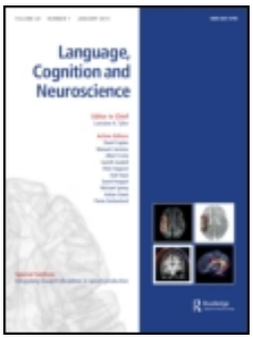

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Animacy information outweighs morphological cues in Russian

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The present study examined the robustness of morphosyntactic information (inflectional case marking) vs. semantic information (animacy) in non-canonical SOV-and-V structures in Russian, a morphologically rich language with relatively free word order. Results from a self-paced moving window paradigm followed by a comprehension question indicated that case marking was a relatively weak cue during online reading and offline comprehension compared to animacy, which was relied upon heavily throughout. The results suggest that even in languages with rich inflectional morphology, morphosyntax is fragile. Furthermore, the results provide support for memory-based models of sentence processing in which similarity-induced interference affects memory for previously encountered constituents and the integration of incoming material.

Keywords: morphosyntactic processing; semantic processing; animacy; morphosyntax; self-paced reading

Background information

Language contains information of various types, including morphosyntactic cues, such as case marking and word order, and semantic information, such as animacy. One goal of psycholinguistics is to understand the relative importance of these information sources during online sentence processing. The relative importance ascribed to these information sources by comprehenders might vary from language to language (Bates & MacWhinney, 1989; Kamide, Altmann, & Haywood, 2003; Yamashita, 1997, 2000), depending on the linguistic characteristics of a given language. Traditionally, syntactic information has been given a prominent role in serial models of sentence processing (Ferreira & Clifton, 1986; Frazier & Clifton, 1996; Frazier & Rayner, 1982). In processing models advocating the immediate availability of multiple sources of information, syntactic cues are also generally assumed to be central to the derivation of a final, coherent interpretation (Boland, 1997; MacDonald, Pearlmutter, & Seidenberg, 1994; Trueswell & Tanenhaus, 1994).

Empirical evidence suggests, however, that syntactic information can be fragile (Christianson, Hollingworth, Halliwell, & Ferreira, 2001; Ferreira, 2003) and decays quickly (Sachs, 1967). One memory-based parsing framework (Lewis & Vasishth, 2005; Lewis, Vasishth, & Van Dyke, 2006; Van Dyke & Lewis, 2003) proposes that comprehension difficulties observed in language processing can be explained via the mechanisms of memory decay and similarity-induced interference between lexical items during their encoding, retrieval, and/or storage. Within such a framework, the more similarity there is between two constituents (e.g., nouns), the more difficult it becomes to differentiate the constituents in memory. When one or both need to be integrated later into the unfolding parse, interference becomes more likely, and the wrong one might even be reactivated. A related class of memory-based processing accounts relies not on similarity but rather distance between a constituent and its eventual integration site (e.g., Gibson, 1998, 2000; Hawkins, 1995; Warren, & Gibson, 2002). The greater distance between the constituent and the integration site, the greater processing cost associated with integration, again, due to decay in memory.

A different class of processing accounts measure complexity according to the relative unexpectedness of an incoming constituent, compared to probabilities calculated from past language experience. These surprisal-based accounts (e.g., Hale, 2001, 2006; Levy, 2008) posit ongoing prediction about the features (syntactic, semantic, phonological, etc.) of upcoming words. The amount of overlap between prediction and the incoming constituent determines the ease with which it is integrated into the parse.

A common thread running between the memory-based and surprisal-based models is that syntactic information is less privileged than serial models assume it to be. If syntactic information does in fact decay quickly in memory, or may be less reliable as a

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predictor of upcoming material, there might be occasions when the parser weighs it less heavily than other types of potentially more stable or reliable information.

Syntactic information does appear susceptible to semantic interference (Kolk, Chwilla, van Herten, & Oor, 2003; Kuperburg, 2007; van Herten, Chwilla, & Kolk, 2006). Ferreira (2003) observed that English speakers were more likely to misidentify the agent of implausible passive sentences such as *The angler was caught by the fish* than either plausible passives (*The fish was caught by the angler*) or implausible actives (*The fish caught the angler*). Christianson, Luke, and Ferreira (2010) found that plausible passives and implausible actives primed the use of passive structures in a subsequent picture description task, but that implausible passives did not. The interpretation of this result and the results of Ferreira (2003) was that syntactic structure is fragile, and quickly overridden by semantic information. The body of work demonstrating syntactic fragility is still small, however, compared to the large number of previous studies demonstrating the privileged status of syntax (e.g., Clifton & Staub, 2008; Staub, 2007; Stroud, & Phillips, 2012; Van Dyke, & McElree, 2011). One potential explanation for the reported dominance of syntactic information is that a majority of psycholinguistic studies are conducted in languages with relatively rigid word orders (e.g., English, Dutch) and relatively sparse morphological paradigms (but cf. work in German: Bornkessel & Schlesewsky, 2006; Bornkessel-Schlesewsky & Schlesewsky, 2009; Chinese: Philipp, Bornkessel-Schlesewsky, Bisang, & Schlesewsky, 2008; or Turkish: Demiral, Schlesewsky, & Bornkessel-Schlesewsky, 2008). In this study, we test the robustness of the syntactic frame and the influence of semantic (animacy) cues in Russian, which displays morphological richness and extremely flexible word order. Serial models of processing predict that morphosyntactic information will outweigh animacy cues. Similarity-interference memory-based accounts (Lewis & Vasishth, 2005; Lewis et al., 2006; Van Dyke & Lewis, 2003) predict that semantic (animacy) cues can outweigh morphosyntactic (case marking) cues if the latter are not informative (ambiguous or null). Surprisal-based accounts and memory-based accounts that rely on a distance metric to calculate processing cost (Gibson, 1998; Hawkins, 1995; Warren & Gibson, 2002) do not differentiate between the morphosyntactic and semantic qualities of the constituents as long as the linear order of the constituents is constant.

