



Bilingual vs. Monolingual Readers: Insights from Eye-Tracking Data

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COLLECTION:
ASPECTS OF
THE BILINGUAL
ACQUISITION OF
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RESEARCH



ABSTRACT

The present eye-tracking study examines silent and oral text reading by Russian-German bilinguals of two age groups (9-10 and 15-16 years) and compares it with their monolingual peers. The bilingual sample represents so-called heritage speakers of Russian who know both the Latin and the Cyrillic script. The paper relies on two global eye movement measures – the averaged total fixation count and the averaged total fixation duration per token – and analyses the effects of three factors: *language profile*, *age*, and *reading mode*. In both age groups, bilinguals made a higher number of fixations per token and fixated the token longer than their peers. This observation holds for both languages and reading modes. However, the gap between bilinguals and their peers was much larger in Russian, and interindividual variation was greater in Russian than in German. The better results in German can be explained by its status as the primary medium of instruction and its dominance in everyday literacy, but the prolonged information processing in both languages suggests the activation of both linguistic systems and their mental lexicon, even if only one language has been triggered by the task. Notably, general language command, more specifically, lexical knowledge and reading experience play a decisive role in reading acquisition and behaviour. These insights should be considered by the educational practice at school as well as by scientific research in multilingualism.

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Reading competencies form a core aspect of literacy, a complex concept that addresses the ability to deal with written and multimodal texts in both receptive and productive manner. The societal relevance of reading skills has resulted in an impressive number of national and international education surveys with a special focus on reading, such as the PISA surveys conducted by the Programme for International Student Assessment with special interest in reading in 2000, 2009, and 2018. These large-scale surveys concentrate on the highest levels of information processing and understanding (Kainz, 1965). However, reading is based on a complex set of basic linguistic processes. At least in alphabetic writing systems, reading requires dealing with phoneme-grapheme relations, phonological rules, and orthographic conventions to retrieve units from the internal lexicon, to process morphosyntactic and syntactic information, and to align language input with linguistic context, textual knowledge, and language-external context on a higher level of processing (Ehlich, 2007). Reading skills are shown to be strongly related to general language knowledge (Daane et al., 2005; Nation & Snowling, 2004). At the same time, as a cultural technique, reading requires special training.

With this as a background, the present paper takes a psycholinguistic perspective on reading and investigates the effects of bilingualism, age, and reading mode. By applying eye-tracking we aim to replace the macroscopic approach of the large-scale studies with a microscopic point of view. This allows real-time tracing of what is happening while bilinguals are reading in two different languages, German and Russian, and in two modes – silently and aloud.¹ For this purpose, we study young Russian-German bilinguals of two different age groups growing up in Germany within Russian-speaking families and compare them to their German and Russian monolingual peers.

THE BILINGUALISM OF HERITAGE SPEAKERS

In contrast to several studies in bilingual reading which analyse data from first and foreign languages (e.g., Dijkstra & van Heuven, 2002; Kaushanskaya & Marian, 2007; Cop et al., 2015; Paz-Alonso et al., 2019), we address so-called *heritage speakers*. The term covers a sociolinguistic category of bilinguals introduced by Valdés (2000). Montrul (2004) describes heritage speakers as “[...] simultaneous bilinguals and child L2 [second language] learners whose family language is a minority language and who live immersed in a linguistic environment where the majority language predominates” (p. 260). Consequently, heritage speakers may be simultaneous as well as early sequential bilinguals. We restrict child L2 learners to the period from age 4 to 6 or 7, that is, until school age in Germany (Montrul, 2008, p. 18).

The attribution of being a heritage speaker does not imply any clear-cut specification of language proficiency. Proficiency may range from minimal receptive abilities to native-like language command and may vary from one competence to the other during life (Montrul, 2016; Polinsky, 2018). Linguistic heterogeneity is a well-established peculiarity of heritage speakers which can be traced back to several language-internal and language-external factors (e.g., Armon-Lotem et al., 2011; De Houwer, 2011; Rodina et al., 2020). Aside from the varying impact of input and output in different communicative domains during lifespan, literacy plays an essential role in language maintenance. Literacy practices restructure the knowledge of the language system, enrich the mental lexicon, and promote awareness about linguistic structures, inventories, and registers (Ehlich, 2005). However, they are strongly attached to the medium of instruction which, at least in Europe, ordinarily coincides with the environment language being used by the majority of inhabitants (Gogolin, 2008). Special effort is usually needed to obtain reading and writing skills in the heritage language as well (Lengyel & Neumann, 2017). This may be even more of a hindrance if learners are confronted with different writing systems or alphabets. Even if people overcome these difficulties, they often have significantly less reading and writing practice in their heritage language than in the environment language. In the end, oral skills usually outperform literacy skills (Achterberg, 2005; Carreira & Kagan, 2011). However, research has established the positive effects of biculturality and biliteracy on literacy skills and general linguistic competencies in both German and Russian (Böhmer, 2015; Usanova, 2019). Nonetheless, an apparent time study on reading aloud demonstrated that most of the biliteral heritage speakers remain behind their Russian peers in processing phonological, morphological,

BILINGUAL READING

All theoretical models conceptualise reading as a complex process which involves several layers of linguistic knowledge and integrates different cognitive activities. Both dual-route and connectionist models, to name the most influential approaches, stress the impact of orthography, phonology, and semantics (Coltheart, 2016; Seidenberg, 2007). Words are considered the core units in reading, even within models operating on sentence and discourse level (Rayner et al., 2012). The automaticity of visual word recognition has been proven to correlate with reading fluency and comprehension (Rayner, 1998). Visual word recognition, in turn, relies on basic perceptual and sublexical orthographic and phonological levels, but also integrates morphological, (morpho-)syntactic, co- and contextual information for semantic interpretation (Carreiras et al., 2014). Therefore, reading research offers valuable insights into the structure and working mechanisms of the mental lexicon and its implementation into language processing.

