

The Nature of Case Interference in On-line Sentence Processing in Russian

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1. Introduction

1.1. Background and motivation

This paper investigates the nature of case interference in on-line sentence comprehension in Russian. We address the following two questions: (1) do partially processed unambiguous structures containing noun phrases (NPs) bearing the same case cause processing difficulty; and (2) if so, which notion of “case” is relevant – abstract case of its morphological realization?

Previous research has suggested that partial structures containing NPs that bear the same abstract case cause processing difficulty (e.g. Stabler, 1994; Lewis, 1996; Uehara, 1996). For example, it has been empirically demonstrated (Babyonyshev & Gibson, 1999) that in Japanese, (1b) where the sentence is initiated by three NPs bearing Nominative case, is more difficult to process than (1a) where the sentence is initiated by one Topic-NP and two Nominative NPs.

- (1) a. NP-top t [NP-nom [NP-nom V Comp] V Comp] V
Takako-**wa** Akira-**ga** Hanako-**ga** nakidasita to itta to omotteiru.
Takako-top Akira-nom Hanako-nom started-crying that said that thinks
'As for Takako, she thinks that Akira said that Hanako started crying.'
- b. NP-nom [NP-nom [NP-nom V Comp] V Comp] V
Takako-**ga** Akira-**ga** Hanako-**ga** nakidasita to itta to omotteiru.
Takako-nom Akira-nom Hanako-nom started-crying that said that thinks
'Takako thought that Akira said that Hanako started crying.'

Lewis's Similarity-based Interference Theory (e.g. Lewis, 1996; Lewis & Nakayama, 2002) postulates that similarity between the attachment site¹ and the elements preceding the attachment site and/or intervening between the attachment site and the incoming element (the retrieval site) has an adverse effect on processing. According to Lewis, the difficulty arises due to the loss of distinctness of the retrieval cues (the properties of the retrieval site which are necessary for locating the attachment site): when the attachment site is preceded and/or followed by one or more similar elements, at the point where the attachment site has to be retrieved, the retrieval cues that are available for identifying the target element overlap between the target element and the interfering element(s), making the selection difficult.

Most of the previous studies on case interference contained an important confound: NPs bearing the same abstract case often surface with the same morphological case-markers (as e.g., in (1) above). It is possible that morphological (and phonological) similarity of the interfering elements contributes to, or is responsible for, the difficulty associated with case repetition. Uehara & Bradley (1996) attempted to selectively examine the effect of case-marker repetition using an off-line difficulty-rating questionnaire in Korean, where case-markers are phonologically conditioned, thus can be manipulated. They did not find increased difficulty ratings for sentences where the same marker was repeated three times, compared to sentences where it was only repeated twice and the third nominal had a different case-marker. Although the reported analysis did not reveal a significant difference, this may be because participants were at a floor level of performance on the complex double-embedded structures that were investigated. Indeed, the results from the single-embedded structures show a numerical trend, suggesting that the different case-marker sentences may have been less difficult.

Moreover, Korean only allows manipulation of case-markers within the same case (e.g., varying *-i* and *-ka* Nominative markers). It might be more informative to examine languages with case syncretism where case-marker forms overlap between different cases, which would allow us to investigate the two effects independently. Experiment 1 was designed to pull apart the effects of abstract case repetition and morphological case-marker repetition.

Another motivation for this research comes from the fact that Lewis and colleagues have focused on the effects of the preceding and/or intervening material on the difficulty of retrieving the attachment site in long-distance dependencies. Lewis et al. distinguish two kinds of interference: proactive interference (coming from the elements prior to the attachment site) and retroactive interference (coming from the elements between the attachment site and the incoming attaching element). To the best of our knowledge, however, the two types of interference have never been examined independently. All the contrasts examined previously involved long-distance dependencies with some material intervening between the attachment site and the

¹ Here and thereafter, we will adopt the following terminology to refer to different parts of syntactic structures, like " $m_1 m_2 \dots m_n \mathbf{X} n_1 n_2 \dots n_n \mathbf{Y}$ ": (1) 'attachment site' (X) will be used to refer to an element with a pending syntactic expectation; (2) 'attaching element' or 'retrieval site' (Y) will be used to refer to an element which satisfies the pending syntactic expectation of X, thus a location where X has to be retrieved in order to be integrated with Y; (3) elements like " $m_1 m_2 \dots m_n$ " and " $n_1 n_2 \dots n_n$ " will be referred to as 'elements preceding the attachment site' and 'elements intervening between the attachment site and the retrieval site' respectively.

attaching element. The structures we examine in Experiment 2 can help address the question of whether the effects of proactive interference can still be observed in the absence of retroactive interference when the attachment site and the attaching element are immediately adjacent, which eliminates the need to search for the attachment site.

