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THE ROLE OF CONTEXTUALLY DRIVEN EXPECTATIONS IN READING REFERENTIALLY AMBIGUOUS AND UNAMBIGUOUS SENTENCES

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Abstract

The current study is focused on referential ambiguity – a situation when a pronoun may be interpreted in favor of several referents. In the eye-tracking study, we aimed to investigate how referentially ambiguous and unambiguous sentences are processed when the readers' expectations are manipulated by context. Two stimuli groups with temporal ambiguity were used: a region with a pronoun was followed by a clause containing disambiguating information. A control unambiguous condition was created for each experimental item. In the first group, there was no specific bias towards any of referents, while in the second group the readers' expectations were biased towards the first-mentioned referent. The results showed that expectations are formed even before the pronoun appears. In the second group in the unambiguous condition it results in a slowdown at the pronoun region when it refers to the unexpected referent. The ambiguous condition allows interpreting the pronoun according to the readers' expectations, so the slowdown occurs only in the disambiguating area when the pronoun is disambiguated towards a less anticipated referent. In both cases the slowdown reflects reprocessing of the text and correcting the discourse representation. As for the stimuli with no predetermined expectation, there was no difference in the first-pass reading time of the region with a pronoun; however, the significant slowdown in the processing of disambiguating area is reported in the ambiguous condition compared to the unambiguous one, regardless of which referent the pronoun refers to. This may be caused by retrieval difficulty, by the necessity to reprocess the previous text or to establish referential relations.

Keywords: reference, pronominal reference, referential ambiguity, anaphora, ambiguous pronouns, context, eye-tracking.

Introduction

Imagine that someone is telling you a story about Sherlock Holmes and Professor Moriarty (and you have never heard it before). In excitement, the person says, "Sherlock and Moriarty were fighting near the waterfall... And then *he* fell off

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the cliff!". It is unobvious who won the fight, since the pronoun *he* in the second sentence may refer to either of the characters. This situation is called *referential ambiguity*, and it is being actively studied by psycholinguists. Most of the research is guided by the aim to define factors that influence the interpretation of an ambiguous pronoun by the addressee (Frederiksen, 1981; Smyth, 1994; Järvikivi, van Gompel, Hyona, & Bertram, 2005; Järvikivi, van Gompel, & Hyona, 2017; Kibrik, 2011; Fedorova, 2014; Prokopenya & Chernigovskaya, 2017, among others). Taken together, these studies show that referential ambiguity resolution does not depend on a single factor. The probability model proposed by A. Kehler and colleagues (2008; 2019) suggests that pronoun interpretation is guided by (i) the activation level of a particular referent in the addressee's cognitive system; (ii) expectations of the addressee regarding the referent to be mentioned next.

Most of the studies devoted to ambiguous pronouns were focused on the final pronoun interpretation. However, the process of establishing referential relations itself is of no less importance. A study by Stewart et al. (2007) revealed that the processing time of referentially ambiguous sentences depends on an experimental task, and if it does not require the resolution of a pronoun, there is no difference in reading time between ambiguous and unambiguous sentences. However, if ambiguity is temporal, i.e. if it is resolved by the following context, a significant slowdown in the disambiguating area in an ambiguous condition occurs. Since the self-paced reading technique was used in this study, it showed only general patterns of the processing, whereas the eye-tracking allows for more detailed registering of written language processing across time. Thus, our recent study showed no difference in the 1st-pass reading time between the phrases with referentially ambiguous and unambiguous pronouns, while there was an effect of ambiguity advantage at the late stages of processing, reflected in the shorter 2nd-pass reading time (i.e. re-reading time) for ambiguous sentences (Prokopenya, 2016). At the same time, a series of EEG-studies (van Berkum, Brown, & Hagoort, 1999; van Berkum, Brown, Hagoort, & Zwitserlood, 2003; Nieuwland, Otten, & van Berkum, 2007; Yurchenko, Fedorova, Kurganskii, & Machinskaya, 2018) show that when a reader or listener encounters an ambiguous noun or a pronoun, it elicits a distinct negative ERP-component *Nref* between 300–500 ms after its onset. There is no clear understanding of what the nature of the processes that underlie the *Nref*-component is: it may reflect the detection of the ambiguity itself, the attempt to preserve two possible interpretations in working memory, or '*controlled, strategic processing in order to solve the ambiguity*' (Ibid., p. 163). Moreover, the amplitude of *Nref* depends on the readers' expectations: the absence of a strong contextual bias towards one of the referents leads to a larger amplitude (Nieuwland & van Berkum, 2006).