In the case of bilingual reading, a large amount of psycholinguistic research supports the idea of non-selective access from an integrated lexicon. Models like the Bilingual Interactive Activation model BIA+ (Dijkstra & van Heuven, 2002) and its successor, the Multilink model (Dijkstra et al., 2019), focus on visual word processing and propose that in both of a bilingual's languages, the orthographic and phonological levels are being activated. Context variables, subjective expectations, the character of the task, and even high language proficiency seem not to be able to entirely suppress one language against the other (Dijkstra et al., 2019). The activation of more than one language results in increased processing time (inhibition). This mechanism seems to be supported by the quality and quantity of the bilingual mental lexicon itself (Perfetti, 2007). As suggested by Bialystok et al. (2010), until at least the age of 10, bilinguals tend to have a smaller number of lexical entries in each language, which, however, may exceed the monolingual lexicon quantitatively when added up.² The input and the frequency of use divided between two languages result in less linguistic practice available for each of them. According to the weaker links hypothesis, this, in turn, results in less stable representations and, subsequently, in slower lexical retrieval – an effect which is reported to be stronger in the weaker of the two languages (Gollan et al., 2008).

Generally stated, both overt and covert characteristics of reading skills are associated with experience. Therefore, research often draws parallels between child and bilingual reading (Cop et al., 2015). For child readers, experience is usually tied to age, while it plays a decisive role in reading rate and accuracy as well as in eye movements. Apart from that, age corresponds to training and follow-up effects of learning (e.g., Chernigovskaya & Petrova, 2018; Rayner, 1986; Rayner et al., 2013). Since Cunningham and Stanovich (1990), print exposure is regarded as an important factor in child reading acquisition. In the case of bilingual adolescents, both age and linguistic experience will contribute to the development of reading skills in both languages.

WRITING SYSTEMS AND ORTHOGRAPHY

The question regarding the extent to which different orthographies develop varying reading strategies is still under discussion (Jasińska & Petitto, 2014; Paz-Alonso et al., 2019). Since Frost et al. (1987), reading research considers orthographic depth as a source of cross-linguistic differences in reading acquisition and processing. The concept posits that languages are on a continuum between shallow and deep orthographies. Shallow, or transparent, orthographies correlate phonemes and graphemes in an unequivocal manner (Frost et al., 1987). In deep orthographies, this relationship is opaque, with graphemes representing different phonemes, and phonemes being represented by different graphemes (Frost et al., 1987). As a consequence, reading acquisition takes longer in deep orthographies (Frith et al., 1998; Seymour et al., 2003), whereas in shallow orthographies, readers may successfully rely on clearly identifiable grapheme-phoneme correspondences – a strategy that, in turn, may result in problems with reading fluency (Ziegler & Goswami 2005). However, the concept of orthographic depth shows an inconsistency which challenges the classification of languages. Traditionally, German is

considered to have a rather shallow orthography (Frith et al., 1998; Seymour et al., 2003), which is based on both the phonemic and morphonemic principle of spelling. Existing inconsistencies are being compensated by the regularity of occurrence. For Russian, the status is still under discussion (Kerek & Niemi 2009; Kornev et al., 2014; Laurinavichyute et al., 2019). Following Kerek and Niemi (2009), we assume that Russian will pose more challenges to readers than German does. This position is based on (i) specific traits of the Russian phonology, e.g., the distinction of palatalized and velarized consonants being marked by the following vocal grapheme in writing; (ii) several phonological rules operating on the morphemic level and not being displayed in orthography, e.g., reduction of unstressed vowels; (iii) the high variability of lexical stress pattern; and (iv) morphemic fusion in combination with a rich inflectional system. Furthermore, we expect Russian-German bilinguals to struggle with difficulties in recognising the Cyrillic letters. The limited exposure to the Cyrillic script will result in less automatised processing and more erroneous output, not least because of graphonological interferences with the more privileged, daily used Latin script.

AIMS AND ISSUES OF THE PRESENT STUDY

The present paper aims to present process-related insights into bilinguals' reading behaviour in languages with different writing systems.³ We consider two key parameters obtained from all word forms (tokens) composing the text: total fixation count (averaged number of fixations per token) and total fixation duration (averaged fixation duration per token) (Conklin et al., 2018; Liversedge et al., 1998; Rayner et al., 2012). Both parameters figure as so-called late measures, which "[...] reflect strategic processing and include revisits and reanalysis that result from processing difficulty. Thus, they signal more effortful and/or conscious processing (e.g., lexical integration in reading)" (Conklin & Pellicer-Sánchez, 2016, p. 455). They correlate with reading rate and are highly informative due to their correlation with several linguistic item characteristics (for Russian, Korneev et al., 2017; Laurinavichyute et al., 2019). Both measures are considered to be strongly related to the mental lexicon and to display processes of lexical retrieval and subsequent contextual integration (Conklin et al., 2018; Radach et al., 2012). Our research is based on coherent age-appropriate texts. Comparing bilinguals with monolingual peers⁴, we address the impact of three factors that may account for differences in reading behaviour: (i) *linguistic background* (bilingual vs. monolingual), (ii) *age* (9–10 and 15–16 years old), and (iii) *reading mode* (silently vs. aloud).

For *language background* (bilingual vs. monolingual), we expect a general delay in reading skills for Russian-German bilinguals in both languages, which should result in longer and more fixations. Such findings will be consistent with current models of bilingual visual word recognition, the impact of linguistic input as a source for implicit learning, and the assumption of weaker links and a frequency-lag in bilinguals. As outlined above, during childhood, the languages of heritage speakers change their status, with the medium of instruction becoming dominant and the heritage language getting weaker (Gagarina & Klassert, 2018). Heritage speakers of Russian maintain some practice in their heritage language but have less exposure to reading and writing in Russian (Anstatt, 2011) and, therefore, are less familiar with the Cyrillic script and the Russian orthography than monolinguals are. Consequently, their reading behaviour should deviate more from Russian monolinguals than from German ones.

