DIFFERENTIAL EFFECTS OF CONSTRAINTS IN THE PROCESSING OF RUSSIAN CATAPHORA

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ABSTRACT

Anaphoric relations between pronouns and their antecedents are subject to a number of different linguistic constraints, which exclude the possibility of coreference in specific syntactic or discourse contexts. Constraints on anaphora may, in principle, impact on-line sentence processing in a couple of different ways. They may act as constraints on the generation of interpretations, preventing illicit anaphoric relations from ever being considered. Alternatively, they may act as later filters on interpretations, rejecting candidate interpretations after initial consideration. A number of previous studies have sought to determine which of these mechanisms accurately describes the on-line impact of constraints on anaphora. The current studies present evidence that there is no uniform answer to this question, and that the two mechanisms are both used, for different constraints. Evidence for this is drawn from studies on the processing of two constraints on backwards anaphora or cataphora in Russian that apply in superficially similar contexts but that differ in a number of respects. One self-paced reading study and two judgment studies are reported. The self-paced reading study manipulates the gender congruency between a pronoun and a following name in three pairs of conditions. In conditions where the pronoun-name configuration violates no constraints on anaphora a gender mismatch effect was observed following the name, as in previous studies, suggesting that comprehenders actively search for an antecedent following a cataphoric pronoun. In conditions where the pronoun-name configuration violates Principle C of the classical binding theory no effect of the gender manipulation was observed, suggesting that comprehenders do not even consider the possibility of interpretations that violate this constraint. In conditions where the pronoun-name configuration violates a Russian-specific constraint on cataphora a gender match effect was observed following the name, the reverse of the finding in the no constraint conditions, suggesting that the constraint applies as a filter on candidate interpretations.

Keywords: backwards anaphora, cataphora, sentence processing, Russian, Principle C
Introduction

Anaphoric expressions such as pronouns (e.g., *she, him, their*) and reflexives (e.g., *herself, yourself*) are expressions that are dependent for their interpretation on other material in the context where they are used. Anaphora resolution is governed by a variety of different constraints at the levels of syntax, semantics, pragmatics and prosody, and these constraints vary across languages and across different anaphoric items within individual languages. Consequently, anaphora resolution has proven to be a fertile testing ground for theories of language processing (e.g., Garnham, 2001), and in particular for studies of the time course of constraint application in language comprehension.

The current study investigates how grammatical constraints impact the search for antecedents for pronouns, with a focus on *backwards anaphora* or *cataphora*, a type of pronominal dependency in which a pronoun linearly precedes its antecedent. A number of previous studies have investigated whether grammatical constraints on anaphora remove potential antecedents from consideration during on-line sentence comprehension. Most studies have found that grammatical constraints do impact anaphora resolution, but there are conflicting findings on exactly when and how ungrammatical antecedents are removed from consideration. Here we examine this issue through the lens of a pair of constraints on backwards anaphora in Russian that apply to superficially similar structures yet differ in a number of respects.

Grammatical constraints on anaphora could, in principle, impact the search for antecedents in at least two ways. Consider a sentence like *John thinks that Bill resents him*, in which the pronoun *him* may corefer with the main clause subject *John* but not with its clause-mate subject *Bill*, due to Principle B of the classical binding theory (Chomsky, 1981) or a more recent counterpart (e.g., Reinhart & Reuland, 1993; Reuland, 2001). The impact of Principle B may be to constrain the generation of candidate antecedents, such that the grammatically inaccessible *Bill* is never even considered as an antecedent for the pronoun. Alternatively the constraint may impact a later processing stage, such that both *John* and *Bill* are initially considered as candidate antecedents, and *Bill* is subsequently filtered out by Principle B. (Sturt (2003) describes these alternatives as ‘early’ and ‘late’ filters, respectively, but we prefer to restrict the term ‘filter’ to the latter cases only.) Sturt (2003) raises a third possibility, where grammatically inaccessible antecedents are blocked from consideration at an initial automatic stage, but under some circumstances may be reconsidered at a later stage.

Existing studies on the on-line impact of binding constraints have yielded conflicting results. In a study using a cross-modal lexical decision task Nicol and Swinney argued that Principles A and B of the classical binding theory act as constraints on the generation of candidate antecedents (Nicol & Swinney, 1989). For example, lexical decision times for words presented immediately after the pronoun *him* in sentences like *The boxer told the swimmer that the doctor for the team would blame him for the recent injury* showed facilitation for semantic associates of the two grammatically accessible antecedents (*boxer, swimmer*) but not for associates of the grammatically inaccessible antecedent (*doctor*). Similar conclusions about the role of constraints on anaphora have been drawn from studies using self-paced reading measures (Clifton, Kennison, & Albrecht, 1987; Lee & Williams, submitted), eye-tracking during reading (Sturt, 2003), and event-related brain potentials (Xiang, Dillon, & Phillips, submitted). However, another group of studies has found evidence of consideration of grammatically inaccessible antecedents, leading to the conclusion that constraints on anaphora act as late filters on a broader initial set of candidates. For example Badecker and Straub’s self-paced reading results suggest interference from grammatically inaccessible antecedents.
in the processing of the pronoun in ‘multiple match’ sentences like *John thought that Bill owed him another chance to solve the problem*, where the NP *Bill* is an impossible antecedent due to Principle B. Similar conclusions have been drawn from studies using self-paced reading (Kennison, 2003) and eye-tracking in the visual world paradigm (Runner, Sussman, & Tanenhaus, 2006).

It is possible that the discrepant results from previous studies may at least partly be due to methodological differences across studies. Measures like cross-modal lexical decision (Nicol & Swinney, 1989) provide good evidence of the activation of specific candidate antecedents, but offer limited time course information. Word-by-word reading measures such as self-paced reading (Badecker & Straub, 2002) and eye-tracking (Sturt, 2003) provide more detailed time-course information but less direct measures of antecedent activation. Even measures such as eye-tracking in the visual world paradigm, which promise continuous data and more transparent measures of referent activation, rely on specific assumptions about the link between gaze patterns and anaphoric dependency formation. Another possible source of discrepancy across different studies may be related to how closely the accessible and inaccessible antecedents were matched in discourse prominence, a property that modulates the impact of potential antecedents on processing (see Badecker & Straub, 2002; Sturt, 2003 for a discussion).

Most previous studies on binding constraints in language processing have focused on cases of forwards anaphora, in which comprehenders encounter a pronoun or reflexive after encoding the potential antecedents in memory. Consequently, forwards anaphora resolution is a retrospective process that potentially requires multiple candidate antecedents to be considered simultaneously. Such situations may be particularly sensitive to the contrasting salience of different antecedents, and this may mask the effects of grammatical constraints. A straightforward way to avoid this concern is to turn to cases of backwards anaphora/cataphora. Cataphora is less frequent than forwards anaphora, yet both natural and common in English, e.g., *When she enters the classroom, Zoe sits down at the art table* (see van Hoek, 1997 for naturalistic data). From the perspective of on-line interpretation the resolution of backwards anaphora proceeds differently from the resolution of forwards anaphora. After identifying a cataphoric pronoun a comprehender may consider each subsequent noun phrase as a potential antecedent and evaluate it individually at the time of its maximal salience in the discourse (i.e., when it is the current incoming word or phrase).

In an eye-tracking study van Gompel and Liversedge (2003) investigated the time course of reference resolution between cataphoric pronouns and grammatically accessible antecedents. Using sentences like *When she was fed up, the {girl/boy} visited the {boy/girl} very often*, they found that comprehenders attempt to link a cataphoric pronoun (*she*) to a potential antecedent (*the girl/boy*) before they have confirmed that the expression is semantically compatible with the pronoun. Evidence for this comes from a slowdown in reading times when readers encountered a noun phrase that mismatched in gender with a preceding pronoun. Van Gompel and Liversedge argue that this gender mismatch effect reflects an unsuccessful attempt to create a referential dependency between the name and the pronoun, and further that this effect could only have arisen if readers attempt to create referential dependencies before verifying its semantic well-formedness. Kazanina, Lau, Lieberman, Yoshida, & Phillips (2007) replicated the gender mismatch effect using a self-paced reading paradigm, and attributed the effect to the parser’s active search for an antecedent. They suggest that when comprehenders encounter a cataphoric pronoun in a clause like *While she was working two jobs to pay the bills...* they anticipate the upcoming main clause subject position and construct a referential dependency between that position and the pronoun. If the sentence continues with a compatible main clause subject, such as ...*Kathryn was taking classes full-time*, then
comprehension proceeds smoothly. But if the main clause subject mismatches the pronoun, as in **Russell was taking classes full-time**, then the dependency must be revised and processing disruption ensues. Kazanina and colleagues regard this mechanism as a counterpart of the active dependency formation mechanism that has been extensively documented for filler-gap dependencies (Frazier & Flores D’Arcais, 1989; Garnsey, Tanenhaus, & Chapman, 1989; Kaan, Harris, Gibson, & Holcomb, 2000; Stowe, 1986). We return in the General Discussion to the issue of the specific mechanisms that underlie the gender mismatch effect.