1.2. Relevant syntactic and morphological properties of Russian

Russian possesses several properties, which make it especially useful for addressing the questions outlined above. First, Russian is a language with flexible word order, which allows, for example, scrambling of direct objects or participle clauses to the clause-initial position. This property allows the presence of sequences of multiple NPs of the same or different case. Second, some transitive verbs in Russian assign quirky case (e.g. Dative) to their complements, increasing the number of possible variations of case-marked nominals in a sequence. Finally, and most importantly for the current experiments, Russian has several declension classes, and the morphological realization of a given abstract case depends on the declension class of a given noun. For example, as shown in (2), the Accusative case-marker for Class I nominals is the same as the Dative case-marker for Class II nominals.

(2)

	Class I nominals	Class II nominals
Accusative Case	-u	-a
Dative Case	-e	-u

These properties of Russian therefore allow us (a) to manipulate abstract case and morphological case-markers independently, and (b) to construct sentences where two nominals bearing same/different abstract case/case-markers can both appear in pre-verbal position.

2. Experiment 1²

This experiment manipulated abstract case (same, different) and morphological case-markers (same, different) in a 2x2 design using self-paced reading paradigm. The aims of the experiment were to determine how each of these two factors contributes to the processing difficulty in the same-case conditions, and whether these two factors affect processing in an independent manner.

2.1. Methods

Participants. Thirty-five native speakers of Russian from the Boston area were paid for their participation. All of the subjects were naive as to the purposes of the study.

² This experiment was originally presented at the Annual CUNY Conference on Human Sentence Processing in 1997 (Babyonyshev & Gibson, 1997), but the findings were not published.

Design and materials. The experiment had a 2x2 design, crossing abstract case (same, different) and morphological case-markers (same, different), resulting in 4 experimental conditions.³ 35 sentences were constructed with four versions each, as shown in (3). The two critical NPs are underlined.

- (3) a. Same abstract case (Acc, Acc)/ same case-markers (-u, -u)
Neposlušnuju devočku sestru ugovorila navestit' bespokojaščajasia mat'
disobedient-acc-fem girl-acc-fem sister-acc-fem convinced visit-inf
worried-nom-fem mother-nom fem
'The worried mother convinced the disobedient girl to visit (her) sister.'
- b. Same abstract case (Acc, Acc)/ different case-markers (-u, -a)
Neposlušnuju devočku brata ugovorila navestit' bespokojaščajasia mat'
disobedient-acc-fem girl-acc-fem brother-acc-masc convinced visit-inf
worried-nom-fem mother-nom fem
'The worried mother convinced the disobedient girl to visit (her) brother.'
- c. Different abstract case (Acc, Dat)/ same case-markers (-u, -u)
Neposlušnuju devočku bratu ugovorila pozvonit' bespokojaščajasia mat'
disobedient-acc-fem girl-acc-fem brother-dat-masc convinced call-inf
worried-nom-fem mother-nom fem
'The worried mother convinced the disobedient girl to call (her) brother.'
- d. Different abstract case (Acc, Dat)/ different case-markers (-u, -e)
Neposlušnuju devočku sestru ugovorila pozvonit' bespokojaščajasia mat'
disobedient-acc-fem girl-acc-fem sister-dat-fem convinced call-inf
worried-nom-fem mother-nom fem
'The worried mother convinced the disobedient girl to call (her) sister.'

Each experimental item consisted of (a) a matrix object NP (an adjective + noun), (b) an embedded object NP, (c) a matrix verb, (d) an embedded verb, and (e) a matrix subject NP (adjective + noun), as shown in (4).