Relevant characteristics of Russian

Russian is a pro-drop language that allows all six basic word orders (SVO, OVS, VOS, VSO, SOV and OSV) but has a canonical SVO order (Babyonyshev, 1996; Bailyn, 1995; but see King, 1995, who favours VSO). Due to its relatively free word order, Russian does not automatically conflate the agentivity of the noun with sentence position. For example, an assertion like *A fox sees a meadow* can be expressed in six different ways, as seen in (1a–f).

(1) a. Лиса увидела поляну.

Fox$_{NOM}$ see$_{3rdPsSG}$ meadow$_{ACC}$

b. Поляну увидела лиса.

Meadow$_{ACC}$ see$_{3rdPsSG}$. fox$_{NOM}$

c. Лиса поляну увидела.

Fox$_{NOM}$ meadow$_{ACC}$ see$_{3rdPsSG}$

d. Поляну лиса увидела.

Meadow$_{ACC}$ fox$_{NOM}$ see$_{3rdPsSG}$.

e. Увидела поляну лиса.

See$_{3rdPsSG}$ meadow$_{ACC}$. fox$_{NOM}$

f. Увидела лиса поляну.

See$_{3rdPsSG}$ fox$_{NOM}$ meadow$_{ACC}$.

A number of corpus studies converge on SVO being most frequent (80%) (Bivon, 1971; Kemp & MacWhinney, 1999; Lobanova, 2011). According to the same sources, the rest of the word orders exhibit the following distribution: OVS 14%, OSV 3%, VOS/VSO 2% and SOV 1%.

Thematic relationships in Russian are encoded with morphological case markings on nouns, adjectives, and pronouns, and tense and aspect inflections on the verbs, gerunds, and participles. Case markings in nominative and accusative cases for some nouns are realised as null endings, resulting in a potential ambiguity in thematic role assignments. (See Appendix 1 for the complete declensional paradigm of Russian nouns used in this experiment.)

In the present experiment, we manipulated nominative and accusative case markings on nominal arguments and the animacy of arguments as participants read non-canonical SOV-and-V structures in a self-paced reading paradigm. This design allowed us to examine the relative salience of morphological vs. semantic information at a delayed point in the main clause (i.e., on the main verb) and in the conjoined clause, as well as at the time of answering an offline comprehension question about each sentence. If mor-

phosyntax is fragile even in a language in which much potentially depends on tracking the case marking on arguments, we anticipated that animacy would be a more salient, stable cue in all conditions, including those in which case was unambiguously marked.

Experiment

Previous studies that focused on canonical SVO and the second most frequent OVS word order have established that inflectional morphology is a very salient source of information during Russian sentence comprehension (Fedorenko, Babyonyshev, & Gibson, 2004; Slioussar, 2011). In SVO and OVS orders, inflectional morphology is a more robust information source than the animacy of the verbal arguments (Kemp & MacWhinney, 1999). But different word orders in a given language might induce different parsing strategies, or at least serve to direct more attention to one factor and away from another. The reason for this strategic or attentional shift may lie in the demands on memory outlined above: If one information source is highly confusable, it may be given less weight than an information source that is less confusable. The least frequent SOV word order allows for the examination of the salience of inflectional morphology on the arguments when they both precede the verb. To increase memory demands beyond the end of the clause, we combined a main SOV clause with the reflexive form of the second verb in the subordinate clause that is co-referenced with the subject of the first clause as seen in (2).

2. [S [$_{VP}$[$_{VP}$OV] and [$_{VP}$V]]].

In this way, we could observe effects of reactivation of the arguments at the main verb, where they are integrated into the current thematic domain (Rizzi, 1990), and later yet at a second verb whose subject is obligatorily the subject of the previous clause. To our knowledge, this is the first time that processing of this type of construction has been investigated.

Methods

The manipulation of both morphology and animacy across conditions resulted in four conditions. The first was a globally ambiguous sentence (3a): both noun phrases have zero inflections and are animate. The conditions in (3b) and (3c) are temporarily ambiguous. In (3b), the temporary ambiguity is induced by the morphological uninformativeness of the first and second nouns, but is disambiguated through the animacy of the second noun: both nouns are marked with zero inflections and are ambiguous between the nominative and accusative cases (subject/object), but the first noun is animate while the second is inanimate.

In (3c), ambiguity is induced by the semantic uninformativeness of both nouns, but is disambiguated through the morphology of the first noun. Both nouns are animate, but the first noun is unambiguously marked with the nominative case marking, while the second noun is the same as the second noun in the globally ambiguous sentence (marked ambiguously for the nominative/accusative case.