Kazanina and colleagues show further that the gender mismatch effect disappears in syntactic contexts where backwards anaphora is excluded by Principle C of the binding theory. Principle C rules out coreference between a pronoun and any referring expression that it c-commands (Chomsky, 1981; Reinhart, 1983). They found that when comprehenders encounter a nominal in the c-command domain of a cataphoric pronoun, as in **She was taking classes full-time while {Kathryn/Russell} was working two jobs to pay the bills**, reading times were unaffected by the gender compatibility between the nominal and the pronoun. This finding was confirmed across several different types of structures that are subject to Principle C. (For related findings in Japanese see Aoshima, Yoshida, & Phillips, in press.) This led Kazanina and colleagues to argue that Principle C acts as a constraint on generation in on-line comprehension (for earlier evidence from a naming study see Cowart & Cairns, 1987). It is unlikely that the structurally inaccessible antecedents were ignored in these studies due to insufficient salience, since the critical data came from reading times when those nominals were in the focus of attention.

The finding that comprehenders are apparently blind to anaphoric dependencies that violate Principle C raises the question of why this constraint should exert such a powerful effect in on-line reference resolution, particularly in light of the inconsistent findings from studies on other constraints on anaphora. At least two possibilities suggest themselves. First, there may be a general advantage for constraints on backwards anaphora, due to the possibility for sequential evaluation of potential antecedents. Second, the structural properties of Principle C may be particularly conducive to exclusion of inappropriate antecedents, since the search mechanism may recognize the irrelevance of an entire structural domain – that is, any domain that is c-commanded by the pronoun – in advance of encountering any bottom-up information about potential antecedents in the input. We explore these questions using Russian, which in addition to Principle C possesses another Russian-specific constraint on backwards anaphora. As described below, the two constraints apply in superficially similar circumstances yet differ in a number of important respects, such as in when and how potential antecedents can be conclusively excluded from an antecedent search.

Russian, like English, generally allows backwards anaphora. This is illustrated in (1) using sentences in which an initial subordinate clause is introduced by the subordinator **posle togo kak** ‘after’. Also like English, backwards anaphora in Russian is constrained by Principle C, such that a pronoun cannot c-command its antecedent. Hence in (2) the pronoun main clause subject cannot be interpreted as coreferential with the subject of the following subordinate clause. Since these two constructions in Russian parallel their English counterparts, we expect that manipulation of the

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1 Apparent exceptions to Principle C have been discussed in the linguistic and psycholinguistic literature, e.g. the sentence **He was threatening to leave when Billy noticed that the computer had died** in which he may be understood as coreferent with Billy (Harris & Bates, 2002). Although we believe that these cases may not ultimately be counterexamples to the structural Principle C (see Kazanina, 2005 for more discussion), we took care to avoid such potential exceptions in constructing the experimental materials for the present study and verified the acceptability of all contrasts under investigation by off-line questionnaires.
gender of the second clause in each case should elicit the same reading time effects previously observed in English.

(1) Posle togo kak oni pročital knigu, Ivan s”el jablko. [no-constraint]
    after he read book Ivan ate apple
    ‘After he read the book, Ivan ate an apple.’

(2) *Oni čital knigu, poka Ivan el jablko. [Principle C]
    he read book while Ivan ate apple
    ‘He read a book while Ivan ate an apple.’

The second Russian-specific constraint on backwards anaphora is exemplified by biclausal sentences such as (3) that begin with the subordinator poka ‘while’ (henceforth, poka-sentences). In (3) coreference between the pronoun on ‘he’ and Ivan is disallowed due to an idiosyncratic constraint on backwards anaphora in Russian (note that in the English translation of (3) coreference between he and Ivan is perfectly acceptable). The constraint, which we will refer to as the poka-constraint for the sake of exposition, is cross-linguistically rare, and appears not to apply even in other Slavic languages that are closely related to Russian, such as Polish or Serbo-Croatian. Critically, even in Russian the scope of the poka-constraint is limited to contexts in which both the pronoun subject of the poka-clause and the following main subject are agentive, as in (3). Sentences in which one of the subjects is non-agentive are acceptable on the coreference reading, as exemplified by (4) with an Experiencer main subject (Kazanina & Phillips, 2001). Thus, the Russian poka-constraint can be summarized as follows: in poka-sentences an agentive pronoun subject of the embedded clause cannot corefer with an agentive main clause subject. The constraint also applies in sentences containing other subordinators that encode simultaneity, such as v to vremja kak ‘at the time when’.

(3) *Poka oni čital knigu, Ivan s”el jablko. [poka-constraint]
    while he read book Ivan ate apple
    ‘While he read the book Ivan ate an apple.’

(4) Poka ona razgovarivala po telefonu, Maša vspeomnili, chto zabyla kupit’ xleba.
    while she talked on phone Masha remembered that forgot buy bread
    ‘While she talked on the phone Masha remembered that she forgot to buy some bread.’

Note that the poka-constraint does not block coreference in sentences in which the embedded clause expresses a habitual event, however, in this paper we will not consider such cases. More detailed treatments of the contexts where the poka-constraint applies and theoretical accounts of the phenomenon can be found in other works (Avrutin & Reuland, 2004; Kazanina, 2005; Kazanina & Phillips, 2001; Reuland & Avrutin, 2005). For the purposes of the current study it is sufficient to note that there is agreement that the constraint is not a purely syntactic restriction, and that it implicates discourse representations. From the perspective of on-line language processing the thematic role restriction on the constraint is particularly interesting, since this implies that the applicability of the constraint depends on thematic information that may not appear in a sentence until after the pronoun-name sequence. This, together with the non-syntactic nature of the constraint, raises the question of whether the poka-constraint impacts on-line reference resolution in the same way that Principle C does, or whether it applies as a late filter on candidate antecedents. In the
studies that follow we first verify Russian speakers’ awareness of Principle C and the \textit{poka}-constraint and investigate their application during online processing (Experiment 1). We then go on to verify that the results from the online task were not confounded by plausibility biases (Experiment 2).

\textbf{Experiment 1}

Experiment 1 had two parts: an off-line rating task and an online self-paced reading task. The off-line rating task (Experiment 1A) tested the prediction that Russian speakers should reject coreference between a cataphoric pronoun and a main clause subject in Principle C or \textit{poka}-contexts, but should accept coreference in other backwards anaphora structures that do not violate any grammatical constraints. The online experiment (Experiment 1B) investigated the process of establishing backwards anaphoric dependencies in real-time processing. In particular, we were interested in whether the different types of grammatical information associated with Principle C and the \textit{poka}-constraint cause grammatically inaccessible antecedents to be removed from consideration in the same fashion.