- (4) Adj+MatrixObject – EmbObject – MatrixVerb – EmbVerb – Adj+MatrixSubject

The critical region was defined as the matrix verb and the embedded verb, as the attachment sites (the two object NPs) have to be retrieved at this point in the sentence.

Two cases were used: Accusative and Dative. The matrix verb always assigned Accusative case to the matrix object, whereas the embedded verb assigned either Accusative or Dative case to the embedded object, thus making the embedded object match or not match the matrix object in case. Nominals of two declension classes were used, making use of the Accusative-Dative case syncretism.

³ There were three additional conditions in this experiment which are not relevant to the present study. We therefore only report the data from the four conditions as described above.

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In addition to the target sentences, 70 filler sentences with various syntactic structures were included. The length and syntactic complexity of the filler sentences was similar to that of the target sentences. The stimuli were pseudo-randomized separately for each participant, with at least one filler separating the target sentences.

Procedure. The task was self-paced word-by-word reading with a moving-window display (Just, Carpenter & Woolley, 1982). Each trial began with a series of dashes marking the length and position of the words in a sentence. Participants pressed the spacebar to reveal each word of the sentence. As each new word appeared, the preceding word disappeared. The amount of time the participant spent reading each word was recorded as the time between key-presses. Participants were instructed to read at a natural pace and to make sure they understand what they read.

To make sure the participants read the sentences for meaning, at the end of each trial a comprehension question appeared asking about the propositional content of the sentence. Participants pressed one of two keys to respond “yes” or “no” to the question. After a correct answer, the Russian word corresponding to “Correct” flashed briefly on the screen, and after an incorrect answer, the Russian word corresponding to “Incorrect” flashed briefly.

2.2. Results

Reading time data. To adjust for differences in word length as well as overall differences in participants’ reading rates, a regression equation predicting reading times from word length was derived for each participant, using all filler and target items (Ferreira & Clifton, 1986; see Trueswell, Tanenhaus & Garnsey, 1994, for discussion). At each word position, the reading time predicted by the participant’s regression equation was subtracted from the actual measured reading time to obtain a residual reading time. Residual reading time data points that were more than two standard deviations away from the mean for a position within a condition were excluded from the analysis, affecting 4.5% of the data. Figure 1 presents the mean residual reading times at the critical region across the four conditions of the experiment.

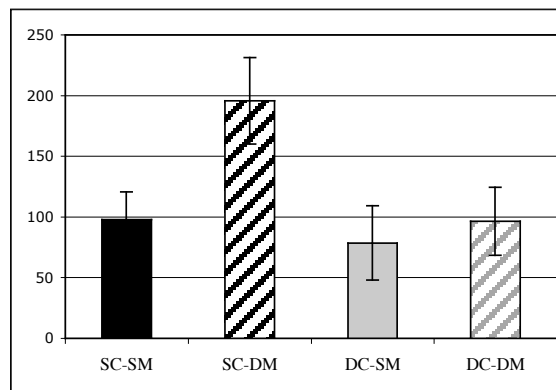


Figure 1. Residual reading times at the critical region in the four conditions of Experiment 1 (S = ‘same’, D = ‘different’, C = ‘abstract case’, M = ‘case-marker’).

The critical region included the matrix verb and the embedded verb. A 2x2 ANOVA on the critical region, crossing abstract case (same, different) and case-markers (same, different) revealed a main effect of abstract case and a main effect of case-markers, with no significant interaction. First, the same abstract case conditions were read slower than the different abstract case conditions ($F(1,34)=10.66, p<.005$). Second, the same case-marker conditions were read faster than the different case-marker conditions ($F(1,34)=5.97, p<.05$).

Response accuracy data. Participants answered the question correctly 82% of the time. A 2x2 ANOVA on the responses revealed no significant effects and no interaction. The mean response accuracies by condition are presented in Figure 2.

