Foregrounding and accessibility effects in the gaze behavior of the readers with different cognitive style

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Abstract

This paper explores accessibility effects in the gaze behavior of readers with different cognitive style, impulsive and reflective, as mediated by graphological and linguistic foregrounding in the discursive acts in 126 areas of interest (AOIs). The study exploits 1890 gaze behavior probes available at open access Multimodal corpus of oculographic reactions MultiCORText. We identified that while graphological foregrounding makes initial or final components of discursive act more accessible for the impulsive readers, reflective readers also observe the components within the act. Linguistic foregrounding produces higher access with impulsive readers in case the linguistic form is visually focalized (phonological foregrounding and parallel structures); meanwhile, with reflective readers this is the information density appearing in elliptical and one-component sentences which maintains higher access.

Keywords: foregrounding, graphological foregrounding, linguistic foregrounding, accessibility, gaze behavior, cognitive style, impulsivity / reflectivity

Выдвижение и доступность информации в глазодвигательном поведении читателей с разным когнитивным стилем

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Аннотация

В работе исследуются особенности доступа к информации через анализ глазодвигательного поведения читателей с разным когнитивным стилем, импульсивных и рефлективных, под влиянием семантического

выдвижения, графологического и лингвистического, в дискурсивных актах (в 126 зонах интереса). Материалом анализа являются 1890 проб глазодвигательного поведения, размещенных в Мультимодальном корпусе глазо-двигательных реакций MultiCORText. Установлено, что графологическое выдвижение инициальных или финальных компонентов дискурсивного акта облегчает доступ к информации для импульсивных читателей; рефлективные читатели обращают внимание и на срединные компоненты дискурсивного акта. Лингвистическое выдвижение, которое делает информацию более доступной для импульсивного читателя, проявляется в ее представлении с помощью определенных формально-языковых средств – фонологических средств и параллельных конструкций. В то же время рефлективных читателей привлекает информация более высокой плотности, которая проявляется в эллиптических и однокомпонентных предложениях как средствах синтаксического выдвижения.

Ключевые слова: выдвижение, графологическое выдвижение, лингвистическое выдвижение, доступность, глазодвигательное поведение, когнитивный стиль, импульсивность / рефлективность

1   Introduction

The present study addresses the research problem of information accessibility in reading attested via gaze behavior of readers. One of the best explored factors mediating accessibility is the information foregrounding (salience, prominence, focalization) which is commonly studied via foregrounding cues or primes. As known, the effects of various types of foregrounding cues have been identified, with syntactic priming, lexical priming, visual cuing, perceptual priming, event orientation cueing. However, other factors apart from foregrounding type may contribute to accessibility effects. In the study, via the readers' gaze behavior we explore the effects of the two factors, the type of foregrounding and the cognitive style of the readers as potentially significant for information accessibility among the readers. The research exploits the data available at the Multimodal corpus of oculographic reactions MultiCORText which is a pilot open-access search corpus of gaze behavior contingent on the text semantic parameters.

2   Theoretical framework

The study is built on two theoretical frameworks to foregrounding effects. While foregrounding is commonly viewed as a construal operation stimulating mental structures activation realized through selected semiotic means, it can be addressed either as an information production operation or the operation which stimulates information accessibility. In the first case, foregrounding becomes the key interest for linguistic studies. In the second case, it is explored as a counterpart of information accessibility for readers displaying different cognitive skills; therefore, it is mainly the cognitive psychological object of research. Although cognitive psychology has developed its methods of studying foregrounding and accessibility effects, the considerable experience of linguistics in analyzing foregrounding can help specify these effects. Still, linguistics will also benefit from these studies as it receives an instrument of ranging linguistic foregrounding effects in terms of their perception.