\textbf{Experiment 1A: Acceptability Rating Task (off-line)}

\textit{Materials and Design.} The experiment was administered in the form of a pen-and-paper questionnaire using a similar methodology to Gordon and Hendrick (1997). Each questionnaire contained 12 target sentences, equally distributed among three conditions (Principle C, \textit{poka}-constraint, no-constraint), exemplified in (5)-(7). Forty-two native speakers of Russian from Moscow (aged 18-32) were asked to judge for each sentence the acceptability of a coreferential interpretation of a boldfaced pronoun-name pair, using a scale from 1 (impossible) to 5 (absolutely natural). The specific form of the question (translated from Russian) was: \textit{Can the pronoun in bold and the noun in bold refer to the same person?}

(5) Principle C condition
\begin{quote}
*Ona pila utrennij kofe, poka \textbf{Olga} rešala kakoj-nibud’ krossvord.
‘She drank her morning coffee while Olga solved a crossword puzzle.’
\end{quote}

(6) \textit{Poka}-condition
\begin{quote}
*Poka \textbf{ona} pila utrennij kofe, \textbf{Olga} rešala kakoj-nibud’ krossvord.
‘While she drank her morning coffee Olga solved a crossword puzzle.’
\end{quote}

(7) No-constraint condition
\begin{quote}
Posle togo kak \textbf{ona} napisala zakazannuju stat’ju, Nataša, pravila tekst neskol’ko raz.
‘After she wrote a commissioned article, Nataša edited the text several times.’
\end{quote}

Materials for the offline task were a randomly chosen subset of truncated versions of the materials used for the online task (see below). Eight pairs of Principle C and \textit{poka}-conditions like (5)-(6) were distributed across two versions of a questionnaire using a Latin Square design. In each pair the sentences contained identical lexical material and differed only in the position of the conjunction \textit{poka} ‘while’. The subjects of the main and embedded clauses were always nominative agents. These conditions were complemented with four no-constraint sentences (7), introduced by the subordinators \textit{do togo kak} ‘before’ or \textit{posle togo kak} ‘after’. The no-constraint items were not.
lexically matched to the other conditions, due to the contrasting aspectual and plausibility-related demands of the different conditions (see below for further discussion). In total each questionnaire contained 12 experimental items (four per condition) interspersed with 8 fillers.

**Results & Discussion.** The mean rating scores were low in the Principle C condition (mean = 1.1, s.e. = .04) and in the *poka*-condition (mean = 1.3, s.e. = .14) and higher in the no-constraint condition (mean = 3.7, s.e. = .17). The differences in the mean ratings were significant (*F*(2, 123) = 340.1, *p* < .001), due to higher acceptability ratings in the no-constraint condition than in the other two conditions (both *ps* < .001, post-hoc tests with Bonferroni correction). Acceptability ratings in the Principle C and *poka*-conditions did not differ reliably from each other (*p* > .1). The acceptability ratings thus confirm that Russian speakers equally strongly disallow coreference in sentences that are subject to Principle C and the *poka*-constraint, whereas they freely accept backwards anaphora in the no-constraint sentences.

**Experiment 1B: Self-paced reading experiment**

**Participants.** A new group of 48 Russian speakers (ages 18-28 years) was recruited in Moscow. All participants had normal or corrected-to-normal vision and no history of language disorders. They gave informed consent and were paid the equivalent of $10 for their participation.

**Materials.** The experiment contained 6 conditions: 4 conditions (Principle C and *poka*-conditions) organized in a 2 × 2 factorial design and 2 additional no-constraint conditions. A full set of materials for the online experiment is shown in Table 1.

Twenty-four sets of items were constructed according a 2 × 2 design with the factors *constraint type* (Principle C vs. *poka*-constraint) and *gender congruency* (gender-match vs. gender-mismatch) affecting the relation between the pronoun in the first clause and the subject of a second clause. Target structures were all embedded inside an enclosing clause, for reasons explained below. The only difference between the gender-congruent and gender-incongruent variants in each pair was the gender of the subject of the second clause (and the following predicate, due to gender agreement on Russian past tense verbs). The gender of the pronoun was counterbalanced across items. The second subject was always a gender-unambiguous proper name, and the number of characters and syllables in the gender-matching and gender-mismatching names was matched. Materials were designed so as to limit the likelihood of a plausibility-bias for or against a coreferential interpretation of the name-pronoun pair, independent of constraints on anaphora. In particular, care was taken to use main and embedded clause events that could plausibly be performed either by different agents or by a single agent. Furthermore, pairs of events were chosen such that the plausibility of the disjoint or coreference interpretation were similar for the Principle C and the *poka*-conditions. This was important in order to exclude the possibility that the reading-time profiles in the two pairs of conditions might differ due to a bias in the stimuli rather than to differences in the online application of the two constraints. Experiment 2 further addresses this issue.

Additionally, the experiment contained 12 pairs of items from the no-constraint conditions. The no-constraint conditions were licit backwards anaphora sentences such as (1) that contained an embedded clause introduced by the subordinators *do togo kak* ‘before’ or *posle togo kak* ‘after’. These embedded clauses linearly preceded the main clause and were therefore structurally parallel to the *poka*-conditions. Similar to the other two conditions, the gender of the second subject NP was
varied to obtain gender-congruent and gender-incongruent variants. These structures do not violate any constraints on coreference, and were included to provide a baseline measure of how Russian speakers establish licit backwards anaphoric dependencies. In light of the previous findings in English we expected a gender-mismatch effect at the second subject position.

The lexical content of the no-constraint conditions differed from the other 4 conditions, because of the differing semantic conditions on the use of the subordinators used. The subordinator *poka* ‘while’ used in the Principle C and *poka*-conditions requires an imperfective embedded verb and is most naturally used with an episodic event, whereas the subordinators *do togo kak* ‘before’ and *posle togo kak* ‘after’ require a perfective embedded verb and are more naturally used with a durative or habitual main event.

In order to ensure that the cataphoric pronoun could be associated with a grammatically acceptable antecedent in every sentence, the target structures were embedded in a further clause introduced by the conjunctions *xotja* ‘although’ or *poskol’ku* ‘since’. The gender of the third clause subject was chosen such that each sentence had a unique grammatical antecedent for the pronoun. This follows a design strategy that proved successful in previous studies on English (Kazanina et al., 2007). In the Principle C and *poka*-conditions the subject of the third clause matched in gender with the pronoun and served as a grammatical antecedent. In the no-constraint conditions the gender of the third clause subject mismatched the pronoun in the gender-match condition, due to the possibility of coreference between the pronoun and the second clause subject, but the third clause subject matched the gender of the pronoun in the gender-mismatch condition. A full list of experimental materials is given in Appendix 2.

<table>
<thead>
<tr>
<th>Principle C conditions, gender-match/gender-mismatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xotja každoe voskresenje ona, pila utrennij kofe, <em>Olga/Yurij</em> rešala/rešal kakoj-nibud’ uvlekatel’nyj krossvord, Marina, nikogda ne predlagala pomoč’. ‘Although every Sunday she drank her morning coffee while Olga/Yurij solved an interesting crossword puzzle, Marina never offered any help.’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Poka-conditions, gender-match/gender-mismatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xotja každoe voskresenje <em>poka</em> ona, pila utrennij kofe, <em>Olga/Yurij</em> rešala/rešal kakoj-nibud’ uvlekatel’nyj krossvord, <em>Marina</em> nikogda ne prinimala učastija v razgadke voprosov. ‘Although every Sunday while she drank her morning coffee Olga/Yurij solved an interesting crossword puzzle, Marina never participated in puzzle solving.’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No constraint, gender-match/gender-mismatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xotja posle togo kak ona, napisala zakazannuju stat’ju, <em>Nataša/Mixail</em> pravila/pravil tekst neskol’ko raz, <em>Mixail/Nataša</em> bol’še vsego gordilsja svoim pervonačal’nym variantom. ‘Although after she wrote a commissioned article Natasha/Michael edited the text several times, Michael/Natasha was most proud about the original version.’</td>
</tr>
</tbody>
</table>

Table 1. A sample set of items used in self-paced reading Experiment 1B. The critical name in the second subject position is underlined. Subscript indices indicate the intended grammatically licit backward anaphoric dependencies.

The target items were distributed among four presentation lists of 36 sentences, each containing 6 exemplars of each experimental condition in a Latin Square design, and interspersed with 84 filler
sentences. The filler sentences varied in length and complexity and were superficially similar to the target items, e.g., they contained proper names or started with a subordinator. Each participant was randomly assigned to one of the lists, and the order of the stimuli within a presentation list was randomized for each participant.