In reading research, *age* is usually associated with experience (e.g., Rayner, 1998). An increase of skills will account for decreased general reading time and fixation count. The more dominant language, German, is expected to have stronger age-related effects due to its role in schooling, its daily use, and its prominence in the linguistic landscape (Redder & Weinert, 2013). By matching two age groups (9–10 and 15–16 years old) in all three samples, we expect a general lag for bilinguals in both German and in Russian.

The *reading mode* (silently vs. aloud) displays somewhat different operating units and processes (Frost, 1989; Share, 2008). Moreover, reading aloud allows for checking reading accuracy and fluency, including stress and prosody. The present paper, however, aims to analyse the relationship between both modes based on eye movements. For reading aloud, longer fixations have been reported for adults (Rayner, 1998; Rayner et al., 2012) and 13–14-year-old adolescents (Kriebler et al., 2017). One might assume that the articulation of single words and the prosodic shape of sentence and text structures require additional cognitive and motoric

effort (Kriebler et al., 2017). Therefore, we expect all test groups to show longer average fixation time and more fixation counts when reading aloud – regardless of the language of the text, the test persons’ language background, and age. For bilinguals, a larger effect seems possible due to the lack of reading experience in Russian.

METHODS

PARTICIPANTS

Six groups participated in this study. Prior to the experiment, the participants and their parents signed a consent form and filled in a questionnaire on language biography, reading habits, and sociocultural and socioeconomic background. The factor *language background* was presented in three groups, each of which was split into two *age* groups ranging from 9 to 10 and from 15 to 16 years, respectively. **Table 1** gives an overview of the participants. In sum, 25 Russian-German bilinguals, 27 monolingually raised speakers of German, and 31 monolingual Russians took part in the study, which was conducted in the cities of Hamburg and St. Petersburg. 20 out of 25 bilingual participants were born and had been living in Germany all their lives. Those who came from the post-Soviet area arrived at Germany before age 2 – with only one exception of one migrating at age 7. All bilingual participants attended a German primary or secondary school. All participants had normal or corrected-to-normal vision. As for the bilingual subsamples, only participants who were able to read both Latin and Cyrillic script were included.

GROUP	RUSSIAN-GERMAN BILINGUALS		GERMAN MONOLINGUALS		RUSSIAN MONOLINGUALS	
Age	9–10	15–16 ^a	9–10	15–16	9–10	15–16
<i>n</i>	13	12	14	13	16	15
Male/female	5/8	7/5	6/8	1/12	5/11	5/10
Born in Germany/in a post-Soviet country	13/0	7/4	14/—	13/—	—/16	—/15
Age of onset: German (years)						
<i>M</i>	1.62	3.05	0	0	—	—
<i>SD</i>	1.46	2.65				
<i>Range (years;months)</i>	0–3;5	0–7;0				
Age of onset: Russian (years)						
<i>M</i>	0.08	0.80	—	—	0	0
<i>SD</i>	0.28	1.14 ^b				
<i>Range (years;months)</i>	0–1;0	0–3;0				
Age of onset: Reading in German (years)						
<i>M</i>	6.04	6.18	6.29	5.75	—	—
<i>SD</i>	0.59	0.98	1.44	1.75		
<i>Range (years;months)</i>	5;0–7;0	5;0–8;0	2;0–8;0	4;0–7;0		
Age of onset: Reading in Russian (years)						
<i>M</i>	5.96	9.91	—	—	4.62	4.30
<i>SD</i>	1.27	3.46			2.07	0.92
<i>Range (years;months)</i>	4;0–8;5	5;0–13;5			3;0–7;0	3;0–6;0

Table 1 General characteristics of the participant groups.

^a For one 15–16-year-old bilingual, no background information was available.

^b One answer had to be excluded due to an invalid value.

According to the parents, all bilinguals have been exposed to Russian no later than age 3;0. For German, the age of onset was more variable – with a mean of 1;6 years for the younger, and 3;0 years for the older bilingual group, the latter being more diverse. Bilinguals of both age groups started to read in German at around age 6;0, when they started to attend school. The same holds for German monolinguals. Interestingly, the Russian monolinguals in our sample reveal earlier reading activity. On average, they began to read between ages 4;0 and 5;0. What all

monolingual groups have in common is a remarkable individual variation. As for bilinguals, the younger ones started reading Russian on average somewhat earlier than German, in contrast to that of the older group, who began reading Russian much later than German.

All bilingual participants came from families with parents who themselves migrated to Germany between age 14 and 39. Parents reported that they use Russian within their families actively: eighteen parents spoke only Russian with their children, five indicated speaking in both languages, and two parents did not clearly answer the question. Most of the bilinguals learned Russian outside the family as well. Ten of the thirteen 9–10-year-old bilinguals took courses in a private Russian afternoon school. All twelve 15–16-year-old participants attended a Russian language course at school. In all courses, the education programme aims for literacy skills, too.

Table 2 gives an overview of the language proficiency assessments by the parents and participants. Parents were asked to estimate their children’s skills for speaking, understanding, writing, and reading separately; the values in **Table 2** represent the mean scores derived from those data. The participants’ data report holistic self-assessments. In the case of bilinguals, both parents and participants agreed in rating proficiency in German higher than in Russian. Interestingly, participants in all groups assessed their skills more negatively than their parents.