2.1   Foregrounding in linguistics

Exploring foregrounding in cognitive linguistics is aimed at scaling its effects in information construal. Foregrounding in text can be attributed to either activating non-verbal information in event construal [26; 27], or activating linguistic information on the text structure [7; 9; 18; 25]. In the present study we address the second stance and consider it as a linguistic operation of directing attention towards definite language structures and their semantics. For instance, in [18] foregrounding in syntax is viewed via Newness expressed in End-Focus in English, whereas in Russian [15] it can appear both in sentence initial and final Rheme as well as in Theme-New in *Истории о своем доме и жизни / старик / не ощутил* (trans. *the stories of his house and life / the old man / did not feel*), in Complex Rheme in *Послышались шаги и веселый говор* (word by word trans. – *were heard the steps and gaily talk;* trans. – *We heard the steps and gaily talk*). Olga Iriskhanova [24] lists the linguistic means of foregrounding in all language levels. For instance, foregrounding in syntax is expressed via sentence-final position for Neutral Focus and sentence-initial position for Contrastive Focus, parallel structures, one-component and elliptical sentences. In morphology it appears in the use of proper names, superlative adjectives, verbs in the perfective aspect, verbs in the historical present. In the lexical level, it is expressed via tropes, expressive means, codes switching. Additionally, graphological foregrounding in letter capitalization, the use of punctuation marks, etc. also contributes to focalizing information [24]. This typology of graphological and linguistic foregrounding cues will serve to analyse foregrounding effects in the present study.

2.2　Foregrounding and accessibility in cognitive psychology

The second framework was developed in cognitive and experimental psychology and is aimed at scaling the accessibility effects produced by information foregrounding. Whereas several linguistic approaches do not differentiate between accessibility and foregrounding [1], in experimental studies accessibility is considered as the operation of obtaining the access to information in the text. The studies mostly name two psychological processes which contribute to information accessibility, which are attention control [6] and working memory activation [4]. Accessibility is vastly explored via foregrounding cues [8; 12, 16], where the latter produce different activation effects.

One of the most efficient methods of exploring accessibility modulated by linguistic foregrounding cues is via gaze behavior [3; 13]. In the study, accessibility is accessed via higher gaze costs or higher values of gaze metrics applied in attesting gaze behavior [14; 17; 21]. For instance, in [17] it was shown that extremely long fixations (>1000ms) provide evidence of information processing difficulties. Therefore, identifying longer gaze duration or higher fixation number can signal about higher information accessibility produced by the foregrounding cues in the text areas of interest (AOIs) under scrutiny.

However, we can hardly expect that accessibility is equally and solely dependent on foregrounding cues. First, they can produce different accessibility effects as shown in [3; 5; 13; 20]. For instance, M. Reingold and K. Rayner show that longer fixations appear on the words given in bold [22]. Second, other factors can affect information accessibility. For instance, in [24; 28] the readers' cognitive style explored via impulsivity and reflectivity was reported to have affected the reaction time and the number of errors made. In [10] it was found that impulsive readers' gaze behavior as opposed to the gaze behavior of reflective readers was more affected by graphological foregrounding cues, which was attributed to the differences in their attention types, bottom-up and top-down attention, consistent with the notion of the impulsive-reflective cognitive style [23]. Overall, the impulsive and reflective styles are treated as a "property of the cognitive system that combines individuals' decision-making time and their performance in problem-solving situations, which involve a high degree of uncertainty" [24: 451].

Therefore, the study seeks to explore the accessibility effects of foregrounding as modulated by two factors, the type of the foregrounding cue (graphological and linguistic, with further specification) and the cognitive style (reflective and impulsive) of the reader.

3　Methods and procedure

3.1　Experiment design

Stimuli. The stimuli were 5 one-page drama texts (authored by L. Petrushevskaya, L. Razumovskaya, A. Arbuzov, A. Vampilov, A. Chekhov) which involved 126 AOIs corresponding to discursive acts or the acts performing "responses and interpretations from an external world" [19]. With each discursive act representing an act of instruction, order, command, recommendation, prayer, plea, etc., we identified three basic formal types of discursive acts in our stimuli: 1) a clause (Она сидит у пианино), 2) two clauses representing one discursive act (Что за ребенок, что за ребенок золотой?), 3) a clause with discourse markers (А в четверг – ну, ей-богу, ну, клянусь – сидел в кресле). Although there were more than 126 discursive acts in the 5 stimuli, we had to choose only the ones which were located in one line since the transfer from one line to another would require higher gaze costs [21].