Procedure. Participants were tested using a Windows laptop computer running the Linger software (developed by Doug Rohde, MIT). Sentences were presented in a standard non-cumulative word-by-word moving window paradigm (Just, Carpenter & Woolley, 1982) using the font Courier New Cyrillic 20. Each sentence initially appeared on the screen masked by dashes that covered all letters and punctuation marks, but left spaces between words unmasked. Each time the participant pressed the spacebar a new word appeared on the screen and the previous word was re-masked by dashes. A yes/no comprehension question appeared after each sentence in a single display. Participants were instructed to read sentences at a natural pace and to respond to the comprehension questions as accurately as possible. If the question was answered incorrectly the word ‘Incorrect’ briefly appeared in the center of the screen. The testing session lasted approximately 40 minutes.

Analysis. Participants were excluded from the final analyses if they failed to correctly answer at least half of the comprehension questions in an individual experimental condition which led to the exclusion of two participants in the no-constraint conditions and in the Principle C and poka-conditions. The final analyses were based on the data from 46 participants. Only sentences for which the comprehension question was answered correctly were included in the analyses of reading times. Furthermore, reading times that exceeded a threshold of 2500 ms were replaced by the threshold value. This winsorising procedure affected 0.4% of data points in the Principle C and poka-conditions and 0.3% of data points in the no-constraint conditions. Reading times were analyzed in regions that corresponded to a single word, with the exception of the last region in each clause, which represented the average per-word reading time for all remaining words in that clause. Reading times were statistically analyzed by fitting a linear mixed effect model using the lmer function from the lme4 package in R (version 2.6.2; CRAN project; The R Foundation for Statistical Computing, 2008). Unlike more traditional ANOVAs, mixed effects models take unaveraged data as input and make it possible to incorporate both random effects of participants and items within a single analysis. Models were fit using a restricted maximum likelihood technique. For the data from the poka- and Principle C conditions the model fitting proceeded as follows: initially a model that only included random factors (participants and items) was applied. This initial model was first enriched by adding the first fixed factor constraint (Principle C vs. poka-constraint) and subsequently by including the other fixed factor gender congruency (gender-match vs. gender-mismatch). Finally the interaction constraint x gender congruency was added to the model. Each successive pair of models was evaluated to assess whether the additional factor improved the model fit to the data. The most complex model that significantly improved the fit over the previous model is considered to be the best fitting model and its estimates are reported below. The fitting procedure was identical for the no-constraint conditions with the exception of involving only one fixed effect (gender-congruency). Model-fitting was performed for each region in the sentence individually. For the analyses of the binary variable ‘accuracy (correct/incorrect)’ a binomial family was used. In all cases where an interaction was significant we report pairwise comparisons and the relevant 95% confidence interval derived by Markov Chain Monte Carlo simulation (Baayen, Davidson & Bates, 2008). Reading times from the no-constraint condition were analyzed separately, with gender congruency (gender-match vs. gender-mismatch) as a fixed factor and participants and items as random factors. All significant main effects and interactions with $p < .05$ are reported.
Results

Comprehension question accuracy. The mean comprehension question response accuracy was 88.6% in experimental items, and 93.2% in filler items. Accuracy rates for individual experimental conditions are summarized in Table 2.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean accuracy (st. error)</th>
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<th>Mean accuracy (st. error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-constraint, gender-match</td>
<td>92.8 (1.1)</td>
<td>Principle C, gender-match</td>
<td>88.0 (1.0)</td>
</tr>
<tr>
<td>No-constraint, gender-mismatch</td>
<td>88.0 (1.4)</td>
<td>Principle C, gender-mismatch</td>
<td>92.4 (.8)</td>
</tr>
<tr>
<td>Poka, gender-match</td>
<td>90.0 (1.7)</td>
<td>Poka, gender-mismatch</td>
<td>84.4 (1.1)</td>
</tr>
<tr>
<td>Poka, gender-mismatch</td>
<td>90.2 (.9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Mean comprehension question accuracy rates by condition from Experiment 1B.

In the no-constraint conditions there was a marginally significant effect of gender-congruency ($z = 1.904, p = 0.057$) with the gender-match condition yielding a higher mean accuracy rate than the gender mismatch condition. The effect of gender-congruency was also significant in the Principle C and poka-conditions ($z = -2.9, p = 0.003$) but the direction of the effect was reversed: a higher mean accuracy rate was found in the gender-mismatch conditions than in the gender-match conditions (91.3% vs. 86.2%). There also was a marginally significant effect of constraint type ($z = 1.8, p = 0.068$) due to higher accuracy rates in the Principle C conditions than in the poka-conditions (90.2% vs. 87.3%).

Figure 1. Mean reading times from the no-constraint conditions in Experiment 1B. A gender mismatch effect (GMME) that appeared two words after the critical subject NP is marked by a box.
Reading Times (RTs).

The results from the no-constraint conditions are reported first, followed by the results from the Principle C and poka-conditions. The region means and the information on the best-fitting model for each region are summarized in Appendix 2.

No-constraint conditions. Figure 1 shows word-by-word reading times in the no-constraint conditions. Mean reading time differences were small throughout the first clause (Regions 1-8), at the critical second subject (Region 9: Natasha/Michael) and in the following region. However, in Region 11, two words after the critical second subject NP, the mean reading time in the gender-incongruent sentences was 65 ms longer than in the gender-congruent sentences (607 vs. 542 ms respectively). This difference led to a marginally significant main effect of gender-congruency ($\beta = -48.3$, $t(497) = -1.86$, $p = .057$). The same numerical trend for longer reading times in the gender-incongruent condition continued at the following two regions, but reached significance only in Region 13 (614 vs. 542 ms, $\beta = -57.6$, $t(497) = -2.06$, $p = .040$). There were no other significant effects in the remainder of the sentence. Thus, reading times in the no-constraint conditions replicate the gender mismatch effect observed in studies of cataphora processing in English (van Gompel & Liversedge, 2003; Kazanina et al., 2007).

Principle C and poka-conditions. Figure 2 shows the results from the Principle C conditions and Figure 3 shows the results from the poka-conditions.

At the determiner in Region 2 there was an unexpected significant effect of constraint type ($\beta = 30.3$, $t(976) = 2.1$, $p = .030$) and a marginally significant constraint $\times$ gender-congruency interaction ($\beta = -36.3$, $t(976) = -1.8$, $p = .069$). This effect must be spurious, since the conditions were identical up to this point, and it should be noted that the effect corresponded to a small difference in mean reading times. At Region 6 of the first clause there was also a marginally significant effect of constraint type ($\beta = 57.5$, $t(976) = 1.94$, $p = .057$) which was most likely due to the presence of an extra word in the poka-conditions compared to the Principle C conditions. There were no other significant effects or interactions at any region in the first clause. There was a main effect of constraint type at the critical second subject in Region 9 due to longer mean reading times in the poka-conditions than in the Principle C conditions (mean reading times 555 ms vs. 499 ms respectively; $\beta = -59.4$, $t(978) = -4.04$, $p < .001$). This effect was likely caused by differences in the lexical material in the immediately preceding region. The subordinator while immediately preceded this region in the Principle C conditions and may have provided an effective cue for the appearance of a subject NP in Region 9. There were no significant effects or interactions in Regions 10-11. However, in Region 12, three words after the critical second subject, there was a significant effect of congruency ($\beta = 57.8$, $t(960) = 2.48$, $p = .015$), and a marginally significant constraint $\times$ congruency interaction ($\beta = -61.7$, $t(960) = -1.89$, $p = .057$). Pairwise comparisons within each level of the constraint factor revealed a significant effect of congruency in Region 12 of the poka-conditions due to longer mean reading times when the second subject matched in gender with the preceding pronoun (581 vs. 523 ms; 95% CI = 96 ms; $\beta = 58.1$, $t(473) = -2.38$, $p = .018$). This is a gender-match effect, the inverse of the effect found in the no-constraint conditions. In the Principle C conditions, on the other hand, reading times were almost identical at both levels of the gender congruency factor (gender-congruent – 528 ms, gender-incongruent – 533 ms; 95% CI = 84 ms; $\beta = -2.0$, $t(487) = -0.09$, $p = .957$). There were no significant effects in Region 13.
Figure 2. Mean reading times from the Principle C conditions in Experiment 1B.