GROUP	RUSSIAN-GERMAN BILINGUALS		GERMAN MONOLINGUALS		RUSSIAN MONOLINGUALS	
Age	9–10	15–16	9–10	15–16	9–10	15–16
<i>n</i>	13	12	14	13	16	15
Background information gathered by the parental questionnaire						
Average score of the participants’ skills in German	1.67 (<i>n</i> = 12)	1.39 (<i>n</i> = 9)	1.41 (<i>n</i> = 14)	1.10 (<i>n</i> = 13)	—	—
Average score of the participants’ skills in Russian	2.62 (<i>n</i> = 13)	2.21 (<i>n</i> = 9)	—	—	1.52 (<i>n</i> = 16)	1.25 (<i>n</i> = 15)
Background information gathered by the interview with participants						
Average score of the participants-skills in German	1.79 (<i>n</i> = 12)	1.96 (<i>n</i> = 12)	2.15 (<i>n</i> = 13)	1.62 (<i>n</i> = 13)	—	—
Average score of the participants-skills in Russian	2.80 (<i>n</i> = 10)	2.67 (<i>n</i> = 12)	—	—	1.83 (<i>n</i> = 12)	1.80 (<i>n</i> = 15)

Table 2 Language proficiency: Assessments from the parent questionnaires and qualitative interviews with students. Note: Gradations used to evaluate student skills are as follows: excellent (1), good (2), satisfactory (3), pass (4), and fail (5).

MATERIAL

We decided to rely on a naturalistic, “ecological” approach, presenting the participants with coherent whole texts. Two original texts with only small adaptations were chosen: Aesop’s fable *Der Fuchs und der Ziegenbock* (*The fox and the billy goat*) in German (Aesop, 2013) and the Russian children’s story *Interesno pridumala* (*An interesting idea*) written by Mikhail Zoshchenko (Zoshchenko 2008), the latter being aimed first and foremost at the linguistic proficiency of Russian-German bilinguals and used in previous reading research (Krause & Savenkova, 2016; Ritter, 2017).

To ensure age-appropriateness and comparability, the text complexity calculator LeStCoR (Batić et al., 2016) was applied to both texts.⁵ The LeStCoR readability score makes use of seven readability measures (**Table 3**). Given the fact that these measures adopt at least partially different text parameters, LeStCoR offers a complex approach to text complexity and difficulty. Furthermore, the tool analyses the number of words which exceed the basic Russian vocabulary. The average score displays a certain grade level beginning with the 5th grade and ending up with college level. For the German text, we got 8.75, for the Russian one 8.55. Thus, both texts show quite similar readability and address nearly the same age group. Some linguistic characteristics of both texts are given in **Table 4**.

READABILITY MEASURES	GERMAN TEXT	RUSSIAN TEXT
LeStCoR Averaged readability score	8.75	8.55
Flesch-Kincaid grade level	9.62	13.27
Coleman Liau Index score	11.64	10.85
SMOG index	8.6	7.72
Automated Readability Index	10.27	7.26
New Dale Chall Adjusted Grade Level	6.00	6.00
Powers-Sumner-Kearl Grade Level	6.31	8.21
(Gunning) Fog	8.84	6.57

Table 3 Readability measures for the German text “Der Fuchs und der Ziegenbock” (The fox and the billy goat) by Aesop and for the Russian text “Interesno pridumala” (An interesting idea) by Mikhail Zoshchenko.

PARAMETER	GERMAN TEXT		RUSSIAN TEXT	
Number of tokens (without title)	199		168	
Number of sentences	12		17	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Number of characters per token	4.83	2.70	4.90	2.51
Number of tokens per sentence	16.58	7.32	9.88	4.76
Number of syllables per sentence	26.00	12.19	21.29	9.16
Number of syllables per token	1.57	.88	2.16	.96

Table 4 Descriptive statistics of the German text “Der Fuchs und der Ziegenbock” (The fox and the billy goat) by Aesop and the Russian text “Interesno pridumala” (An interesting idea) by Mikhail Zoshchenko.

PROCEDURE

The bilingual participants read the German and Russian texts within the same session, first silently, then aloud. This setting was regulated by requirements from the participating schools, but at the same time, resembled real situations of language change in everyday life. Reading in German, the presumably more trained language, was followed by Russian after a break of approximately 5–10 minutes. This procedure was chosen to reduce psychological barriers and to ensure interpersonal comparability. Monolinguals also started with silent reading. All sessions took place in a dimly lit, quiet room.

Eye movement data were recorded with a Tobii TX300 eye tracker. Reading aloud was additionally recorded with a digital audio recorder Olympus LS-11. All participants were seated 60–70 cm from the screen. Before starting to read, a 9-point calibration was executed for each person and each text. The participants were instructed to move their head and body as little as possible while reading. The texts were presented in black, 20-point Times New Roman font with a line spacing of 2.5 on a light grey background. They appeared on the screen in two parts, with a maximum of 122 tokens presented at once. Participants independently switched to the final text part by pressing the left mouse button. After reading in one language, they carried out some comprehension tasks not reported here.

STATISTICS

The present paper examines two late-stage eye movement parameters which give a comprehensive insight into the processes going on during reading. These are the total fixation count, defined as the averaged sum of fixations per token, and the total reading time or total fixation duration, the averaged sum of fixation durations per token. Statistical analyses were performed using SPSS Statistics 24 (for the data see Appendix A, B). We tested the statistical significance of between-group variation of both dependent variables in relation to three factors (independent variables): (i) *language profile* (bilingual, monolingual), (ii) *age* (9–10, 15–16), and (iii) *mode of reading* (silently, aloud). When the dependent variable showed normal distribution and homogeneity of variance, ANOVA and Gabriel’s post hoc test were performed. If homogeneity was violated, Welch’s ANOVA and Games-Howell post hoc test were chosen for comparing all possible combinations of group differences (Field, 2013). In case of non-normal

data distribution, the Kruskal-Wallis test was followed by Dunn-Bonferroni tests for pairwise comparisons (Field, 2013). For descriptive purposes, box plots were created in Excel 2016.