The AOIs were annotated using the semantic protocol incorporated into the Multimodal corpus of oculographic reactions MultiCORText which is an open access database (https://multicortext.lin-guanet.ru/) that allows parametric search using both semantic parameters and gaze metrics. Graphological foregrounding implied the use of italics, bold type, brackets, letters/words capitalization, full stop, comma, exclamatory/question mark, hyphen, etc. Linguistic foregrounding was annotated in all language levels, in phonological level (onomatopoeia, alliteration, etc.), lexical level (proper name, superlative degree of adjective/adverb, perfective/imperfective verb form, etc.), phraseological and syntactic level (phraseological units and set phrases, elliptical sentences, parallel constructions, etc.). Below, we present several examples of annotation:

In (AOI 38) / Заждалась вас, радость моя, светик…/ we mark the graphological cues, here first letter capitalization, comma, dots (suspension points). Linguistic foregrounding cues appear in perfective aspect of a verb, nonce word, expressive means, one-component sentence, parallel constructions.

In (AOI 60) / Варя подбрасывает карты, Михалев отбивается. / we identify the graphological cues which are first letter capitalization, full stop, comma. Linguistic foregrounding is realised through proper name, parallel constructions.

In (AOI 120) / *Она говорит тихо даже в минуты волнения.)* / we mark italics, brackets, first letter capitalization, full-stop, proper name, expressive means.

We presume that the effects of conventionality appearing in the more frequent use of several foregrounding means in all levels might cause the differences in the gaze behavior; still in the experiment two participants' groups were exposed to the same stimuli, which allows to disregard it in contrastive analysis.

Experiment procedure. The experiment was a two-step procedure. At the first step, the psychological test to identify impulsivity / reflectivity score was conducted. At the second step, the eye tracking experiment was carried out. 16 (15) subjects (students, age range 20-26, mean age 22) participated in the study.

Impulsivity / reflectivity score was measured with traditional Familiar Figures Test (MFFT) [11]. In the test, the subjects are expected to find a match for a target image among eight variants. Impulsivity / reflectivity assessment is carried out considering 1) latency (time taken to respond) and 2) accuracy (number of mistakes) score; consequently, the subjects are classified as impulsive if they manifest short latency and low accuracy, and reflective if they manifest long latency and high accuracy. As known, gaze patterns of impulsive and reflective subjects vary in visual search task [2]; therefore, we hypothesized that significant distinctions in gaze behavior would be observed for the reading task as well. MFFT allowed to identify two subject groups: more reflective and more impulsive participants.

During the eye tracking experiment, the eye tracker SMI Red-x binocular system, frequency = 60 Hz, accuracy = 0.4°, head movement 40x20 cm, operating distance = 60-80 cm, was applied. 126 AOIs gaze data were further analyzed in BeGaze 3.0 software. We received 1890 probes which were later subjected to analysis. Since there were two subject groups (more reflective and more impulsive), the probes were analyzed in 2 data sets with each data set annotated for presence or absence of 28 parameters of graphological and linguistic foregrounding. In the experiment, 3 gaze metrics were considered: First Fixation duration, Max Fixation duration, and Average Fixation duration in AOIs; they were selected following the gaze behavior studies employing text stimuli with AOIs [21; 14].

JAMOVI software was applied to explore gaze behavior variance and identify the degree of accessibility. Kruskal-Wallis One-way ANOVA (non-parametric) tests preceded by Shapiro-Wilk normality tests were performed to identify whether there are significant distinctions in gaze behavior of reflective and impulsive readers. The tests were used to estimate how the means of a dependent variable (First Fixation duration, Max Fixation duration, Average Fixation duration) change according to the 2-level independent variable, the presence or absence of each of the 28 foregrounding cues in two participant groups. We then scaled the Kruskal-Wallis χ^2-values of foregrounding cues (considering only the cases with significant p-values) as mediated by impulsive and reflective participants.

4   Results

4.1   Gaze metrics

MFFT [11] conducted at the first step of the experiment allowed to assess the time taken to respond (T) and the number of mistakes (MN) made by 16 participants (the gaze results of one participant were further discarded due to calibration problems). Two subject clusters were identified, 9 impulsive subjects (T = 370.3 s, MN =10.7) and 7 reflective subjects (T = 756.7 s, MN = 4.9). The gaze results of 15 participants were subjected to analysis. In Table 1 we show the gaze metrics (First Fixation duration, Max Fixation duration, Average Fixation duration) extracted from MultiCORText, which were further split into 2 data sets, for impulsive and reflective readers.