The control condition (3d) provides the highest level of syntactic and semantic informativeness: the first noun is unambiguously marked with the nominative case inflection and is animate. Although the second noun is still morphologically ambiguous between the nominative and accusative case, it is inanimate. According to the selectional restrictions on both verbs, it can only fulfil the role of Patient.

(3) a. Global ambiguity:

Рысь	лань	почуяла и	насторожилась.
Bobcat Acc/Nom	fallow deer Acc/Nom	sensed and	pricked up its ears.

'Bobcat sensed a fallow deer and pricked up its ears.'

b. Syntactic ambiguity:

Рысь	вонь	почуяла и	насторожилась.
Bobcat Acc/Nom	bad smell Acc/Nom	sensed and	pricked up its ears.

'Bobcat sensed a bad smell and pricked up its ears.'

c. Semantic ambiguity:

Лиса	лань	почуяла и насторожилась.	
Fox Nom	fallow deer Acc/Nom	sensed and	pricked up its ears.

'Fox sensed a fallow deer and pricked up its ears.'

d. Control sentence:

Лиса	вонь	почуяла и насторожилась.	
Fox Nom	bad smell Acc/Nom	sensed and	pricked up its ears.

'Fox sensed a bad smell and pricked up its ears.'

e. Question:

Вопрос: Кто насторожился?

Question: What pricked up its ears?

Predictions

If morphosyntax is given priority in online sentence comprehension in Russian, then the case marking information will be critical. Under such a scenario, the semantically temporary ambiguous condition (3c) and control condition (3d) will show the least signs of processing difficulty in both response times and accuracy. If morphosyntactic information is less influ-

ential than animacy, then the semantically informative but syntactically temporarily ambiguous condition (3b) and control condition (3d) will show the least signs of difficulty in online and offline measures.

Since the second verb occupies a sentence's final position, any effects associated with the processing of the second verb could be ascribed to sentence wrap-up effects (Just & Carpenter, 1980; Rayner, Kambe, & Duffy, 2000). However, recent investigations suggest that sentence wrap-up effects are not only affected by non-linguistic factors but also by processing difficulties of the sentence material (Warren, White, & Reichle, 2009). Any systematic variation across manipulated parameters (syntax/semantic) at the point of the second verb, even if ascribed to wrap-up effects, would in turn indicate additive effects of extended difficulty caused by verbal arguments appearing three words earlier.

Procedure

Sentences were displayed one at a time in a word-by-word self-paced, non-cumulative reading paradigm (Just, Carpenter, & Wooley, 1982). The words were replaced with underlines that maintained word length, spacing and punctuation. Participants progressed through each sentence by pressing a button on a standard game controller. The amount of time participants spent reading a word was taken to indicate the processing time needed for that particular word. After each sentence, participants saw a comprehension question that asked who performed the action. Two answers were displayed under the question, counterbalanced for order across lists. Participants pressed the button that corresponded to the correct answer. Stimuli were displayed and all dependent measures were collected using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA, USA).

Participants

Thirty-two native speakers of Russian (23 females; average age 35, range 20–67), either residing in or visiting the Champaign-Urbana community, participated in the experiment. Participants were recruited by word of mouth and compensated $10 for their time.

Design

The experiment employed a 2 × 2 repeated measures design. Each item had four versions (e.g., (3)), which were distributed across four lists in a Latin square design such that each participant saw each item in only one of its versions on any given list.

The response times for each of the five words in the stimuli (NP1, NP2, VP1, AND and VP2), the response time for the answer to the question, and the accuracy of the answer to the question were all dependent measures.

Materials

Frequencies of the nouns and verbs used in the stimuli were controlled. Frequency counts were taken from Sharoff's online Russian frequency dictionary (http://bokrcorpora.narod.ru/frqlist/frqlist-en.html). Differences within and between word classes were non-significant (Appendix 2).

Sentences were controlled for plausibility in a separate norming procedure that measured the reversibility of the arguments. We selected items in which both nouns were rated as equally plausible as either agent or patient of the main verb and the subject of the second verb (Appendix 3).

Expectations of the continuation after the conjunction 'and' were also tested in two additional sentence-completion norming studies. First norming study included not only items in SOV order (which was the order used in the main experiment here), but also OSV, SVO and OVS orders and unambiguous case markings. In the second study, the beginning of the sentences were the exactly the same as in the experimental conditions (ambiguous/unambiguous case marking and animate/inanimate nouns). Results revealed that regardless of the word order in the main clause or animacy of the verbal arguments (animate/animate, animate/inanimate), the verb was preferentially co-referenced with the subject of the main clause 90% of the time whether the case marking was ambiguous or not (Appendix 4).

Due to the difficulty of constructing items to fit the condition parameters (see norming description in Appendix 3), there were only 12 items. All items appear in Appendix 5.

There was a four-item practice session. There were a total of 48 trials in each session, including 36 filler sentences. Twenty-four fillers contained ambiguity between a non-verbal secondary predicate and an adjunct by-phrase, the agent in passive constructions. The other 12 fillers were not ambiguous and varied from simple single-clause structures to more complex structures. Questions for filler sentences did not probe the subject/object, nor did they probe the ambiguities in the 24 ambiguous fillers.