For reading mode, another focus was on within-group variation. We analysed the differences in reading silently and aloud using the paired samples t-test for normal distribution, and the Wilcoxon test if non-normal distribution appeared.

RESULTS

TOTAL FIXATION COUNT

Firstly, we analysed the relation between averaged fixation count per token in reading German and Russian (Figures 1 and 2). In both languages, the factor *language background* reveals significant differences insofar as monolinguals need fewer fixations than bilinguals do. This holds true for both age groups and reading modes. However, the differences between bilinguals and monolinguals are smaller in German than in Russian. While reading German silently, 9–10-year-old bilinguals fixated a token on average 2.09 times, whereas their peers from the monolingual group made significantly fewer fixations ($M = 1.33$; $z = 3.24$, $p = .007$). The older participants reached lower counts ($M = 1.62$ for bilinguals, $M = 1.0$ for monolinguals), performing significantly differently too ($z = 3.91$; $p = .001$). In reading aloud, these tendencies recurred: Average fixation counts differed significantly ($p = .001$; 142.41, 95%CI [58.79, 226.03]) between 9–10-year-old bilinguals ($M = 2.17$) and their monolingual peers ($M = 1.45$) and between 15–16-year-old bilinguals ($M = 1.51$) and monolinguals ($M = 1.21$; $p = .001$; 59.33, 95%CI [27.41, 91.24]). In Russian, the impact of *language background* leads to greater differences between bilinguals and monolinguals. In the case of silent reading, we observed significantly more fixations per token for young bilingual readers ($M = 3.14$) than for monolinguals ($M = 1.13$; $p < .001$; 337.82, 95%CI [253.54, 422.09]). The same tendency holds for the older bilinguals ($M = 3.0$) and their Russian peers ($M = .81$; $p < .001$; 362.02, 95%CI [213.73, 510.31]). While reading Russian aloud,

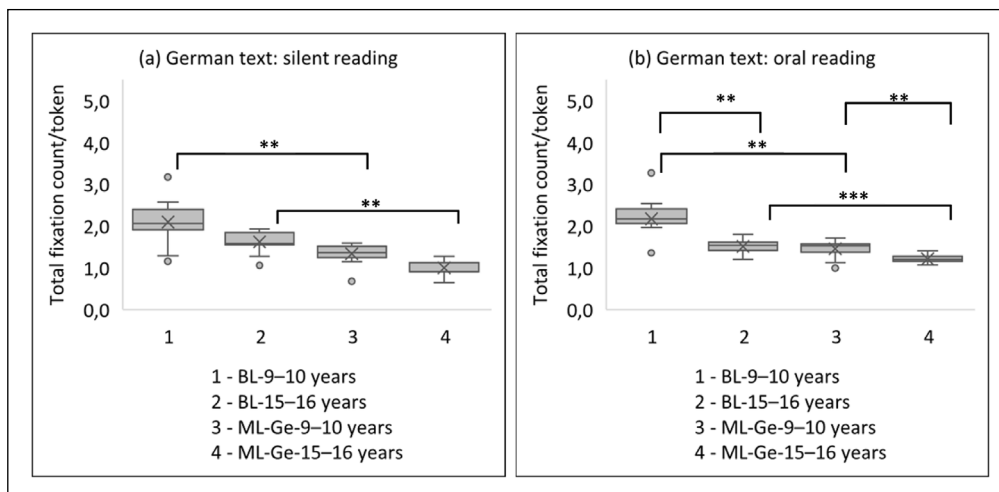


Figure 1 Total fixation count for (a) silent and (b) oral reading of the German text by Russian-German bilinguals (BL) and German monolinguals (ML-Ge). Note: The median Mdn is marked by a solid line between the 25th and 75th percentile that delimit the boxes; the mean M is indicated by x. * $p < .05$. ** $p < .01$. *** $p < .001$.

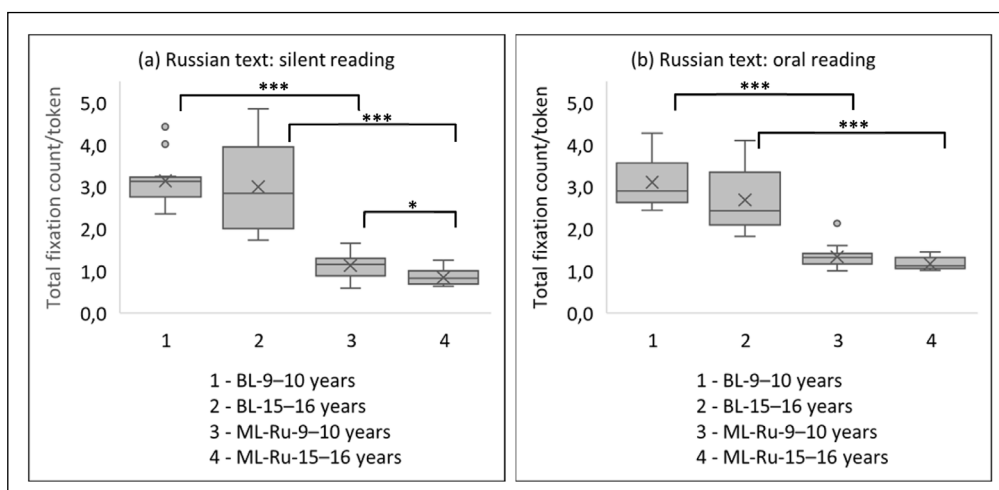


Figure 2 Total fixation count for (a) silent and (b) oral reading of the Russian text by Russian-German bilinguals (BL) and Russian monolinguals (ML-Ru). * $p < .05$. ** $p < .01$. *** $p < .001$.

the younger bilinguals showed $M = 3.11$ fixations per token. Their monolingual peers, however, fixated $M = 1.34$ times per token ($z = 4.38$; $p < .001$). In the older groups, we found $M = 2.69$ fixations per token for bilingual readers, and $M = 1.17$ for monolingual ones ($z = 4.58$; $p < .001$). In addition, the factor *language background* has a clear impact on interindividual variation which appears to be stronger in bilinguals than in monolinguals and more prominent in Russian than in German.