Xotja₁ / každœ₂ / voskresenje₃ / ona₄ / pila₅ / utrennij₆ / kofe₇ / pokas₈ / Olga (Yurij)₉ / rešala (rešal)₁₀ / kako-jnibud’₁₁ / uvlekatel’nyj₁₂ / krossvord₁₃ / Marina₁₄ / nikogda₁₅ / ne₁₆ / predlagala1 pomoč’,₁₇ ‘Although every Sunday she drank her morning coffee while Olga (Yurij) solved an interesting crossword puzzle, Marina never offered any help.’

Figure 3. Mean reading times from the pokas-conditions in Experiment 1B. A gender-match effect (GME) that started three words after the critical subject NP is marked by a box.

Xotja₁ / každœ₂ / voskresenje₃ / pokas₄ / ona₅ / pila₆ / utrennij₇ / kofe₈ / Olga (Yurij)₉ / rešala (rešal)₁₀ / kako-jnibud’₁₁ / uvlekatel’nyj₁₂ / krossvord₁₃ / Marina₁₄ / nikogda₁₅ / ne₁₆ / prinimala učastija v razgadke voprosov.₁₇ ‘Although every Sunday while she drank her morning coffee Olga (Yurij) never participated in puzzle solving.’

At the subject of the third clause in Region 14 there was a main effect of gender-congruency ($\beta = 45.9, t(977) = 2.85, p = 0.006$). In both the Principle C conditions and the pokas-conditions mean reading times for the third subject NP were slower in conditions where the earlier second subject NP had matched the gender of the pronoun. Recall that in all four of these conditions the third subject NP provided a grammatically accessible antecedent for the pronoun. In Region 15 there was a main effect of congruency ($\beta = 52.9, t(976) = 2.76, p = 0.006$) and a significant constraint $\times$ congruency interaction ($\beta = -74.3, t(976) = -2.76, p = 0.005$). Resolution of this interaction revealed that the
effect of congruency was significant in the pokä-conditions, due to longer mean reading times in the gender-congruent condition than in the gender-incongruent condition (527 vs. 473 ms respectively; 95% CI = 78 ms; $\beta = 51.8$, $t(480) = 2.59$, $p = 0.013$), but not in the Principle C conditions (gender-congruent – 477 ms, gender-incongruent – 502 ms; 95% CI = 66 ms; $\beta = -14.7$, $t(496) = -0.86$, $p = 0.397$). There were no significant or marginally significant main effects or interactions in the remainder of the sentence (Regions 16-17).

Discussion

In Experiment 1B we found that manipulation of the gender of the subject of the second clause led to a gender-mismatch effect in the no-constraint conditions and had no impact on reading times in the Principle C conditions. These results from Russian replicate earlier findings based on similar English sentences (van Gompel & Liversedge, 2003; Kazanina et al., 2007). Additionally, we found a gender-match effect at the same region in the pokä-conditions, which are subject to a Russian-specific grammatical constraint. This gender-match effect is the inverse of the reading-time pattern observed in the no-constraint conditions.

It is worth noting that the comprehension accuracy results are very consistent with the findings based on mean reading times. In the no-constraint conditions the gender-congruent condition yielded a significantly higher accuracy rate than its gender-incongruent counterpart, whereas the pattern was reversed in the other two pairs of conditions. This is likely because in the no-constraint condition the congruent variant was the easier one: the parser actively anticipated an antecedent in the second subject position and this expectation was fulfilled. In the Principle C and the pokä-conditions, on the other hand, the second subject was easier to rule out in the gender-incongruent condition when it was ‘doubly’ illicit, due to the constraint and to the mismatch in gender with the pronoun.

It is interesting that the Principle C and the pokä-constraint conditions yielded different reading-time profiles, despite the fact that both structures are quite similar on the surface and yielded similarly low acceptability ratings for backwards anaphora interpretations. Before interpreting these results it is important to ensure that the differences in the processing of the two sets of conditions were indeed due to the different constraints on coreference, rather than to artifacts of the stimuli that we used. The sentences in the Principle C and pokä-conditions differed only in the position of the subordinator while. Ideally, this manipulation should have had no other effect beyond changing the sentence structure so that the sentence either invoked Principle C or the pokä-constraint. However, this structural change was accompanied by a shift in the figure/ground relation of the two events (E1 and E2) described in the sentence, as illustrated in (8):

$$\text{(8) Principle C: } \begin{array}{l} E1, \text{ while } E2 \\ \text{pokä-condition: } \text{While } E1, E2 \end{array} \quad [E1 = \text{figure}, E2 = \text{ground}] \quad [E1 = \text{ground}, E2 = \text{figure}]$$

The subordinator while establishes a relation in which the embedded event serves as a ground for the main event, which is a figure (also known as foregrounding/backgrounding, e.g. Matthiessen & Thompson, 1988). Thus, in addition to the structural differences between the conditions in (8), the sentences also differed in which of the events E1 and E2 was figure or ground. This change of figure/ground relations may be important, because many pairs of events do not have the property that either event can serve as figure while the other takes the role of ground in a while-clause. (9) illustrates a pair of events that meet this criterion, whereas the events in (10) do not.
All stimuli used in Experiment 1B were constructed using symmetric event pairs like the pair in (9). However, it is important to also ensure that the pair of events preserves its figure/ground symmetry when the two events are performed by the same agent. This is important, since a semantic bias against a coreferential interpretation of the two subject NPs might lead to spurious evidence for the effects of a grammatical constraint. The examples in (11) and (12) illustrate an event pair that shows figure/ground symmetry when the events have different agents, but that is less clearly symmetric when the events are performed by the same agent.

(11) E1 = feeling dizzy, E2 = cleaning the floor
   a. Jane was feeling dizzy while Bill was cleaning the floor. [E1 figure, E2 ground]
   b. While Jane was feeling dizzy, Bill was cleaning the floor. [E1 ground, E2 figure]

(12) E1 = feeling dizzy, E2 = cleaning the floor
   a. Jane was feeling dizzy while she was cleaning the floor. [E1 figure, E2 ground]
   b. While Jane was feeling dizzy, she was cleaning the floor. [E1 ground, E2 figure]

(11) shows that the pair of events E1 and E2 is symmetric. When events E1 and E2 are performed by different agents, either of them can serve as a semantically plausible background for the other. Hence, (11)a and (11)b are equally plausible. However, the symmetry disappears if the same events are performed by the same person, as in (12). (12)a is quite natural on the coreference reading and it suggests that E1 and E2 can in principle be performed simultaneously by the same agent. However, the coreference reading in (12)b is less plausible, for the reason that feeling dizzy is not an ideal setting for an event of cleaning the floor in a setting where these events describe a simultaneous activity by the same person.

The existence of asymmetries like the one in (11)-(12) raises the question of whether the materials in Experiment 1 might have contained similar biases. We therefore sought to verify that the pairs of events described in each set were such that switching their figure/ground relation would not introduce a semantic bias towards a coreference or disjoint interpretation, as in (12). If both figure/ground combinations of the events were equally plausible under a coreference interpretation, we could more confidently attribute the processing differences between the Principle C and the pok-conditions to the fact that they invoke different constraints on coreference. Experiment 2 addresses this issue.

**Experiment 2**

Experiment 2 was a pencil-and-paper questionnaire. Its aim was to verify that the pairs of events used in the materials for the Principle C and pok-conditions in Experiment 1 were balanced and that
inverting their figure/ground configuration did not create a bias for a coreferential or disjoint interpretation of the two subject NPs. Additionally, we wanted to ensure that all sentences used in Experiment 1 were amenable to a coreference interpretation in all respects except for the effect of grammatical constraints on coreference.

Participants. Experiment 2 was administered to 24 native speakers of Russian (10 males, 14 females; mean age 30.8 years, range 18-45 years) residing in Moscow.

Materials and Design. All gender-matched variants of the Principle C and pokā-conditions from Experiment 1 were used in Experiment 2, thus yielding 24 sets of two conditions. The sentence-initial subordinators although or since and the enclosing third clause were discarded to yield sentences like those in (5)-(6). Furthermore, the order of the pronoun and the name was reversed to obtain forwards anaphora, as illustrated in Table 3. Consequently, stimuli from the Principle C conditions were transformed into forwards anaphora sentences in which the main clause preceded the embedded clause (‘forwards anaphora, main-first’), whereas stimuli from the pokā-conditions were transformed into sentences with forwards anaphora in which the embedded clause preceded the main clause (‘forwards anaphora, embedded-first’). Changing the pronoun-name order used in Experiment 1 to forwards anaphora sentences with a name-pronoun order in Experiment 2 rendered Principle C and the pokā-constraint irrelevant and thus made it possible to identify any potential effect of the figure/ground relation of the events on sentence interpretation.