Results

Reaction times ±3 SD from the condition mean for each critical region were eliminated. These criteria resulted in the removal of less than 0.03% of the data. Reading time data were analysed using linear mixed effects (LME) modelling (Baayen, Davidson & Bates, 2008). LME analyses often have more power than ANOVAs, and can reveal effects that ANOVAs would not detect (Luke & Christianson, 2011). Given the small number of items and relatively limited participant pool of the present study, maintaining maximum statistical

Table 1. Mean response times by regions and conditions.

	NP1	NP2	VP1	AND	VP2	Questions	Accusative
Globally ambiguous	493.5	618.5	992.3	522.5	2210.1	3526.3	0.92
Syntactically ambiguous	500.3	672.3	869.0	454.9	1296.5	2298.8	0.98
Semantically ambiguous	482.9	650.4	917.4	487.1	1635.0	2705.7	0.93
Control	485.6	626.4	865.4	458.3	1150.5	2107.3	0.98

power was of paramount importance. For the analyses of the question accuracy data, we relied on a logit version of the mixed model analysis (Jaeger, 2008).

Reading times were analysed at the following regions: the first noun (NP1), the second noun (NP2), the first verb (VP1), the conjunction (*and*) and the second verb (VP2). Predictors were morphological ambiguity (ambiguous vs. unambiguous) and animacy (animate vs. inanimate).

For all models, random effect structure was fitted using likelihood ratio tests, while the fixed effect structure was fitted using a stepwise model selection procedure, with only predictors and interactions that were significant ($p < 0.05$) retained in the model. *P*-values for fixed effects were obtained using Markov chain Monte Carlo sampling. Only predictors that significantly contributed to the model are reported below. All final models reported below had random intercepts for participants and items. The model for reading times at the second verb also included random by-participant slopes for animacy. No other random slopes or interactions contributed significantly to the model (all *p*-values > 0.056). Mean reading times, question response times and question accuracy are provided in Table 1.

There was no significant difference in the response times or interaction across conditions during the processing of NP1, NP2 or VP1. It is difficult to conclude what is going on based on null results and a number of possible alternatives will be considered in the *Discussion* section.

The first significant difference emerged at the point of processing the conjunction *and*. A significant effect of animacy (Estimate $= -0.068$, SE $= 0.034$, $t = -1.98$, $p < 0.05$; effect size $= 30$ ms) indicated that syntactically ambiguous (3b) and control conditions (3d), which both had animate NP1 and inanimate NP2, were processed faster than the semantically ambiguous and globally ambiguous conditions, which both had two animate NPs. This suggests that semantic information (animacy of the NPs) was more salient than syntactic information (morphological case marking). Note, however, that there was a trend towards an interaction, whereby the semantic ambiguity penalty may have been exacerbated when accompanied by syntactic ambiguity. It is thus possible that we failed to find a reliable syntactic effect at the conjunction due to low statistical power. Future work will be required to test this possibility.

Given the self-paced reading methodology, it is not possible to determine whether the semantic effect was induced by the conjunction *and* or the matrix verb that preceded the conjunction. A follow-up study using eye-tracking could help answer this question.

Large effects of both syntactic (Estimate $= -0.2$, SE $= 0.06$, $t = -3.32$, $p < 0.001$; effect size $= 256$ ms) and semantic (Estimate $= -0.28$, SE $= 0.074$, $t = -3.8$, $p < 0.001$; effect size $= 347$ ms) informativeness emerged at the processing of the subordinate verb. The fixed effects coefficients indicate that conditions with two animate noun phrases (NPs) as well as conditions with ambiguous case marking on the first NP slowed processing at the subordinate verb.

This pattern of results rules out either the primacy of the first verbal argument or the primacy of syntactic information and shows the importance of both verbal arguments and of both information sources. The unambiguously nominative case marking (*-a*) in the semantically ambiguous condition (3c) was not strong enough to override processing difficulty induced by animacy and the null case ending of the second NP, just as the animacy cue associated with the inanimate second NP in syntactically ambiguous sentences (3b) was not strong enough to override the syntactic ambiguity of both nouns.

We found an identical pattern of results at the processing of the question. Both syntactic (Estimate $= -0.12$, SE $= 0.05$, $t = -2.44$, $p < 0.05$; effect size $= 329$ ms) and semantic ambiguity (Estimate $= -0.29$, SE $= 0.05$, $t = -5.73$, $p < 0.001$; effect size $= 713$ ms) affected response times to the question. This suggests that the process of sorting out syntactic and semantic information was either repeated in order to answer the question, despite having also been performed in the immediately prior region, or was not completed prior to making the button press to proceed to the question.

In the analysis of question response accuracy,[1] the effect of animacy was significant (Estimate $= 1.71$, SE $= 0.72$, $z = 2.36$, $p < 0.05$; effect size $= 1.1\%$), with somewhat lower accuracy when two animate NPs were present in the sentence. When there was no difference in animacy between the NPs, it was harder to assign the thematic roles to the subject and the object. Morpho-

syntax appeared to be unhelpful in answering the questions.