In the present eye-tracking study we aimed to investigate how sentences containing temporal referential ambiguity and unambiguous sentences are processed when the readers' expectations are manipulated by context. Taking into account the ERP data, which showed that contextual bias leads to a decrease in the amplitude of the Nref-component, we suggest that in a case when the readers' expectations are biased towards one of the referents, the pronoun will be immediately interpreted in favor of this referent. If it turns out that the pronoun, in fact, refers

to a less anticipated referent there will be a significant slowdown in the disambiguating area since the reader has to reprocess the sentence and change an incorrect interpretation of the pronoun. Oppositely, there will be no difference from the unambiguous condition (i.e. no slowdown), when the ambiguous pronoun refers to the more anticipated referent.

On the other hand, previous studies showed that even though there is a particular ERP component, which amplitude is larger for ambiguous rather than for unambiguous pronouns, no difference in reading times between them is found. Based on this, we assume that in sentences without contextual bias the interpretation of an ambiguous pronoun can be postponed. This should lead to the absence of differences in processing time of the region with a pronoun between ambiguous and unambiguous conditions, but will cause a slowdown in the reading times of the disambiguating area (regardless of which referent the pronoun refers to), since the readers need time to integrate both the pronoun clause and the disambiguating clause at the same time when they get disambiguating information.

Method

Materials. We created two groups of discourse fragments, which consisted of two sentences:

1) with no contextual bias for any referent

(a) (b) Tanya was calmly moving down the street when Nadya suddenly came off the corner on rollerblades. Fortunately, she managed to stop quickly, and ***(a) Nadya / (b) Tanya moved on quietly****, without even recognizing the possibility of a crash.*

(c) (d) Tanya was calmly moving down the street when Misha suddenly came off the corner on rollerblades. Fortunately, (c) she / (d) he managed to stop quickly, and ***(c) Misha/(d) Tanya moved on quietly****, without even recognizing the possibility of a crash.*

Transliteration of the original Russian text:

(a) (b) Tanya spokoyno ehala po ulitse, kogda Nadya neozhidanno vyletela iz-za ugla na rolikah. K schastyu, ona zatormozila pochti momentalno, i ***(a) Nadya / (b) Tanya proehala spokoyno****, dazhe ne zametiv ugrozy stolknoveniya.*

(c) (d) Tanya spokoyno ehala po ulitse, kogda Misha neozhidanno vyletel iz-za ugla na rolikah. K schastyu, (c) ona zatormozila / (d) on zatormozil pochti momentalno, i ***(c) Misha proehal / (d) Tanya proehala spokoyno****, dazhe ne zametiv ugrozy stolknoveniya.*

2) with contextual bias towards the 1st referent

(a) (b) Lucy insulted Lera during the New Year party at school. Obviously, she tried to mend fences first, but ***(a) Lera / (b) Lucy turned the phone off****, as there was no time for sorting out their relationship.*

(c) (d) Lucy insulted Ilya during the New Year party at school. Obviously, (c) she / (d) he tried to mend fences first, but ***(c) Ilya / (d) Lucy turned the phone off****, as there was no time for sorting out their relationship.*

Transliteration of the original Russian text:

(a) (b) Lyusya silno obidela Leru na novogodney vecherinke v shkole. Ochevidno, ona pytalas pomiritsya pervoy, no ***(a) Lera / (b) Lyusya otklyuchila telefon****, tak kak vremeni dlya vyyasneniya otnosheniy ne bylo.*

(c) (d) Lyusya silno obidela Ilyu na novogodney vecherinke v shkole. Ochevidno, (c) ona pytalas / (d) on pytalsya pomiritsya pervoy, no ***(c) Ilya otklyuchil / (d) Lyusya otklyuchila telefon****, tak kak vremeni dlya vyyasneniya otnosheniy ne bylo.*

All referents were introduced by four-letter male and female names; each name appeared in each position an equal number of times. In the stimuli with no contextual bias (1) the first sentence consisted of two clauses with both referents serving as subjects of their clauses. In the stimuli with contextual bias (2) we used implicit causality (IC)[1] verbs with the "stimulus", or the cause of action, being the subject of the clause. The second referent, in turn, acted as the object of the same clause. Only the sentences with the 1st referent being more anticipated were used, since our goal was to create a strong contextual bias regardless of the factors that form readers expectations. The predetermined expectations for both stimuli groups were confirmed in the pretest, where participants[2] were asked to rate on a 4-point Likert scale the possibility of a pronoun to refer to a particular character.