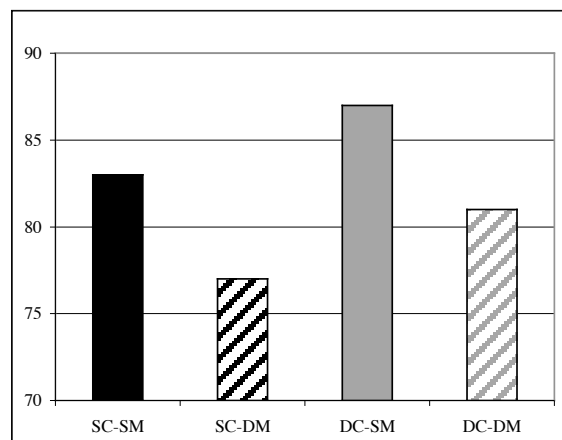


Figure 2. Mean response accuracies in the four conditions of Experiment 1.

2.3. Discussion

The results of Experiment 1 were somewhat unexpected. Specifically, as described above, the effects of abstract case repetition and case-marker repetition seem to apply in opposite directions. Whereas the effect of abstract case repetition is consistent with the previous findings (same abstract case conditions were processed slower than different abstract case conditions), the effect of case-marker repetition is unexpected (same case-marker conditions were processed faster than different case-marker conditions).

The surprising results led us to analyze the experimental design and materials in greater depth. This analysis revealed a number of potential confounding factors in the design of Experiment 1, which could have obscured the real pattern of results.

First, a number of theories of sentence processing postulate that there is a resource cost associated with keeping track of incomplete phrase structure rules (Chomsky & Miller, 1963), incomplete clauses (Kimball, 1973), or expected syntactic heads (Gibson, 1998, 2000). Under these analyses, there is a higher resource cost associated with processing the same abstract case conditions compared to the different abstract case conditions. In particular, in the constructions used in Experiment 1, at the point when the

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two object NPs have been processed, two verbs are always required in the same abstract case conditions for the sentence to be grammatical, whereas one verb may be sufficient in the different abstract case conditions. For example, consider the two different abstract case conditions ((3c) and (3d) above). The sentence-initial string *Neposlušnuju devočku bratu/sestre...* (disobedient girl-acc-fem brother-dat-masc/sister-dat-fem...) can be continued by a single ditransitive verb, as shown in (5).

- (5) *Neposlušnuju devočku bratu/sestre pokazala Lena.*
disobedient-acc-fem girl-acc-fem brother-dat-masc/sister-dat-fem showed Lena
'Lena showed the disobedient girl to (her) brother/sister.'

Therefore, the above-mentioned theories of sentence complexity make the same prediction as the Interference hypothesis: the same abstract case conditions should be more difficult to process than the different abstract case conditions.

A second problem in Experiment 1 is that the same abstract case conditions are globally ambiguous. Whereas the intended reading of the string of the two nouns is for the first noun to be the matrix object and for the second noun to be the embedded object, the reverse reading is also allowed in Russian. Despite some native speakers' off-line preferences for the first reading, this ambiguity might partially be responsible for the slower reading times in the same abstract case conditions.

Finally, in the "same abstract case/ different case-marker" condition, there exists an alternative interpretation of the string of two nouns. Specifically, due to the Accusative/Genitive case syncretism for certain nouns, in (3b) above, the string *devočku-brata*-Acc (girl-Acc brother-Acc) can be interpreted as *devočku-brata*-Gen (girl(-friend)-Acc brother-Gen). This condition was found to be the slowest of the four conditions. It is difficult to say how this ambiguity might have contributed to the slow reading times during the critical region of the "same abstract case/ different case-marker" condition.

Experiment 2 was designed to address the issues outlined above.

3. Experiment 2

In Experiment 2, we used constructions with sentence-initial participle-clauses to avoid the confounds present in Experiment 1. Participles in Russian assign case to their objects, just like verbs do, and they agree with the head noun (the noun that the participle clause modifies) in gender, number and case, just like adjectives do. For example, as shown in (6a), the participle clause *čitajuščij knigu* (reading book-Acc) modifies the noun *malčik* (boy-Nom). The participle *čitajuščij* (reading) agrees with the head noun *malčik* (boy) in gender (masculine), number (singular), and case (Nominative). Furthermore, the participle *čitajuščij* (reading) assigns Accusative case to its object *knigu* (book-Acc). (6b) is a scrambled version of (6a): the participle clause *čitajuščij knigu* (reading book-Acc) has been fronted.