Trial order was a significant predictor of accuracy (Estimate = 0.07, SE = 0.03, $z = 2.62$, $p < 0.05$, effect size = 6%). As participants progressed through the experiment, accuracy improved from 94.5% at the beginning of the experiment to 99.5% at the end. Trial order did not interact with any other factor.

Discussion

In a self-paced reading study we examined the salience of syntactic information in Russian. We used conjoint non-canonical matrix and subordinate clauses as a testing ground. Rather late effects of semantic information (animacy) at the point of processing the conjunction *and* reflects difficulty with subject/agent role assignment at the matrix verb preceded by two animate NPs, even when the first NP was marked unambiguously for nominative case (semantically ambiguous condition). In the non-canonical SVO word order used here, morphosyntactic information in Russian thus appears to be fragile (Ferreira, 2003; Kuperberg, 2007), and animacy is a more salient source of information.

Within memory-based parsing models (Lewis & Vasishth, 2005; Lewis et al., 2006; Van Dyke & Lewis, 2003), this pattern can be accounted for by positing that case markings are not well differentiated in memory, and thus difficult to reactivate when its time comes to assign thematic roles to the main verb. Animacy information, on the other hand, provides a more reliable retrieval cue. Notice that memory-based accounts relying on a distance metric (Gibson, 1998, 2000; Warren & Gibson, 2002) do not predict any differential effects of animacy. Furthermore, given that the distance between the arguments and the main and conjoined verb was always constant, it is not clear that this class of accounts predicts any differences between morphological conditions, either.

The main effects of animacy and morphology found at the processing of the conjoined verb (V2) indicate extended difficulty caused by verbal arguments appearing three words earlier. Given that the norming study testing the expectations of a syntactic category after the conjunction (Appendix 4) found a 90% preference for a verb whose subject was co-referential with the subject of the first sentence, we can rule out the possibility that the processing difficulty was induced by the conjoined verb per se, as might be predicted by a surprisal-based parsing account[2] (Hale, 2001, 2006; Levy, 2008). The parser integrated available information sources, but conflicting semantic (two animate nouns) and syntactic (morphologically ambiguous arguments) information caused slower reaction times not only in processing the conjoined verb, but also at the post-interpretative stage, as demonstrated by slower reaction times to the comprehension questions and decreased accuracy.

Statistical differences between online and offline patterns of results also shed some light on how different information sources affect the final interpretation of a sentence. Sentences that were morphosyntactically ambiguous and semantically unambiguous were read more quickly than sentences that were morphosyntactically unambiguous and semantically ambiguous. Moreover, sentences with the former configuration were comprehended more accurately and more quickly than sentences with the latter configuration. This pattern therefore does not appear to be an example of a speed-accuracy trade-off, but rather akin to a 'labour in vain' effect (Nelson & Leonesio, 1988). Semantic ambiguity, i.e., the lack of animacy cues, slowed reading at both points: arguments needed to be reactivated for thematic role assignment, and when a comprehension question about those thematic roles was asked. This perseverative effect of animacy strongly supports the interpretation that it was assigned more weight than the morphosyntactic cues.

Our data are compatible with accounts that attribute comprehension difficulties to similarity-based interference during memory encoding, retrieval and/or storage (Gordon & Lowder, 2012; Lewis & Vasishth, 2005; Lewis et al., 2006; McElree, 2006; Van Dyke & Lewis, 2003). Both ambiguous case marking and unbiased animacy (both animate nouns) made reactivation of the preferred subject NP at the conjoined verb more difficult. The same difficulty was reflected in comprehension question response latencies and accuracy; however, when it came to settling on a final interpretation, only animacy remained a reliable cue, suggesting that the morphological cues had decayed to such an extent that they were difficult to differentiate during retrieval.

It should also be noted that hybrid models, which separate animacy from such semantic sources as discourse context and world knowledge and assume parallel integration of animacy and syntactic information on verbal arguments, can also account for the obtained pattern of results by assuming competition for the actor role (e.g., extended Argument Dependency Model (eADM), Bornkessel & Schlesewsky, 2006; Bornkessel-Schlesewsky & Schlesewsky, 2009). However, eADM would need to be slightly modified to incorporate the processing of subordinate or conjoined clauses, like the one in the present materials, as in its current state the model is underspecified with regard to processes outside of the main clause.

Despite limitations imposed by the small number of items, the present study represents the first to directly

pit case marking against animacy in the online processing of the non-canonical SOV word order in Russian. The results strongly suggest that, even in a language with rich morphological information, morphosyntax is a fragile information source. On the other hand, animacy information was a salient cue from the earliest point that effects were observed, through the conjoined clause, and into the post-interpretive processing required to answer the comprehension question. The pattern of results is consistent with memory-based models of sentence processing that posit similarity-induced interference as a primary source of processing complexity.

Notes

1. In the globally ambiguous condition, we considered a 'correct' answer to be the one that was consistent with the results of the norming study, in which the first noun was assigned as the subject of the second verb 90% of the time.
2. Note that both the lack of effects observed at the main verb and the effects observed at *and* might be attributable to surprisal: participants were expecting a verb after two NP arguments, but not expecting the sentence to continue past the current thematic processing domain. However, given that there is no clear reason to expect differential surprisal at *and* contingent on the various morphological/animacy conditions used here, we are sceptical of the surprisal explanation for these results.