Participants rated the plausibility of each sentence using a scale from 1 (impossible) to 5 (absolutely natural). The critical name and pronoun were highlighted in bold and participants were explicitly told that they referred to the same person. Twenty-four sets of targets were distributed among two lists using a Latin Square design and interspersed with 12 control sentences, half of which were highly plausible (‘control, highly-plausible’) or highly implausible (‘control, highly-implausible’) on the coreference reading. These controls masked the target sentences and served as a measure that the participants understood the task correctly.

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| Forwards anaphora, main-first | Olga pila utrennj kofe, pokā ona rešala kakoj-nibud’ krossvord. | ‘Olga drank her morning coffee while she solved a crossword puzzle.’ |
| Forwards anaphora, embedded-first | Pokā Olga pila utrennj kofe, ona rešala kakoj-nibud’ krossvord. | ‘While Olga drank her morning coffee she solved a crossword puzzle.’ |
| Control, highly plausible | Tak kak za poslednie tri goda ona ni razu ne brala otpuska, Olesja tverdo rešila, čto v etom godu uedet otdyxat’ na more. | ‘Since in the last three years she had never taken time off, Olesja firmly resolved to go to a seaside resort.’ |
| Control, highly implausible | Pokā Inna naxodilas’ po bedro v gipse, ona bez truda begala po lestnicam. | ‘While Inna’s leg was in a cast, she could easily climb stairs.’ |

Table 3. Sample set of items from Experiment 2.
Results and Discussion. The results of the rating test are summarized in Table 4.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean score (St. Err.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forwards anaphora, main-first</td>
<td>3.2 (.15)</td>
</tr>
<tr>
<td>Forwards anaphora, embedded-first</td>
<td>3.1 (.15)</td>
</tr>
<tr>
<td>Control, highly-plausible</td>
<td>4.5 (.10)</td>
</tr>
<tr>
<td>Control, highly-implausible</td>
<td>1.3 (.10)</td>
</tr>
</tbody>
</table>

Table 4. Mean plausibility ratings, Experiment 2.

As expected, the plausible control sentences received the highest coreference score and the implausible controls received the lowest score. The forwards-anaphora conditions yielded mean ratings in the middle of the scoring range, suggesting intermediate plausibility of these sentences. There was a significant effect of condition as a whole ($F(3, 860) = 24, p < .0001$). Importantly, a planned comparison of ratings in the two forwards anaphora conditions shows that the ratings for the main-first and the embedded-first forwards anaphora conditions did not significantly differ ($t(574) = 1.45, p = .149$). Experiment 2 therefore confirmed that the stimuli used in the Principle C and poka-conditions were balanced in terms of the figure/ground relation between the main and embedded events. There was no bias towards higher or lower plausibility of the coreference reading associated with reversal of the figure/ground relation of the events in the two conditions. Furthermore, the fact that the crucial forwards anaphora conditions in Experiment 2 received intermediate ratings lends further support to the claim that the low ratings for their backwards anaphora counterparts in Experiment 1 were due to reasons other than semantic plausibility. We can therefore be more confident that the different reading time profiles observed in Experiment 1B reflect differences in the constraints that apply to each condition.

General Discussion

We investigated the processing of backwards anaphora in Russian with the goal of understanding how grammatical constraints impact the search for antecedents for pronouns. A self-paced reading experiment (Experiment 1B) investigated the processing of three types of structures containing a cataphoric pronoun in the first clause. In the no-constraint conditions the subject of the second clause was a licit antecedent for the pronoun. In the remaining conditions the second subject was an illicit antecedent due to a constraint on coreference, either Principle C or the Russian-specific poka-constraint. The gender of the NP in the second subject position was manipulated such that it either matched or mismatched the gender of the cataphoric pronoun. The presence of an effect of this manipulation on reading times signaled that the parser at least temporarily considered the second subject as a potential antecedent for the cataphoric pronoun. The parser’s behavior following the critical second subject was different in each of the three condition pairs. In the no-constraint conditions the reading times following the second subject NP were longer when that NP mismatched in gender with the anaphoric pronoun (gender-mismatch effect). There was no effect of gender congruency on the second subject in the Principle C condition. Finally, in the Russian-specific poka-condition reading times were longer when the second subject matched in gender with the preceding
pronoun (gender-match effect). Experiment 2 confirmed that these results cannot be explained by a plausibility bias in the pairs of events chosen for Principle C and poka-conditions.

The gender-mismatch effect found in the no-constraint condition in Russian replicates earlier findings by van Gompel and Liversedge (2003) and by Kazanina et al. (2007) for similar cases in English and suggests that across languages the parser uses a similar mechanism to search for an antecedent for a cataphoric pronoun. The no-constraint conditions feature a dependency between a pronoun and a linearly following antecedent. In the absence of a previously mentioned discourse referent the pronoun is temporarily left without a referent and the parser initiates a search for a licit antecedent in the upcoming input. The gender-mismatch effect in the no-constraint conditions reflects the parser’s surprise upon encountering a gender-incongruent NP in a position where an antecedent was expected. Importantly, as van Gompel and Liversedge point out, the existence of the gender-mismatch effect implies that the parser is not hesitant in forming cataphoric dependencies. In order to be disrupted upon recognizing that a noun phrase in the input is gender-incongruent, the parser must have initiated dependency formation prior to that moment. This observation about the earliness of cataphoric dependency formation could reflect either of two mechanisms. Van Gompel and Liversedge (2003) suggest that it is a consequence of an architectural property of the parser that makes word category information about incoming words available before more fine-grained semantic information. In contrast, Kazanina and colleagues regard early formation of cataphoric dependencies as a counterpart of ‘active’ dependency formation found in the processing of filler-gap dependencies (Crain & Fodor, 1985; Frazier & Flores d’Arcais, 1989; Garnsey et al., 1989; Stowe, 1986; Traxler & Pickering, 1996). They argue that dependency formation may be initiated as a cataphoric pronoun is encountered, and before a candidate antecedent appears in the bottom-up input. A mechanism of this kind presupposes the possibility of predictive structure building, but it also avoids the need to assume that an architectural constraint makes syntactic category information available more quickly than other properties of incoming words. Both of these accounts of the gender-mismatch effect are compatible with the findings presented here. Moreover, we contend that the two mechanisms are in fact rather similar, since the mechanism proposed by van Gompel and Liversedge must be active to some degree. Even if cataphoric dependency formation is only attempted after a candidate antecedent is encountered in the bottom-up input, the parser must already be in a control state that encodes the fact that it is searching for an antecedent for a pronoun. Without such a mechanism, cataphoric dependency formation could only arise from a massively redundant mechanism that searches backwards for a pronoun every time that it encounters a noun phrase, an unlikely state of affairs. In addition the control state must be sensitive to which structural positions the parser does and does not treat as suitable antecedent positions. This sensitivity is needed to capture the sensitivity of the gender mismatch effect to grammatical constraints on cataphora, as found in this and other studies.

The lack of any effect of the gender manipulation in the second subject in the Principle C conditions replicates earlier findings in English (Kazanina et al., 2007). In both languages we take the lack of an effect as evidence that the parser does not consider the second subject as a potential antecedent position for the cataphoric pronoun. This apparent blindness to the possibility of coreference in the Principle C conditions cannot easily be dismissed as a consequence of the discourse salience of the second subject NP, since the crucial reading time measures are taken at a point in time when that NP is in the focus of attention. The Russian findings add cross-linguistic evidence to earlier conclusions from English, and lend further support to the view that Principle C is a cross-linguistically robust constraint on structure generation. In other words, rather than generating
representations that violate Principle C and subsequently rejecting them based on application of a filter, such illicit coreference patterns are never even considered by the parser (Kazanina et al., 2007). More generally, early sensitivity to Principle C can be added to a growing body of evidence that complex and grammatically accurate representations can be built in real time (Stowe, 1986; Crain & Fodor, 1985; Traxler & Pickering, 1996 among others).