- (6a) *Malčik čitajuščij knigu* sidit na divane.
boy-Nom reading book-Acc is-sitting on couch
'The boy who is reading a book is sitting on the couch.'

- (6b) Čitajušćij knigu malčik sidit na divane.
reading book-Acc boy-Nom is-sitting on couch
'The boy who is reading a book is sitting on the couch.'

The stimuli in Experiment 2 are similar in form to (6b). Furthermore, they have the same sentence-complexity costs across conditions (e.g., they involve the same number of expected syntactic heads in all conditions), are globally unambiguous, and do not contain any locally-ambiguous strings.

3.1. Methods

Participants. Forty native speakers of Russian from the Polytechnical Institute in Volgograd, Russia between the ages of 18 and 22 were paid for their participation. All of the subjects were naive as to the purposes of the study.

Design and materials. The experiment had a 2x2 design, crossing abstract case (same, different) and morphological case-markers (same, different), resulting in four conditions. 32 sentences were constructed with four versions each, as shown in (7):

- (7) a. Same abstract case/ same case-markers
Uvažavšuju skripačku pianistku razozlil dirižer iz izvestnoj konservatorii posle generalnoj repetitsii.
respecting violinist-fem-Acc pianist-fem-Acc angered conductor-Nom from famous conservatory after final rehearsal
'The conductor from a famous conservatory angered the pianist who respected the violinist after the final rehearsal.'
- b. Same abstract case/ different case-markers
Uvažavšuju skripača pianistku razozlil dirižer iz izvestnoj konservatorii posle generalnoj repetitsii.
respecting violinist-masc-Acc pianist-fem-Acc angered conductor-Nom from famous conservatory after final rehearsal
'The conductor from a famous conservatory angered the pianist who respected the violinist after the final rehearsal.'
- c. Different abstract case/ same case-markers
Pozvonivšuju skripaču pianistku razozlil dirižer iz izvestnoj konservatorii posle generalnoj repetitsii.
calling violinist-masc-Dat pianist-fem-Acc angered conductor-Nom from famous conservatory after final rehearsal
'The conductor from a famous conservatory angered the pianist who called the violinist after the final rehearsal.'

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- d. Different abstract case/ different case-markers
Pozvonivšuju skripačke pianistku razozlil dirižer iz izvestnoj konservatorii
posle generalnoj repetitsii.
calling violinist-fem-Dat pianist-fem-Acc angered conductor-Nom from
famous conservatory after final rehearsal
'The conductor from a famous conservatory angered the pianist who
called the violinist after the final rehearsal.'

Each experimental item consisted of (a) a participle clause (a participle and its object), (b) a matrix object, (c) a verb, (d) a matrix subject, and (e) two adjunct prepositional phrases, as shown in (8).

(8) Participle – EmbObject – MatrixObject – Verb – MatrixSubject – PP1 – PP2

Similarly to Experiment 1, the critical region was defined as the verb since the attachment site (the matrix object) has to be retrieved at this point in the sentence

As in Experiment 1, two cases were used: Accusative and Dative. Half of the matrix verbs assigned Accusative case (as in (7)), and the other half, Dative case. The participles also assigned either Accusative or Dative case to the embedded object.

In addition to the target sentences, 40 filler sentences with various syntactic structures other than participle clauses were included. The length and syntactic complexity of the filler sentences were similar to that of the target sentences. This experiment was also combined with another unrelated experiment containing an additional 24 items. The stimuli were pseudo-randomized separately for each participant, with at least one filler item or one item from the second experiment separating the target sentences.

Procedure. The procedure was identical to that used in Experiment 1.

3.2. Results

Reading time data. Five subjects and three items were excluded from the analyses on the basis of low response accuracies (below 55%; mean accuracy for the remaining subjects and items = 70.5%). Moreover, residual reading time data points that were more than three standard deviations away from the mean for a position within a condition were excluded from the analysis, affecting 2.7% of the data. Figure 3 presents the mean residual reading times at the critical region across the four conditions of the experiment.