	First Fixation duration	Max Fixation duration	Average Fixation duration
N	700 / 637	700 / 637	700 / 637
Mean	169 / 164	210 / 200	165 / 161
Standard deviation	65.6 / 63.2	87.6 / 85	49.5 / 48.2
Variance	4309 / 3991	7675 / 7228	2447 / 2327

Table 1: Gaze metrics of impulsive / reflective readers

Descriptive statistics shows that although the differences in Mean values are not high, in all cases the values are lower for reflective readers. To identify the effects of foregrounding onto accessibility, individual gaze probes (700 for impulsive readers and 637 for reflective readers) were subjected to analysis. Since the gaze data do not have normal distribution (Shapiro-Wilk test with p< .001 proves it), a series of Kruskal-Wallis One-way ANOVA non-parametric tests (Kruskal-Wallis H tests) was conducted. Since 28 foregrounding cues were explored, 56 tests were carried out (in JAMOVI software).

4.2   Graphological foregrounding

15 Kruskal-Wallis H tests in each of the two groups were carried out with graphological foregrounding cues, 1a) no graphic foregrounding, 1b) italics, 1c) bold type, 1d) spacing, 1e) brackets, inverted commas, 1f) first letter capitalization, 1g) words capitalization 1h) non-standard graphology, 1i) tabulation, 1j) no orthographic foregrounding, 1k) full stop, 1l) comma (commas), 1m) exclamatory/question mark, 1n) dots, colon, 1o) hyphen. Both impulsive and reflective readers were affected by graphological foregrounding; still, we observed several differences.

Importantly, in the group of impulsive readers, only Max Fixation duration was modulated by foregrounding. We identified 5 foregrounding cues which produced significant effects onto the gaze behavior, which are first letter capitalization (Kruskal-Wallis χ^2 (1, 699) =5, p=0.025), tabulation (χ^2 (1, 699) = 6.13, p=0.013), full stop (χ^2 (1, 699) = 6.14, p=0.013), comma (χ^2 (1, 699) = 9, p=0.003), dots, colon (χ^2 (1, 699) = 6.85, p=0.009). The results show that impulsive readers were mostly affected by initial or final discursive act foregrounding cues, like in / Лицо ее выражает глубокое горе. / with both first letter capitalization and full stop, / Пауза. / with tabulation, first letter capitalization and full stop. This means that initial or final discursive act foregrounding cues make information more accessible for the impulsive readers.

In the group of reflective readers, both First Fixation duration and Max Fixation duration were affected. First Fixation duration was modulated by italics (χ^2 (1, 636) = 3.66, p=0.056) and brackets, inverted commas (χ^2 (1, 636) = 4.85, p=0.028). Max Fixation duration was modulated by bold type (χ^2 (1, 636) = 3.69, p=0.055), first letter capitalization (χ^2 (1, 636) = 7.44, p=0.006), words capitalization (χ^2 (1, 636) = 6.78, p=0.009), tabulation (χ^2 (1, 636) = 6.41, p=0.011), comma (χ^2 (1, 636) = 4.69, p=0.03). The results manifest that reflective readers observe the foregrounded information which appears both in the initial and final position of the discursive act and in within the discursive act like in / МИХАЛЕВ. / with words capitalization, / Я обомлела, когда вошла. / with comma. We can deduce that reflective readers develop a better access to any component of a discursive act than impulsive readers who mostly observe its beginning and its end.

4.3   Linguistic foregrounding

13 Kruskal-Wallis H tests in each of the two groups were carried out with linguistic foregrounding cues, 2a) phonological foregrounding (onomatopoeia, alliteration, etc.), 2b) proper name, 2c) superlative degree of adjective/adverb, 2d) perfective verb form, 2e) present tense verb manifesting past action, 2f) nonce-word, 1g) repetition of a word or word combination, 1h) code shifting, 1i) expressives and tropes, 1j) phraseological units and set phrases, 1k) elliptical or one-component sentence, 1l) sentence-final position for neutral syntactic focus, and sentence-initial position for contrastive syntactic focus, 1m) parallel constructions. In both groups, only Max Fixation duration was modulated by linguistic foregrounding cues.