The *poka*-conditions offered a comparison that has not been possible in previous studies in other languages, as it was possible to compare the reading-time profiles of sentences that are impacted by two different constraints on backwards anaphora. The Principle C conditions and the *poka*-conditions had many features in common: the dependent elements were the same pronouns (*on* ‘he’ or *ona* ‘she’); the lexical material was identical; the thematic roles of all nominals was the same, and plausibility was matched across conditions; the linear distance between the pronoun and the potential antecedent was very similar. In addition, the rating study (Experiment 1A) showed that the two constraints led to similarly low acceptability scores. Furthermore, the two constraints were tested using a within-subjects design. Despite these parallels, the reading-time profiles were quite different, with a gender-match effect in the *poka*-conditions and no effect of gender-congruency in the Principle C conditions. This shows clearly that the two grammatical constraints impact parsing in different ways.

Some previous studies have investigated the impact of different constraints on forwards anaphora on language processing. Nicol and Swinney argued that constraints on reflexives and pronouns have parallel early impacts on antecedent activation (Nicol & Swinney, 1989), whereas Badecker and Straub argued that both types of constraints act as later filters on antecedents, although the results from their series of studies were more equivocal (Badecker & Straub, 2002). Runner and colleagues used eye-fixation patterns to argue for differences in the processing of reflexives and pronouns (Runner et al., 2006), but their study focused on special syntactic contexts (*picture noun phrases*, such as *Harry’s picture of himself*), and ultimately concluded that reflexives in picture noun phrases are exempt from standard grammatical constraints on reflexives. Thus, the current study shows more unequivocally than previous studies that constraints on coreference do not impact language processing in a uniform fashion.

The gender-match effect following the critical second subject in the *poka*-conditions implies that participants at least fleetingly considered that subject as a potential antecedent for the preceding pronoun. We interpret the slowdown in the gender-congruent condition as reflecting difficulty that arises when the parser is forced to retract its initial consideration of an analysis in which the name is the antecedent of the preceding pronoun. Indeed, if the parser considered and then accepted the coreference interpretation, then we should have expected to find no disruption in the gender-congruent condition, as observed in the no-constraint conditions (and that would go against the very low acceptability ratings found in Experiment 1A). On the other hand, if the parser were simply blind to the possibility of coreference between the pronoun and the name, then we should have expected to find no gender-congruence effect, as found in the Principle C conditions. Thus, it seems hard to avoid the conclusion that the coreference interpretation is temporarily considered and subsequently rescinded.

At the moment, however, we remain agnostic regarding how actively the cataphoric dependency in the *poka*-conditions was initially pursued. A first possibility is that cataphoric dependency formation proceeded actively, just as in the no-constraint conditions, leading to disruption upon encountering the gender-incongruent name (i.e. a gender-mismatch effect), but that this effect was overridden in the reading times by the immediately following disruption in the gender-congruent
condition. A second possibility is that the construction of cataphoric dependencies proceeds in a less active fashion when a pronoun is introduced in a *poka*-clause, and hence a dependency is only attempted after a semantically compatible antecedent has been encountered. The currently available data does not allow us to adequately distinguish between these accounts, but this does not undermine the more important conclusion that a coreference interpretation is fleetingly considered in the *poka*-conditions.

The finding that Principle C acts to block the generation of coreference dependencies, whereas the *poka*-constraint acts as a filter on dependencies that are initially considered, naturally raises the question of why the two constraints should impact parsing so differently. The current findings are consistent with a number of possible accounts of this difference. It could reflect the fact that Principle C applies to syntactic configurations (Chomsky, 1981) whereas the *poka*-constraint is a constraint that invokes discourse representations (Avrutin & Reuland, 2004; Kazanina & Phillips, 2001; Reuland & Avrutin, 2005), or it could reflect the fact that Principle C is a cross-linguistically robust constraint, whereas the *poka*-constraint is a more idiosyncratic property of Russian. In earlier work we found a developmental dissociation between the two constraints: Russian children have already mastered Principle C at age 3, whereas the *poka*-constraint does not reliably constrain their interpretations until age 5-6 (Kazanina & Phillips, 2001). However, we suggest that the most likely cause of the different on-line effects of the two constraints is the time course of information availability relevant to the two constraints. In the case of Principle C the parser may determine that an entire structural domain is irrelevant to the search for an antecedent, and this can be ascertained in advance of any bottom-up information about potential antecedents. This kind of pre-computation is not possible in the case of the *poka*-constraint. Recall that the *poka*-constraint applies to pronoun-name sequences in which both nominals have the semantic role of agent. Although agent is by far the most common thematic role for a nominative subject, the thematic role of the subject cannot be confirmed until the predicate of the clause is identified. Therefore, when faced with a sequence *poka pronoun*NOM ... *name*NOM the parser may continue to entertain the possibility that the pronoun and the name may be coreferential, because the thematic role of the name is not yet confirmed. Only when the predicate is reached is it possible to confirm that the name bears an agent role, and at that point the *poka*-constraint becomes relevant and the coreference relation must be rescinded, leading to reading-time slowdown. This interpretation is consistent with the time-course of the gender-match effect, which in Experiment 1B appeared at Region 13, slightly later than the gender-mismatch effect in the no-constraint conditions. If this is the appropriate account of why the *poka*-constraint acts as a filter rather than as a constraint on generation of antecedents then it is interesting to ask why Russian speakers do not immediately assume that a nominative subject is an agent, a statistically likely outcome, and a plausible consequence of parsing with superficial heuristics (e.g. Townsend & Bever, 2001). However, the likelihood that a nominative subject NP is an agent must be balanced against the likelihood that a *pronoun ... name* sequence of subject NPs involves a coreference relation. Consequently, more detailed analyses of Russian corpora would be needed in order to determine whether speakers’ behavior in our study genuinely ignores distributional constraints.

**CONCLUSION**

A number of previous studies have investigated the question of how grammatical constraints impact the search for antecedents for anaphoric expressions in on-line language processing. Constraints may act either as constraints on the generation of candidate interpretations, which
prevent grammatically inaccessible antecedents from ever being considered, or they may act as later filters on interpretations, which serve to remove illicit coreference relations only after they have been initially considered. It is common in discussions of this issue to proceed under the assumption that there is a uniform answer to this question. However, results from our studies of closely matched constraints on backwards anaphora in Russian indicate that a uniform answer may not be possible. Russian speakers appear to implement Principle C as a constraint on generation of interpretations and the poka-constraint as a filter on temporarily considered interpretations. This contrast can be understood in terms of the detailed time course of information that is relevant to application of the two constraints.

**APPENDIX 1. Full list of stimuli from the self-paced reading task, Experiment 1**

The experiment contained 24 sets the Principle C and poka-conditions and 12 sets of no-constraint conditions:

<table>
<thead>
<tr>
<th>Principle C &amp; poka-conditions</th>
<th>No-constraint conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition a: Principle C, gender-match</td>
<td>Condition a: no-constraint, gender-match</td>
</tr>
<tr>
<td>Condition c: poka-constraint, gender-match</td>
<td></td>
</tr>
<tr>
<td>Condition d: poka-constraint, gender-mismatch</td>
<td></td>
</tr>
</tbody>
</table>

**Principle C & poka-conditions**

1a/b. Поскольку перед Рождеством он сбывал с рук драгоценност, пока Марат/Алина пытался/пыталась получить визы в Аргентину, Стас опасался вызвать подозрение у окружающих.

1c/d. Поскольку перед Рождеством, пока он сбывал с рук драгоценност, Марат/Алина пытался/пыталась получить визы в Аргентину, Стас опасался вызвать подозрение у окружающих.

2a/b. Поскольку уже в полдень он скрупулезно изучал внутреннюю структуру купола, пока Михаил/Тамара делал/делала карандашные зарисовки постройки, архитектор рассчитывал иметь всю необходимую информацию о храме к концу дня.

2c/d. Поскольку уже в полдень, пока он скрупулезно изучал внутреннюю структуру купола, Михаил/Тамара делал/делала карандашные зарисовки постройки, архитектор рассчитывал иметь всю необходимую информацию о храме к концу дня.