Design. 64 experimental texts were constructed (32 per each group). Each text was presented in four conditions: (a) ambiguous, the pronoun refers to the 1st referent; (b) ambiguous, the pronoun refers to the 2nd referent; (c) unambiguous, the pronoun refers to the 1st referent; (d) unambiguous, the pronoun refers to the 2nd referent. Four experimental lists were created using a Latin square method: each list contained an equal number of texts in each condition and within the list each text was presented in only one condition.

Participants. 36 students of Saint Petersburg State University aged from 18 to 22 years (M = 19.6, SD = 1.4) with normal or corrected to normal vision took part in the experiment. All of them gave their written consent for participation.

Apparatus. An EyeLink 1000 Plus eye-tracker with 1000 Hz temporal resolution was used. Eye-movements were recorded in monocular mode with the head fixed, with 13-point calibration. The stimuli were presented in 14pt Arial font on a 1600x1024 pixels resolution monitor at an 81 cm distance.

Procedure. After the eye-tracker was calibrated, participants were instructed to read texts one by one at a comfortable pace and answer comprehension questions following randomly 1/3 of the texts. The experiment lasted for 30 minutes.

Results

Two areas of interest (IA) were chosen for the analysis: a) the clause containing a pronoun (*critical region*)[3]; b) the clause containing disambiguating information

[1] Implicit causality effect – "verbs used to describe interpersonal events give rise to different assumptions about the causes of the respective event" (Rudolph & Försterling, 1997, p. 192).

[2] None of them participated later in the main study.

[3] Underlined with a single line in examples (1) and (2)

(*post-critical region*).[4] For each area, the following measures were analyzed: 1st-pass reading time (time spent in an IA before moving forward or backward), go-past time (1st-pass + time spent on the returns to the previous areas before crossing the right boundary of an IA), total reading time of IA (Table 1). Repeated-measures ANOVA[5] with two within-subject factors (ambiguity x reference) was used for the analysis. Two recordings were discarded due to the tracker loss. A separate analysis was conducted for two stimuli groups.

Critical region. For stimuli with no contextual bias (1) there was a significant effect of ambiguity on the total reading time with more time spent in the region in an ambiguous condition ($F(1, 33) = 4.477$, $p = .042$), but there was no effect on 1st-pass or go-past time (*ps* > .05). There was no effect of reference on any of reading measures (*ps* > .05). There was a significant interaction of ambiguity and reference for 1st-pass time ($F(1, 33) = 6.405$, $p = .016$), but not for go-past or total reading time (*ps* > .05). However, a paired *t*-test for the 1st-pass time showed no difference between sentences with a pronoun referring to the 2nd referent and referring to the 1st referent in ambiguous and unambiguous conditions (*ps* > .05). When reading contextually biased stimuli (2) participants spent more time in total in the pronoun region in an ambiguous condition compared to an unambiguous one ($F(1, 33) = 18.622$, $p < .001$), but there was no significant difference between these conditions for the 1st-pass and go-past time (*ps* > .05). There was also a significant effect of reference

Table 1

Means of Eye Movement Measures, ms (SDs are Printed in Brackets)

		GROUP 1 equal anticipation for both referents				**GROUP 2 1st referent is more anticipated**			
AMBIGUITY		Ambiguous		Unambiguous		Ambiguous		Unambiguous	
REFERENCE		1st	2nd	1st	2nd	1st	2nd	1st	2nd
CRITICAL REGION	First-pass time	852 (56)	789 (54)	780 (45)	843 (56)	874 (54)	829 (54)	831 (47)	925 (60)
	Go-past time	967 (67)	1064 (65)	937 (62)	1000 (64)	1045 (58)	1069 (64)	972 (60)	1081 (68)
	Total time	1561 (101)	1542 (102)	1415 (102)	1469 (92)	1540 (100)	1642 (129)	1242 (72)	1455 (101)
POST-CRITICAL REGION	First-pass time	661 (42)	690 (39)	602 (34)	625 (33)	724 (42)	747 (48)	696 (39)	680 (38)
	Go-past time	845 (68)	836 (65)	652 (67)	667 (50)	967 (79)	1165 (98)	859 (64)	813 (57)
	Total time	1207 (76)	1277 (75)	967 (76)	959 (60)	1248 (85)	1372 (90)	969 (60)	1013 (65)

[4] Underlined and highlighted in bold in examples (1) and (2).