Both impulsive and reflective readers showed higher gaze costs with parallel constructions (χ^2 (1, 699) =7.11, p=0.008 with impulsive readers, and χ^2 (1, 636) = 5.49, p=0.019 with reflective readers). This means that repeatability of linguistic structures attracts attention and consequently provides better access to information. Impulsive readers were also affected by phonological foregrounding (onomatopoeia, alliteration, etc.) (χ^2 (1, 699) =4.91, p=0.027). Reflective readers had higher gaze costs with elliptical or one-component sentence (χ^2 (1, 636) = 7.66, p=0.006). We assume that different reasons may cause these accessibility effects. Phonological foregrounding in a written text is expressed via graphic means mostly displayed in repetition of letters or combination of letters like in / Суббота, суббота – хороший вечерок. / where there is the repetition of letters and root morphemes or in the onomatopoetic words like in / Снова взрыв веселья. / where the combination of letters -в-з-р-в-

indicates an onomatopoetic sound combination. In both cases this type of foregrounding implies that a graphic form is focalized since it differs from other graphic forms. With reflective readers the situation is different. Higher gaze costs which appear in elliptical or one-component sentences indicate that these AOIs attract more attention because (in most cases) the propositional information is not distributed among the subject and the predicate but is packed within one syntactic unit, consequently it requires higher gaze costs to unpack it. Therefore, higher density of information can increase its accessibility for reflective readers. Seen in this way, the higher access of the reflective readers to parallel structures may be also explained by higher density of information produced by replicating either nominative structures like in / Заждалась вас, радость моя, светик… / or predicate ones like in / Добрый он, хороший. /.

5   Discussion

In this section we will present the foregrounding and accessibility effects on a systemic basis, for impulsive and reflective readers separately.

5.1   Foregrounding and accessibility with impulsive readers

The results have shown that only Max Fixation duration (out of 3 gaze metrics tested) was modulated by foregrounding cues. The results are in line with current trends, indicating that central tendency measures of fixation duration alone are not sufficient for eye movement analysis of information processing [17]. As shown by S. Negi and R. Mitra, extremely long fixations (>1000ms) contribute negatively to learning; therefore, Max fixation metric can provide evidence of information processing difficulties.

Major effects were observed with graphological foregrounding, which attests to the results of M. Reingold and K. Rayner [22] regarding longer fixation duration on the words in boldface. Still, we specified the foregrounding cues which produced higher gaze costs: first letter capitalization, tabulation, full stop, comma, dots, colon. We hypothesized that initial or final discursive act foregrounding cues make information more accessible for the impulsive readers, which conforms to the results received in the previous research [10]. Linguistic foregrounding does not produce such significant effects. Still, parallel constructions and phonological foregrounding (onomatopoeia, alliteration, etc.) appeared to attract higher attention. We assumed that these effects also account for graphic focalization, since in both cases we observe repeatability of linguistic structures. Consequently, this is the foregrounding by means of visually focal information which becomes more accessible for impulsive readers.

5.2   Foregrounding and accessibility with reflective readers

We found that both Max Fixation duration and First Fixation Duration displayed variance modulated by foregrounding effects; however, First Fixation Duration was affected only in two cases of graphological foregrounding. The results show that two metrics can be applicable to assess information processing difficulty, with initial processing manifesting in First Fixation Duration and processing difficulty manifesting in Max Fixation Duration.

Similarly with impulsive readers, reflectives were mostly attracted by graphological foregrounding; however, we observed that they had high access to both the information which appeared in the initial and final position of the discursive act and within the discursive act. The results indicate that their attention is guided by the position of foregrounding features in AOI. Importantly, linguistic foregrounding which produced higher access (parallel constructions and elliptical or one-component sentences) relates to the type which accounts for higher information density. This means that reflective readers tend to demonstrate top-down attention, which is consistent with the notion of the impulsive-reflective cognitive style [23]. The findings also prove that the developed semantic protocol specifying foregrounding cues following [7; 9; 18; 26; 27] is an efficient instrument to explore information accessibility.

6   Final remarks

In the paper, we explored the interrelation of foregrounding and information accessibility in reading. The study showed that information accessibility is maintained by at least two factors, different types of foregrounding (here – graphological and linguistic) and the readers' cognitive style (here – impulsive and reflective). The results help predict possible clines for impulsive and reflective readers attributed to

the differences in their attention types, bottom-up and top-down. Importantly, the results allow to range linguistic foregrounding effects in terms of their perception. Additionally, the study paves the way for developing a synergetic approach to information foregrounding and accessibility, which will make both linguistics and cognitive psychology benefit from it.

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