts (Table 2). Furthermore, there were no differences in landing positions between Russian and English readers: Incoming saccades landed consistently near the word center, specifically 0.3 letters to the left of it (English participants landed the eye-gaze 0.4 letters to the left).

Conclusions. In sum, we established that readers in Russian indeed were able to rapidly adjust the saccade length to the unusual visual input (sentences containing words of the same length). Crucially, however, we did not find evidence of Russian readers producing longer saccade lengths than readers in English, even in the stimuli that were length-matched across languages. These results corroborate the *dynamic adjustment* account and emphasize the role of visual-perceptual demands on the saccadic planning above the language-specific expectations formed by the readers' previous experience with the language.

(1) Examples of stimuli

Block 1 (U3)	Наш	кот	ест	всё,	что	ему	дал	наш	дед.
	Our	*cat*	*eat$_{PRS-3SG}$*	*everything*	*that*	*him*	*give$_{PST-3SG}$*	*our*	*grandfather*

'Our cat eats everything our grandfather gave him.'

Block 2 (U4)	Пока	наши	дети	спят,	няне	надо	быть	дома.
	While	our	children	sleep$_{PRS-3PL}$	nanny	have$_{STAT}$	be$_{INF}$	home

'While our children are asleep the nanny needs to be at home.'

Block 3 (U5)	Сосед	часто	пасёт	стадо	коров	возле	моего	сарая.
	Neighbor	*often*	*graze$_{PRS-3SG}$*	*herd*	*cows*	*near*	*my*	*barn*

'The neighbor often grazes a herd of cattle close to my barn.'

Block 4 (NU)	Все	люди	были	рады,	что	ночью	пошёл	дождь.
	All	people	*be$_{PST-3PL}$*	*happy*	*that*	*night*	*go$_{PST-3SG}$*	*rain*

'All people were happy that it rained at night.'

Table 1. The LMMs summary for the saccade length (left) and landing position relative to word center (right). U4 (uniform 4-letter word sentences) was the reference level. The asterisk indicates that the 95% confidence interval (in square brackets) does not include zero.

	Saccade length	**Landing position**
Intercept	5.23 [4.96, 5.49] *	-0.34 [-0.50, -0.18] *
U3	-0.96 [-1.10, -0.83] *	0.03 [-0.08, 0.14]
U5	1.02 [0.91, 1.14] *	0.10 [0.00, 0.20] *
NU3	0.41 [0.24, 0.58] *	0.01 [-0.14, 0.17]
NU4	0.49 [0.35, 0.63] *	0.05 [-0.08, 0.18]
NU5	0.74 [0.60, 0.87] *	0.01 [-0.11, 0.12]
Frequency (log)	0.10 [0.05, 0.15] *	0.05 [0.01, 0.09] *

Table 2. Mean saccade length in letters for each Sentence Type. SDs are given in parentheses

Source	U3	U4	U5	NU
This study	4.30 (1.11)	5.21 (1.28)	6.25 (1.49)	5.85 (1.45)
Cutter et al., 2017	4.87 (1.16)	5.45 (1.16)	6.18 (1.45)	5.80 (1.45)
Difference (letters)	0.57	0.24	0.07	0.05

References

Cutter, M. G., Drieghe, D., & Liversedge, S. P. (2017). Reading sentences of uniform word length: Evidence for the adaptation of the preferred saccade length during reading. Journal of *Experimental Psychology: Human Perception and Performance, 43*(11), 1895–1911. https://doi.org/10.1037/xhp0000416.

Liu, Y., Reichle, E. D., & Li, X. (2016). The effect of word frequency and parafoveal preview on saccade length during the reading of Chinese. *Journal of Experimental Psychology: Human Perception and Performance, 42*(7), 1008–1025. https://doi.org/10.1037/xhp0000190

McConkie, G. W., Kerr, P. W., Reddix, M. D., & Zola, D. (1988). Eye movement control during reading: I. the location of initial eye fixations on words. *Vision Research, 28*(10), 1107 – 1118.