The total fixation amount per token decreases with age in all settings, with bilinguals starting in both languages with more fixations per token than their monolingual peers. However, statistical tests confirm significant age-related distinctions only partially.⁶ Clearly significant results were obtained for reading aloud German, with $p = .002$ for bilinguals (131.44; 95%CI [48.23, 214.65]) and $p = .003$ for monolinguals (48.36; 95%CI [15.04, 81.68]). For reading German silently, the boxplots in **Figure 1** suggest a significant impact of the age factor which, however, was not confirmed by the Kruskal-Wallis test neither for bilinguals ($z = 1.46$, $p = .867$), nor for monolinguals ($z = 2.34$; $p = .117$).⁷ In the case of Russian, the factor *age* also does not lead to significant differences between the bilingual groups (with $p = .973$; 23.94, 95%CI [-134.62, 182.51] for silent and with $z = 0.824$, $p = 1.000$ for oral reading). However, interindividual variation becomes more obvious in the older bilingual group. For Russian monolingual readers, age-related differences seem to be relatively small (**Figure 2**). Nevertheless, they obtain statistical significance ($p = .023$) for silent reading (48.14, 95%CI [5.43, 90.85]). For oral reading, no significant difference between younger and older monolingual Russian readers was found by applying the Kruskal-Wallis test ($z = 1.31$; $p = 1.000$).⁸

As the third factor under investigation, *reading mode* seems to influence the reading behaviour of monolingual participants, but is obviously less relevant for bilinguals. All four monolingual groups show significantly more fixations during oral reading ($p < .005$, Appendix A). As for bilinguals, the differences between modes are less remarkable. In reading German, the 9–10-year-olds reached the statistical significance level ($z = 1.96$; $p = .050$), but the difference between the total amount of fixations in both modes was very small. No significant difference was obtained for young bilinguals who were reading the Russian text silently and aloud ($t(13) = .32$; $p = .753$). The older bilinguals did not fixate significantly more often in one of the reading modes in both languages (with $t(11) = 1.37$; $p = .199$ in German and $t(11) = 1.96$; $p = .075$ in Russian). However, interestingly, they fixated in both languages less often when reading aloud.

TOTAL READING TIME

The averaged total reading time serves as another cue towards complex reading processes. The boxplots in **Figures 3** and **4** present the data for reading German and Russian. Again, the factor *language background* has an influence on the dependent variable. Russian-German bilinguals fixated tokens in both languages significantly longer than their monolingual peers do. The differences are, however, much more pronounced in Russian than in German. While reading German silently, 9–10-year-old bilinguals were fixating a token for $M = 685$ ms, and their monolingual peers for $M = 330$ ms ($p = .002$; 71.03, 95%CI [26.21, 115.85]). The averaged total fixation duration during silent reading in Russian, however, was $M = 1604$ ms for the 9–10-year-old bilinguals, in contrast to $M = 242$ ms for the monolinguals of the same age ($z = 4.22$; $p < .001$). This is similar for the older groups, with $M = 403$ ms for bilinguals and $M = 212$ ms for monolinguals in German ($p < .001$; 38.17, 95%CI [23.57, 52.78]) and $M = 1265$ ms (bilinguals) and $M = 178$ ms (monolinguals) in Russian ($z = 4.81$, $p < .001$). The same tendencies were observed for reading aloud. 9–10-year-olds were looking at a token for $M = 694$ ms (bilinguals) and $M = 392$ ms (monolinguals) in German ($p < .001$; 60.43, 95%CI [23.87, 97.00]) and for $M = 1469$ ms and $M = 359$ ms in Russian ($p < .001$; 186.52, 95%CI [109.07, 263.97]). As for the 15–16-year-olds, the averaged total reading time was $M = 385$ ms for bilinguals and $M = 294$ ms for their monolingual peers in German ($p < .001$; 19.18, 95%CI [9.62, 28.74]). When reading the Russian text aloud, the older bilinguals were fixating a token for $M = 1019$ ms while their Russian peers needed $M = 318$ ms per token ($p < .001$; 117.83, 95%CI [60.73, 174.93]). As in the case of averaged total fixation count, bilinguals revealed much more interindividual variance in Russian.

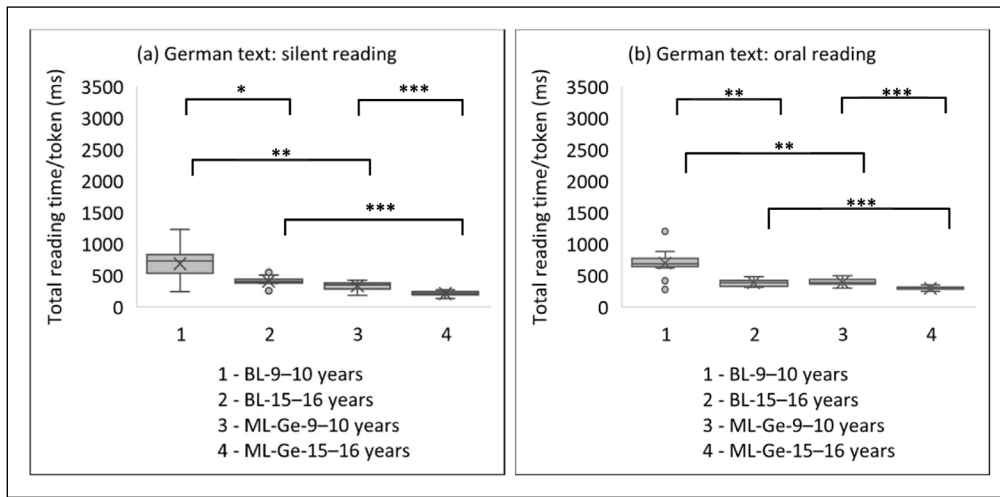


Figure 3 Total reading time (ms) for (a) silent and (b) oral reading of the German text by Russian-German bilinguals (BL) and German monolinguals (ML-Ge).
 * $p < .05$. ** $p < .01$. *** $p < .001$.