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Appendix 1: Russian nominal declension system[a]

Table 1. Type 1: singular (feminine nouns ending in a consonant and a vowel "a").

Case	Hard		Soft		
Nominative	черта stroke	мама mother	статья article	буря storm	линия line
Genitive	черты	мамы	статьи	бури	линии
Dative	черте	маме	статье	буре	линии
Accusative	черту	маму	статью	бурю	линию
Instrumental	чертой	мамой	статьёй	бурей	линией
Locative	(о) черте	(о) маме	(о) статье	(о) буре	(о) линии

Table 2. Type 2: singular (masculine nouns ending in a consonant).

Case	Hard		Soft			
Nom.	серп sickle	Человек man	Пахарь plowman	Гений genius	Конь male horse	руль rudder
Genitive	серпа	человека	пахаря	гения	коня	руля
Dative	серпу	человеку	пахарю	гению	коню	рулю
Accusative	серп	человека	пахаря	гения	коня	руль
Instr.	серпом	человеком	пахарем	гением	конём	рулём
Locative	(о) серпе	(о) человеке	(о) пахаре	(о) гении	(о) коне	(о) руле

Table 3. Type 3: feminine nouns ending in a palatalized consonant.

Case	Soft	
Nominative	Мысль thought	мышь mice
Genitive	мысли	мыши
Dative	мысли	мыши
Accusative	мысль	мышь
Instrumental	мыслью	мышью
Locative	(о) мысли	(о) мыши

[a] Plural case markings are omitted as the experimental stimuli were all singular. Ambiguous nominative/accusative endings are shaded.

Appendix 2. Frequency norming study

Frequency counts were taken from Sharoff's online frequency dictionary (http://bokrcorpora.narod.ru/frqlist/frqlist-en.html) for Russian. Differences within and between word classes were nonsignificant (Table 1).

Table 1. Nouns and verbs frequency counts.

	Type	N	Mean	SD	SEM	t	df	Sig (2-tailed)
FreqVerb	VP1	12	60.1567	71.02786	10.25199	.844	84	.401
	VP2	12	48.6450	62.38121	9.00395			
FreqNoun	NP1	12	52.0342	120.90744	17.45149	.287	94	.775
	NP2	12	46.4404	59.98768	8.65848			

Appendix 3. Plausibility norming study

Sentences were controlled for plausibility in a separate norming procedure that measured plausibility of the globally ambiguous sentences. In the norming, each globally ambiguous sentence, such as (1), had six possible variants.

(1) рысь	лань	почуяла и	насторожилась.
Bobcat -Acc/Nom	fallow deer -Acc/Nom	sensed and	pricked up its ears.

We selected items in which both nouns had equal plausibility ratings for being the subject or the object of the main verb and the subject of the second. In order to measure this, pairs of sentences such as (2 a-b) were created.

(2a) рысь	почуяла	лань	и	насторожилась.
Bobcat Acc/Nom sensed		fallow deer Acc/Nom		and pricked up its ears.
(2b) лань	почуяла	рысь	и	насторожилась.
fallow deer Acc/Nom	sensed	Bobcat Acc/Nom	and	pricked up its ears.

Next, to ensure that nouns would have equal plausibility ratings as both subject and object only for the main verb, pairs of sentences such as (3a –b) were created.

(3a) рысь	почуяла	лань
Bobcat Acc/Nom sensed		fallow deer Acc/Nom
(3b) лань	почуяла	рысь
Fallow deer Acc/Nom	sensed	bobcat Acc/Nom.

Finally, to ensure that both nouns had equal ratings as subject of the second verb a third set of sentence pairs such as (4a-b) were created.

(4a) рысь насторожилась.

Bobcat Acc/Nom pricked up its ears.

(4b) лань насторожилась.

fallow deer Acc/Nom pricked up its ears.

Each sentence was rated on a scale from 1 (impossible) to 5 (only happens this way). The instructions (written in Russian) included examples for each of the ratings on the scale.

A total of 72 sentences were divided into two lists of 36 sentences. Sentences were randomized in such a way that only three of the above six sentences for each condition were in one list and there were several sentences between those three sentences in a list. The surveys were distributed among 100 native-speaking Russian participants, none of whom took part in the main experiment. The average rating for each of the six conditions was calculated and then the means were compared in such a way that 1 was compared with 2, 3 with 4, and 5 with 6, as illustrated in Table 1. Paired t-tests revealed no significant difference between the ratings (Table 1).

Table 1. Acceptability ratings.