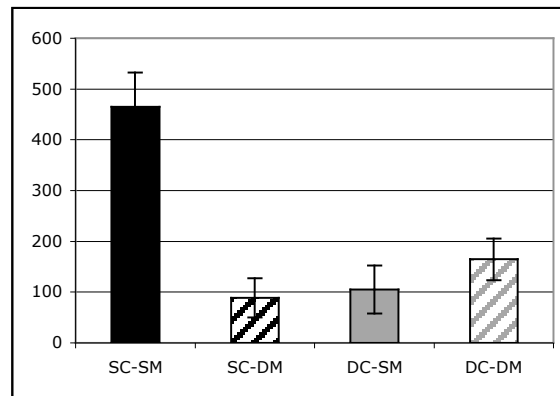


Figure 3. Residual reading times at the critical region in the four conditions of Experiment 2.

A 2x2 ANOVA on the critical region, which included the matrix verb, crossing abstract case (same, different) and case-markers (same, different), revealed two main effects and an interaction. First, there was a highly significant interaction between abstract-case and case-marker, such that the difference between same case-marker conditions and different case-marker conditions was larger for the same abstract case conditions ($F(1,33)=18.53$; $MSe=1613732$; $p<.0005$; $F(1,28)=16.47$; $MSe=1330672$; $p<.0005$). This interaction resulted in two main effects: (a) the same abstract case conditions were read slower than the different abstract case conditions ($F(1,33)=10.9$; $MSe=686236$; $p<.005$; $F(1,28)=9.69$; $MSe=622994$; $p<.005$); and (b) the same case-marker conditions were read slower than the different case-marker conditions ($F(1,33)=10.83$; $MSe=850278$; $p<.005$; $F(1,28)=10.65$; $MSe=710421$; $p<.005$). Finally, the “same abstract case/ same case-marker” condition was read significantly more slowly than any of the other three conditions ($F_s > 5$; $p_s < .01$), and there were no significant differences among the other three conditions ($F_s < 2$).

Response accuracy data. Participants answered the question correctly 70.5% of the time. A 2x2 ANOVA on the responses revealed no significant effects and no interaction. The mean response accuracies by condition are presented in Figure 4.

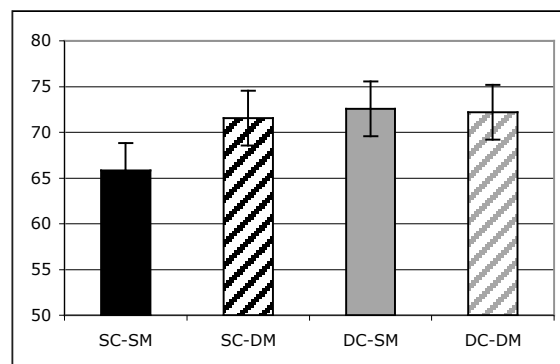


Figure 4. Mean response accuracies in the four conditions of Experiment 2.

3.3. Discussion

In contrast to Experiment 1, the results of Experiment 2 demonstrated that the effect of abstract case repetition and that of case-marker repetition are not in conflict, suggesting that the results of Experiment 1 are probably due to one or more of the confounding factors that were identified above. Moreover, the two effects are not independent. Neither factor by itself caused an increase in processing difficulty. But together, the two factors caused increased difficulty as measured by increased reading times at the verb and numerically lower accuracy rates for comprehension questions.

4. Summary and conclusions

This paper has investigated the nature of case interference in on-line sentence processing in Russian. Results from previous studies were inconclusive as to the role that morphological case-marker repetition plays in case interference in sentence comprehension. The results from Experiment 1 superficially suggested independent and opposing roles for morphological case and abstract case. But several confounds were identified in the design of that experiment. The design of Experiment 2 addressed these confounds and the results demonstrated that the effects of abstract case and morphological case interference are not independent: the effects are not apparent unless both factors are present. That is, neither morphological case nor abstract case interference cause processing difficulty when manipulated alone, but when both are present, processing becomes costly. Thus it is possible that the lack of a significant difference between the same case-marker condition and the different case-marker condition in Uehara & Bradley (1996) was due to the high overall complexity of the structures that were investigated, as discussed above. Furthermore, the results of Experiment 2 show that even in the absence of retroactive interference, the effects of proactive interference are measurable, as long as both the morphological case and the abstract case of the relevant NPs interfere.

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