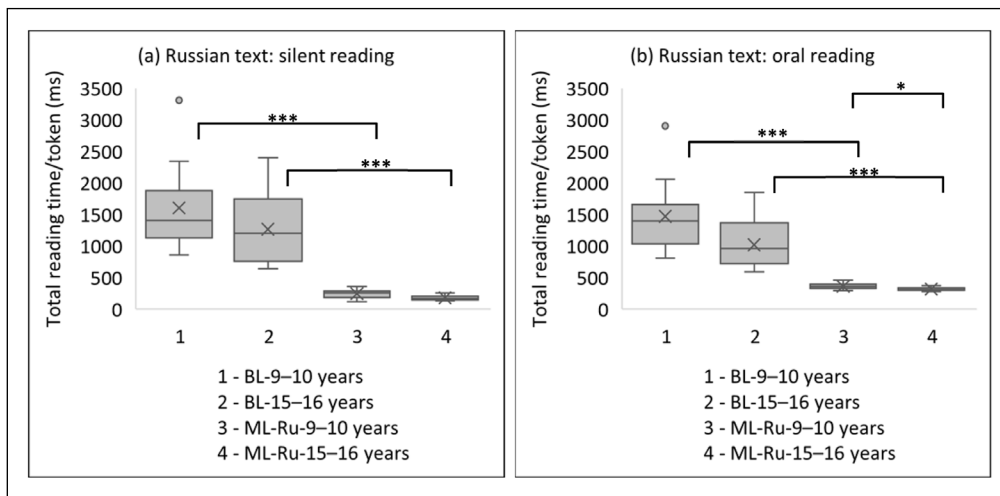


Figure 4 Total reading time (ms) for (a) silent and (b) oral reading of the Russian text by Russian-German bilinguals (BL) and Russian monolinguals (ML-Ru).
 * $p < .05$. ** $p < .01$. *** $p < .001$.

Regarding the factor *age*, both bilinguals and monolinguals differed significantly in German and Russian as well. For German, the bilingual groups (aged 9–10 and 15–16) fixated tokens with significantly different averaged durations ($p = .013$; 56.21, 95%CI [11.02, 101.41] for silent reading, $p = .001$; 61.50, 95%CI [24.90, 98.09] for oral reading). The same holds for German monolinguals (with $p > .001$; 23.35, 95%CI [11.34, 35.36] for silent and $p > .001$; 19.18, 95%CI [9.62, 28.74] for oral reading). When reading in Russian, the factor *age* was relevant only for Russian-speaking monolinguals, and only for reading aloud ($p = .025$; 6.91, 95%CI [0.70, 13.12]). As for bilinguals, an age-related improvement of basic reading skills cannot be confirmed in Russian.

The factor *reading mode* leads to a clear distinction between bilinguals and monolinguals in both languages. German monolinguals performed differently in reading silently and aloud ($t(13) = -3.94$, $p = .002$ for the 9–10-year-olds, $t(12) = -7.92$, $p > .001$ for 15–16-year-olds). For bilinguals reading in German, no significant effect of reading mode can be reported (with $t(12) = -0.33$, $p = .751$ for the younger and $t(11) = 0.85$, $p = .416$ for the older group). In Russian, both the younger and the older bilinguals showed longer fixations per token in silent reading. However, whereas the difference in total reading time between both modes fails to reach the level of significance ($t(12) = 1.80$, $p = .097$) for young bilinguals, it becomes statistically significant for 15–16-year-olds ($t(11) = 3.73$, $p = .003$). In contrast to these findings, Russian monolinguals of both ages fixate significantly longer when reading aloud ($p < .001$, with $t(15) = 7.84$ and $t(14) = -14.12$).

DISCUSSION

In this paper we present data from a reading experiment with Russian-German bilinguals, who represent so-called heritage language speakers of Russian, and their monolingual peers in Germany and Russia. We examined the effects of *language background*, *age*, and *reading mode* onto two parameters of reading behaviour: the total number of fixations per token and the total reading time per token. Our data is based on reading whole texts in German and Russian.

As expected, *language background* plays a crucial role in our data. We noticed significant differences between bilinguals and monolinguals. Regardless of their age, the bilingual groups made more fixations and produced longer fixation durations in both languages and in both reading modes than their monolingual peers did. These findings are in line with our hypotheses. Following the weaker link hypothesis (Gollan et al., 2008), we argued that the less dominant language would require more processing time due to slower lexical retrieval and lower general language competence. Furthermore, we assumed that literacy practices would be less common in the heritage language. In the case of Russian, the distinct and obviously less familiar Cyrillic script and the complex grapheme-phoneme-relations and orthographic principles are considered further obstacles. The data also confirm bilinguals to be much more heterogeneous in their reading behaviour than monolinguals. Still, even the most successful bilingual readers did not reach the level of their peers.