Comparison of Sentence type	t-test (p =)
Complete sentences in the canonical SVO word order. 1. рысь почуяла лань и насторожилась. Bobcat Acc/Nom sensed fallow deer Acc/Nom and pricked up its ears. 2. лань почуяла рысь и насторожилась. Fallow deer Acc/Nom sensed bobcat Acc/Nom and pricked up its ears.	0.49
Main clause only 3. рысь почуяла лань. Bobcat Acc/Nom sensed fallow deer Acc/Nom 4. рысь почуяла лань.	0.30

Fallow deer Acc/Nom sensed bobcat Acc/Nom	
Conjoint phrase only. 5. рысь насторожилась. Bobcat Acc/Nom pricked up its ears 6. лань насторожилась. Fallow deer Acc/Nom pricked up its ears.	0.16

Appendix 4. Continuation studies to test expectations induced by the conjunction

In order to facilitate the interpretation of the effects obtained at the conjunction, a continuation study was conducted to elicit the expectations of the processing system. Twenty participants who did not take part in the main experiment finished a total of 96 given beginnings of the sentences distributed via an online survey. The survey consisted of 12 items for each of the 8 following structures: $S_{anim}VO_{anim}$ and…/$O_{anim}VS_{anim}$ and…/$S_{anim}O_{inanim}V$ and …/$O_{inanim}S_{inanim}V$ and … . None of the lexical items were repeated throughout the survey.

Both NPs were unambiguously marked for subject (Nominative case) or object (Accusative case). Subjects were always animate because all the subjects in the main study were animate as well, but objects were either animate or inanimate. The continuation study was testing whether animacy of the NPs and the word order of the main clause would change preferences for the continuation structure of the conjoined second phrase.

(1a) $S_{anim}VO_{anim}$ and…

Лошадь разглядела собаку и …

$Horse_{NOM}$ saw dog_{ACC} and…

‘A horse saw a dog and …’

(1b) $O_{anim}VS_{anim}$ and…

Собаку разглядела лошадь и …

Dog_{ACC} s saw $horse_{NOM}$ and…

‘A horse saw a dog and …’

(1c) $S_{anim}O_{anim}V$ and …

Лошадь собаку разглядела и …

$Horse_{NOM}$ dog_{ACC} saw and…

‘A horse saw a dog and …’

(1d) $O_{anim}S_{anim}V$ and …

Собаку лошадь разглядела и …

Dog_{ACC} $horse_{NOM}$ saw and…

‘A horse saw a dog and …’

(1e) $S_{anim}VO_{inanim}$ and…

Лошадь разглядела улицу и …

$Horse_{NOM}$ saw $street_{ACC}$ and…

'A horse saw a street and …'

(1f) $O_{inanim}VS_{anim}$ and…

Улицу разглядела лошадь и …

$Street_{ACC}$ saw $horse_{NOM}$ and…

'A horse saw a street and …'

(1g) $S_{anim}O_{inanim}V$ and …

Лошадь улицу разглядела и …

$Horse_{NOM}$ $street_{ACC}$ saw and…

'A horse saw a street and …'

(1e) $O_{inanim}S_{anim}V$ and …

Улицу лошадь разглядела и …

$Street_{ACC}$ $horse_{NOM}$ saw and…

'A horse saw a street and …'

Percentages and raw means of how many times the pro-dropped subject of the conjoined verb was co-referential with the subject of the main clause were very consistent across different word orders (Table 1). Paired t-test comparisons confirmed that continuation preferences did not change significantly either with the animacy of the object or with the word order of the arguments within the main clause.

Table 1. Percentage and raw means of the conjoint verb constructions with the dropped subject.

Construction types	% of conjoint verb with dropped subject (Raw means)
$S_{anim}VO_{anim}$ and…	90% (10.8)
$O_{anim}VS_{anim}$ and…	90% (11.0)

$S_{anim}O_{anim}V$ and …	90% (10.9)
$O_{anim}S_{anim}V$ and …	90% (11.0)
$S_{anim}VO_{inanim}$ and…	90% (11.0)
$O_{inanim}VS_{anim}$ and…	90% (10.7)
$S_{anim}O_{inanim}V$ and …	90% (10.8)
$O_{inanim}S_{anim}V$ and …	90% (10.8)

Table 2. Results of one-sample paired t-test comparisons.

Construction type comparisons	p-values (2-tailed)
$S_{anim}VO_{anim}$ and… vs. $O_{anim}VS_{anim}$ and…	0.67
$S_{anim}O_{anim}V$ and… vs. $O_{anim}S_{anim}V$ and…	0.76
$S_{anim}VO_{inanim}$ and…vs. $O_{inanim}VS_{anim}$ and…	0.59
$S_{anim}O_{inanim}V$ and… vs. $O_{inanim}S_{anim}V$ and…	0.63

Appendix 5. Experimental stimuli

1.

A. Ambiguous case/unbiased agency:

рысь	лань	почуяла и	насторожилась.
Bobcat Acc/Nom	fallow deer Acc/Nom	sensed and	pricked up its ears.
(5.13)	(1.38)	(11.41)	(14.7)

B. Ambiguous case/biased agency:

рысь	вонь	почуяла и	насторожилась.
Bobcat Acc/Nom	bad smell Acc/Nom	sensed and	pricked up its ears.
(5.13)	(9.11)	(11.41)	(14.7)

C. Unambiguous case/unbiased agency:

Лиса	лань	почуяла и насторожилась.	
Fox Nom	fallow deer Acc/Nom	sensed and	pricked up its ears.
(6.05)	(1.38)	(11.41)	(14.7)

D. Unambiguous case/biased agency:

Лиса	вонь	почуяла и насторожилась.	
Fox Nom	bad smell Acc/Nom	sensed and	pricked up its ears.
(6.05)	(9.11)	(11.41)	(14.7)

Вопрос: Кто насторожился?
Question: Who pricked up its ears?