3a/b. Поскольку перед началом спектакля она разговаривала по рации с охраной, пока Раиса/Сергей рассаживала/рассаживал по местам высокопоставленных гостей, Инна не видела приближавшегося с генералом каза.

3c/d. Поскольку перед началом спектакля, пока она разговаривала по рации с охраной, Раиса/Сергей рассаживала/рассаживал по местам высокопоставленных гостей, Инна была очень благодарна ей за помощь.

4a/b. Поскольку перед эфиром она просматривала тексты сообщений, пока Марина/Даниил грирмировалась/грирмировался к началу съёмок, Зоя первой узнала сенсационную новость.

4c/d. Поскольку перед эфиром, пока она просматривала тексты сообщений, Марина/Даниил грирмировалась/грирмировался к началу съёмок, Зоя сама определила порядок репортажей в выпуске.

5a/b. Поскольку вчера днем он подключал измерители давления, пока Артур/Клара настраивала/настраивала специальную вакуумную камеру, Виталий был уверен в полной синхронизации установки.

5c/d. Поскольку вчера днем, пока он подключал измерители давления, Артур/Клара настраивала/настраивала специальную вакуумную камеру, Валерий надеялся наладить оборудование до наступления сумерек.

6a/b. Поскольку всю неделю перед парным финалом он беспечно заигрывал с многочисленными поклонницами, пока Всеволод/Кристина отрабатывала/отрабатывала на корте ключевые удары, Дмитрий отыграил в финальном матче значительно хуже своего партнера/своей партнерши.

6c/d. Поскольку всю неделю перед парным финалом, пока он беспечно заигрывал с многочисленными поклонницами, Всеволод/Кристина отрабатывала/отрабатывала на корте ключевые удары, Дмитрий не мог не признать вклад своего партнера/своей партнерши решающим в их победе.

7a/b. Поскольку после контрольной она просматривала учебные тетради, пока Ольга/Борис вводила/вводил в компьютер статистику по ошибкам, учителяницы могла сравнивать результаты между классами.
7c/d. Поскольку после контрольной, пока она просматривала ученические тетради, Ольга/Борис вводила/вводил в компьютер статистику по ошибкам, учительница знала подобные результаты сразу по окончании проверки.

8a/b. Хотя в прошлом году он впервые тестировал новый вид дюветы, пока Ярослав/Варвара готовился/готовилась к ответственному этапу чемпионата мира, Глеб без опасений внедрил свои новшества в схему питания спортсмена/спортсменки.

8c/d. Хотя в прошлом году, пока он впервые тестировал новейший вид дюветы, Ярослав/Варвара готовился/готовилась к ответственному этапу чемпионата мира, Глеб без опасений внедрил свои новшества в схему питания спортсмена/спортсменки.

9a/b. Хотя в январе она готовилась к квалификационным экзаменам, пока Алла/Иван отдыхала/отдыхал на Канарских островах, Вика не созвала на судью.

9c/d. Хотя в январе, пока она готовилась к квалификационным экзаменам, Алла/Иван отдыхала/отдыхала на Канарских островах, Вика не созвала на судью.

10a/b. Хотя в воскресенье она учила билеты по физике, пока Варя/Вова слушала/слушал прямой радиорепортаж с 'Евровидения', Рита умудрялась не обращать внимание на происходящее.

10c/d. Хотя в воскресенье, пока она учила билеты по физике, Варя/Вова слушала/слушал прямой радиорепортаж с 'Евровидения', Рита умудрялась не обращать внимание на происходящее.

11a/b. Хотя почти все утро он искал представителей редкого вида гусеницы, пока Егор/Маша снимал/снимала на камеру наиболее красивые уголки парка, Аркадий так и не нашел нужный ему экземпляр.

11c/d. Хотя почти все утро, пока он искал экземпляр редкого вида гусеницы, Егор/Маша снимал/снимала на камеру наиболее красивые уголки парка, Аркадий переживал, что мальчик/девушка скучает.

12a/b. Хотя каждое воскресенье она пила утренний кофе, пока Оля/Юра решала/рассказала какой-нибудь увлекательный кроссворд, Марина никогда не предлагала помочь.

12c/d. Хотя каждое воскресенье, пока она пила утренний кофе, Оля/Юра решала/рассказала какой-нибудь увлекательный кроссворд, Марина никогда не принимала участия в разгадке вопросов.

13a/b. Поскольку в магазине он болтал с симпатичными кондитершами, пока Максим/Наташа пробовал/пробовала разные виды пирожных, Дима получил огромное удовольствие от похода за покупками.

13c/d. Поскольку в магазине, пока он болтал с симпатичными кондитершами, Максим/Наташа пробовал/пробовала разные виды пирожных, Дима захотел тоже попробовать что-нибудь из сладкого.

14a/b. Хотя уже в полустороне она украшала зеленью салаты, пока Галина/Сережа спешно накрывала/накрывал стол, хозяйка так и не успела закончить приготовление до прихода гостей.

14c/d. Хотя уже в полустороне, пока она украшала зеленью салаты, Галина/Сережа спешно накрывала/накрывал стол, хозяйка не надеялась закончить приготовление до прихода гостей.

15a/b. Хотя всю субботу она полола разбушевавшиеся сорняки, пока Света/Вадим срезали/срезал сухие ветви с кустов, Валентина, в отличие от подруги/мужа, совершенно не чувствовала усталости.

15c/d. Хотя всю субботу, пока она полола разбушевавшиеся сорняки, Света/Вадим срезали/срезали сухие ветви с кустов, Валентина считала уборку сада полностью своей заслугой.

16a/b. Поскольку весь вечер она составляла квартальный отчет, пока ЛидаВася смотрела/смотрел повтор 'Рождественских встреч', Марина считала себя вправе не готовить ужин.

16c/d. Поскольку весь вечер, пока она составляла квартальный отчет, ЛидаВася смотрела/смотрел повтор 'Рождественских встреч', Марина не могла полностью сосредоточиться на работе.

17a/b. Хотя в ресторане она курила на террасе, пока Алина/Борис обсуждала/обсуждал с официантом прелести японской кухни, Галя смычала всё детали их разговора.

17c/d. Хотя в ресторане, пока она курила на террасе, Алина/Борис обсуждала/обсуждал с официантом прелести японской кухни, Галя настояла на заказе исключительно европейских блюд.

18a/b. Поскольку в самомелете она расшивала блестками костюм, пока Алена/Гриша заучивала/заучивала нашу у слова финальной песни, Жанна старайлась не отвлекать дочь/сына своими просьбами и расспросами.

18c/d. Поскольку в самолете, пока она расшивала блестками костюм, Алена/Гриша заучивала/заучивала нашу у слова финальной песни, Жанна невольно выучила текст вместе с дочерью/сыном.

19a/b. Поскольку все утро он пылесосил ковры в лоджии, пока Денис/Ксюша обзванивал/обзванивал друзей относительно предстоящей встречи, Семен не мог с собой о решении встретиться у них дома.

19c/d. Поскольку все утро, пока он пылесосил ковры в лоджии, Денис/Ксюша обзванивал/обзванивал друзей относительно предстоящей встречи, Семен плотно закрыл все двери и старался не шуметь.

20a/b. Хотя весь день он выписывал основные цитаты, пока назначенный на четверг доклад, Кирилл не хотел вникать в суть его/ее работы.
Поскольку в прошлую пятницу он проветрил рабочее помещение, пока Яков/Элла распечатывал/распечатывала копии праздничных рекламных листовок, Костя винил себя в простуде коллектива.

Настя отказалась присоединиться к новой труппе, поскольку вникать ей в курсы упражнений не хотелось.

Хотя Юрий/Михаил не мог получить место на дискотеке, поскольку он/она не настаивал на дополнительном спектакле, о котором раньше договорился с организаторами. 

No-constraint conditions

Валентина/Александр недвусмысленно намекнула/намекнула на возможность арендовать помещения вместе, поскольку они уже работали над одним проектом.
**APPENDIX 2.**
Mean reading times (standard error) for each region in each condition in the online Experiment 1b. Fixed effect(s) for the best fitting model for each region are shown in the last comment with ‘—’ indicating the model with no fixed factors other than the intercept. All models had participants and items as random factors.

### No-constraint conditions

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### Principle C and poka-conditions

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REFERENCES