The more interesting results come from the German data. Assuming that German usually becomes the dominant and literacy-trained language during childhood and schooling, one could expect that bilinguals would perform as well as German monolinguals. On average, the data show the opposite. Only two or three bilingual readers of each age group achieved values for fixation count and duration that were better than the lowest results of their monolingual peers. These results strongly point towards models which propose the competition of both languages during reading (Brysbaert et al., 2002; Dijkstra & van Heuven, 2002; Dijkstra et al., 2019; Lehtonen et al., 2012).

Age-related improvements have been described for various eye movement measures and different ages (e.g., Blythe & Joseph, 2011; Rayner et al., 2012; Reichle et al., 2013). The factor *age* did have an impact on the reading behaviour in our study as well, although it could not always be confirmed statistically. A post hoc Z-transformation of averaged fixation duration revealed that, for young monolingual readers aged 9–10, the Russian text was easier than the German one. For the older monolinguals, both German and Russian texts had nearly the same level of difficulty. Nevertheless, in both age groups, we observed less difference between bilinguals and monolinguals in German. Bilinguals demonstrated sufficient age-related improvement in reading German, whereas skills in Russian tended to stall. Age and reading experience correlated much less in the readers' heritage language. At the same time, the inter-individual variability of reading performance increased with age in Russian and decreased in German. These results point to the relevance of training literacy skills. However, while reading German, the effects of bilingualism did not disappear in the older bilingual group. A cross-comparison brought to light how the 15–16-year-old bilinguals of our sample behaved very much like the 9–10-year-old German monolinguals (lacking significant differences in both reading modes and eye movement measures). Against this backdrop, the age-related results once more suggest the activation of both languages, in particular the lexicon, even in a task that focuses on one language alone (Grosjean, 2013).

In the case of *reading mode*, we analysed variation in reading aloud and silently. German and Russian monolinguals behaved in line with our hypothesis. They made more and longer fixations during oral reading. There may be several reasons for this behaviour. Besides oculomotor and linguistic activity, reading aloud requires the clear articulation of every single word and the realisation of stress and intonation pattern within the sentences (Kriebler et al., 2017). The data from bilinguals, however, do not fully match these findings. As a tendency, the older bilinguals fixated tokens for a shorter period and less often in both languages while reading aloud. However, these differences did not reach statistical significance, with the only exception of averaged total duration in Russian. The younger bilinguals demonstrated a more differentiated picture. When reading in German, they tended to perform like their monolingual peers: on average, they made more and slightly longer fixations during oral reading, however, only fixation count reached statistical significance. When reading in Russian, they behaved like the older bilinguals. Summing up, we have to state a lack of sufficient differences in reading modes for bilinguals of both age groups and in both languages. Even as far back as in the late 1930s, Anderson and Swanson (1937) found a smaller difference between the two modes in less skilled adult readers than in highly skilled ones. Kriebler et al. (2017, p. 7) suggest “[...] that an increase in reading skills decreases the time needed to process written content during silent reading, but less so during oral reading”. All in all, our results indicate that the bilingual readers of our sample performed like less experienced readers.

CONCLUSION

The analysis of two measures, the total fixation count and the total fixation reading time, showed significant differences between Russian-German bilinguals (Russian heritage speakers) and monolinguals. In both languages and both reading modes, Russian-German bilinguals made more and longer fixations than their monolingual peers, with stronger contrast for reading in Russian. Obviously, processing Russian requires more effort from the bilinguals than German, is more time-consuming and less automatised. For reading German, we observed greater closeness between bilinguals and monolinguals than for Russian. We assume that this tendency is an effect of language dominance resulting, in particular, from schooling and daily literacy practices. Not surprisingly, we found much more ingroup homogeneity in reading German than Russian. Age-related differences emerged much more strongly in German than in Russian, for both bilinguals and monolinguals and in both reading modes. For bilinguals, consistent age-related improvements were found in German, but not in Russian. However, even in German, on average, the 15–16-year-old bilinguals in our sample were at the level of the 9–10-year-old monolinguals. Our research strongly supports the idea of more processing effort required from bilinguals in both languages. We suppose that bilinguals who share the language background of those in our sample simultaneously activate the two language systems. In this process, the systems – their vocabulary, grammar, script – compete. That is, even focusing one language during reading does not suppress the bilingual mode – the latter being understood as a psycholinguistic stance. This insight should find its application in teaching and test practice.

NOTES

- 1 The terms *reading aloud* and *oral reading* are used synonymously in this paper.
- 2 See De Houwer (2009) for a contrary position.
- 3 The project was supported by a three-year Ph.D. grant, which one of the authors received from the Graduate School of Humanities, University of Hamburg.
- 4 Monolinguals are understood as peers raised with only one language and using only one language daily.
- 5 LeStCoR has been developed specifically for Russian but, according to a personal statement of the original authors, may also be used for German.
- 6 As pointed out by Hirschauer and Becker (2020), statistically non-significant results are often found in small samples. Nevertheless, they recommend that prominent findings due to a non-confirmed statistical effect should not be ignored.
- 7 However, the robust Mann-Whitney test confirmed the significance of age, with $U = 29.00$, $p = .006$ for bilinguals and $U = 22.00$, $p < .001$ for monolinguals.
- 8 Again, the Mann-Whitney test pointed towards significant differences between both monolingual Russian age groups, with $U = 56.50$, $p = .011$ for reading silently and $U = 62.00$, $p = .021$ for reading aloud. One might assume that the applied statistical methods differ in their sensitivity towards the peculiarities of data distribution in small samples like ours.

ADDITIONAL FILES

The additional files for this article can be found as follows:

- **Online Appendix A.** Reading the German text (Krause and Ritter). DOI: <https://doi.org/10.16993/jhhr.36.s1>
- **Online Appendix B.** Reading the Russian text (Krause and Ritter). DOI: <https://doi.org/10.16993/jhhr.36.s2>

COMPETING INTERESTS

The authors have no competing interests to declare.

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