[5] Bonferroni adjustments were used for multiple comparisons.

on total reading time (F (1, 33) = 6.418, p = .016) but not on the 1st-pass and go-past times (ps > .05). Again, there was a significant interaction between ambiguity and reference for 1st-pass (F(1, 33) = 9.117, p = .005), but not for the go-past or total reading time (ps > .05). A paired t-test for the 1st-pass showed that there was a significant slowdown in the unambiguous condition when the pronoun referred to 2nd referent (t(33) = −3.018, p = .005). There was no significant difference in the ambiguous condition (p > .05).

Post-critical region. For stimuli with no contextual bias (1) there was a significant effect of ambiguity on all three measures: the 1st-pass (F(1, 33) = 7.257, p = .011), the go-past time (F(1, 33) = 9.008, p = .005), and the total reading time (F(1, 33) = 49.885, p < .001) — more time was spent in the region in ambiguous condition. No other significant effects for this group were found (ps > .05). For contextually biased stimuli (2) the same effect of ambiguity was found for the 1st-pass (F(1, 33) = 6.345, p = .017), the go-past (F(1, 33) = 37.146, p < .001) and the total reading times (F(1, 33) = 19.457, p < .001). More time in total was spent in the region when a pronoun referred to the 2nd referent (F(1, 33) = 4.512, p = .041). The was no effect of reference on the 1st-pass and go-past time (ps > .05). Finally, there was a significant interaction of ambiguity and reference for the go-past time (F(1, 33) = = 8.036, p = .008) but not for other two measures (p > .05). A paired t-test showed a longer go-past reading time when the pronoun referred to the 2nd referent in an ambiguous condition (t(33) = −2.548, p = .016). There was no such effect in the unambiguous condition (p > .05).

Discussion

In general, the results confirmed our hypothesis. The processing of referentially ambiguous and unambiguous sentences is influenced by contextually formed the readers' expectations: different reading patterns were obtained for two stimuli groups. There was no difference in the 1st-pass reading time between ambiguous and unambiguous conditions for stimuli with no contextual bias (1). This means that at the early stages of processing referential ambiguity does not require any additional processing cost, regardless of whether at this moment the ambiguity is only noticed, or the pronoun is immediately assigned to one of the referents (as in the unambiguous condition). However, a significant slowdown in the processing of a disambiguating area is reported in the ambiguous condition when compared with the unambiguous one. This shows that as soon as readers receive disambiguating information additional efforts are needed to process it: they are not moving further unless this part is integrated into the previous discourse and, if necessary, they return to the pronoun area to re-read it (as shown by the increased total time of this region). Three possible theoretical interpretations may be proposed to explain this slowdown in an ambiguous condition. Firstly, according to some theories, the interpretation of an ambiguous pronoun may be postponed unless disambiguating information is received (Poesio, Sturt, Artstein, & Filik, 2006; Karimi & Ferreira, 2015). If this is the case, then the slowdown in the disambiguating area may be explained by the necessity to finally interpret an ambiguous pronoun. On the other

hand, the recent study by Karimi et al. showed that referential processing is not only affected by the number of accessible referents or discourse coherence, but by the difficulty of retrieving a particular referent from memory (Karimi, Swaab, & Ferreira, 2018). Thus, ambiguity slowdown effect may be attributed to retrieval difficulty: ambiguous stimuli with no pre-determined expectations do not have any specific cues (such as gender, for example) that help readers distinguish between two referents. As a result, readers must return to the previous context in order to build a coherent discourse representation. Finally, it is possible that readers do not notice the ambiguity at all, and they interpret an ambiguous pronoun immediately after encountering it even in sentences with no predetermined expectations. In this case, the pronoun is assigned to a particular referent with 50% probability. And if the initial interpretation is wrong, the reader has to re-process the sentence after receiving disambiguating information, which in turn results in a slowdown (Stewart, Holler, & Kidd, 2007, pp. 1687–1688). This interpretation is probabilistic in nature and assumes that one of the referents is at least slightly preferable to another in each case for each particular reader. However, such explanation contradicts ERP-data that shows a greater amplitude for the *Nref*-component for ambiguous pronouns compared to unambiguous ones, thus reflecting differences in processing.

Analysis of the contextually biased stimuli (2) showed the clear effect of the readers' expectations. A significant slowdown in the 1st-pass reading time in the unambiguous condition when the pronoun referred to a less anticipated referent shows that expectations indeed were formed. When readers encountered an unexpected pronoun, it took some time to correct the discourse representation. In contrast, there was no such effect in the ambiguous condition, as the pronoun could be interpreted in line with the readers' expectations. This resembles the ambiguity advantage effect which was previously reported for syntactic and referential ambiguity (van Gompel, Pickering, Pearson, & Liversedge, 2005; Prokopenya, 2016). Ambiguity leaves a possibility for a reader to interpret it according to personal preferences, and in case of global ambiguity (with no disambiguation), there is no need to re-process the text. At the same time, as shown by the results of our study, in case of temporal ambiguity this advantage is only temporal as well. When an ambiguous pronoun was disambiguated towards a less anticipated referent there was a significant increase in the go-past time in the disambiguating area. This shows that readers returned to the previous areas in order to re-interpret the pronoun and correct the discourse representation before moving to the last part of the text.

Our study shows that referential processing of ambiguous and unambiguous sentences is affected by the readers' expectations that are formed by context. When these expectations are shifted towards one of the referents, an ambiguous pronoun is interpreted accordingly. This, in turn, leads to consequent reprocessing of a sentence when it is disambiguated towards a less anticipated referent. The mismatch between expectations and a real continuation of the discourse affects unambiguous sentences as well, since the expectations are formed even before the pronoun appears. In this case, readers need to correct their discourse representation as soon as the pronoun related to an unexpected referent is encountered. It was also shown

that when there are no predefined expectations, referential ambiguity requires more processing efforts when disambiguating information is received. This may be caused by retrieval difficulty, by the necessity to reprocess the previous text or to establish referential relations.

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Роль контекстно заданных ожиданий при чтении референциально однозначных и неоднозначных предложений

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Резюме

Данное исследование посвящено референциальной неоднозначности — ситуации, которая возникает, когда местоимение может быть потенциально проинтерпретировано в пользу нескольких упомянутых ранее референтов. С помощью методики регистрации движений глаз изучалось влияние контекстно заданных читательских ожиданий на обработку референциально однозначных и неоднозначных предложений. В качестве стимулов использовались короткие фрагменты дискурса с временной референциальной неоднозначностью: за фрагментом с местоимением следовала информация, разрешающая неоднозначность.

При этом стимулы были поделены на две группы. В первой группе не было более предпочтительного референта для местоимения, в то время как во второй группе первый упомянутый референт был более ожидаем. Каждый стимул был также представлен в однозначном условии. Результаты показали, что ожидания формируются еще до того, как появляется местоимение. Это приводит к тому, что при чтении однозначных стимулов из второй группы наблюдается замедление на фрагменте с местоимением, если оно относится к менее ожидаемому референту. Неоднозначное условие дает возможность проинтерпретировать местоимение в соответствии с ожиданиями, поэтому замедление возникает только при чтении разрешающего неоднозначность фрагмента, если оказывается, что местоимение относится к менее ожидаемому референту. В обоих случаях замедление связано с необходимостью заново обработать предложение и скорректировать ментальную репрезентацию. В стимулах с равно ожидаемыми референтами наблюдалось замедление при чтении фрагмента, разрешающего неоднозначность, независимо от того, к какому референту относится местоимение. Это может быть обусловлено трудностью извлечения референта из памяти, необходимостью повторной обработки предыдущего текста или самим процессом установления референциальных отношений.

Ключевые слова: референция, местоименная референция, референциальная неоднозначность, анафора, неоднозначные местоимения, контекст, ай-трекинг.

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