2

A. Ambiguous case/unbiased agency:

Лошадь	лебедь	разглядела и	взрогнула
Horse Acc/Nom	swan Acc/Nom	saw and	jerked
(130.73)	(16.69)	(40.58)	(39.43)

B. Ambiguous case/biased agency:

Лошадь	площадь	разглядела и	взрогнула
Horse Acc/Nom	town sqare Acc/Nom	saw and	jerked
(130.73)	(132.65)	(40.58)	(39.43)

C. Unambiguous case/unbiased agency:

собака	лебедь	разглядела и	взрогнула
Dog Nom	swan Acc/Nom	saw and	jerked
(209.56)	16.69)	(40.58)	(39.43)

D. Unambiguous case/biased agency:

собака	площадь	разглядела и	взрогнула
Horse Nom	town sqare Acc/Nom	saw and	jerked
(209.56)	(132.65)	(40.58)	(39.43)

Вопрос: Кто взрогнул?
Question: Who jerked?

3.

A. Ambiguous case/unbiased agency:

моль	мышь	почувствовала и	замерла
moth Acc/Nom	mouse Acc/Nom	sensedand	froze up
(5.4)	(26.91)	(164.42)	(60.22)

B. Ambiguous case/biased agency:

моль	печь	почувствовала и	замерла
moth Acc/Nom	oven Acc/Nom	sensed and	froze up
(5.4)	(42.72)	(164.42)	(60.22)

C. Unambiguous case/unbiased agency:

сова	мышь	почувствовала и	замерла
Owl Nom	mouse Acc/Nom	sensed and	froze up
(6.74)	(26.91)	(164.42)	(60.22)

D. Unambiguous case/biased agency:

сова	печь	почувствовала и	замерла
owl Nom	oven Acc/Nom	sensed and	froze up
(6.74)	(42.72)	(164.42)	(60.22)

Вопрос: Кто замер?
Question: What froze?

4.

A. Ambiguous case/unbiased agency:

вертолет	самолет	обошел и	взлетел
helicopter Acc/Nom	planeAcc/Nom	came around and	took off
(46.17)	(165.8)	(42.07)	(22.09)

B. Ambiguous case/biased agency:

вертолет	поворот	обошел и	взлетел
helicopter Acc/Nom	turn Acc/Nom	came around and	took off
(46.17)	(54.76)	(42.07)	(22.09)

C. Unambiguous case/unbiased agency:

ракета	самолет	обошла и	взлетела
Rocket Nom	planeAcc/Nom	came around and	took off
(56.05)	(165.8)	(42.07)	(22.09)

D. Unambiguous case/biased agency:

ракета	поворот	обошла и	взлетела
Rocket Nom	turn Acc/Nom	came around and	took off
(56.05)	(54.76)	(42.07)	(22.09)

Вопрос: Что взлетело?
Question: What took off?

5.

A. Ambiguous case/unbiased agency:

крейсер	лайнер	засек	и	остановился.
Cruiser Acc/Nom	cargo liner Nom/Acc	noticed	and	stopped.
(4.75)	(5.13)	(5.74)		(238.81)

B. Ambiguous case/biased agency:

крейсер	остров	засек	и	остановился.
Cruiser boatAcc/Nom	island Nom/Acc	noticed	and	stopped.
(4.75)	(104.59)	(5.74)		(238.81)

C. Unambiguous case/unbiased agency:

лодка	лайнер	засекла	и	остановилась.
boat Nom	liner Nom/Acc	noticed	and	stopped.
(88.2)	(5.13)	(5.74)		(238.81)

D. Unambiguous case/biased agency:

лодка	остров	засекла	и	остановилась.
boat Nom	island Nom/Acc	noticed	and	stopped.
(88.2)	(104.59)	(5.74)		(238.81)

Вопрос: Что остановилось?
Question: What stopped?

6.

A. Ambiguous case/unbiased agency:

грузовик	автобус	объехал	и	развернулся.
Truck Acc/Nom	bus Acc/Nom	passed	and	turned around.
(49.54)	(81.04)	(4.59)		(29.32)

B. Ambiguous case/biased agency:

грузовик	поселок	объехал	и	развернулся.
Truck Acc/Nom	village Acc/Nom	passed	and	turned around.
(49.54)	(59.99)	(4.59)		(29.32)

C. Unambiguous case/unbiased agency:

телега	автобус	объехала	и	развернулась.
Dray Nom	bus Acc/Nom	passed	and	turned around.
(21.94)	(81.04)	(4.59)		(29.32)

D. Unambiguous case/biased agency:

телега	поселок	объехала	и	развернулась.
Dray Nom	village Acc/Nom	passed	and	turned around.
(21.94)	(59.99)	(4.59)		(29.32)

Вопрос: Что развернулось?
Question: What turned around?

7.

A. Ambiguous case/unbiased agency:

кенгуру	газель	унюхала	и	завернула.
Kangaroo Acc/Nom	gazelle Acc/Nom	sensed	and	turned.
(4.4)	(1.23)	(1.07)		(27.3)

B. Ambiguous case/biased agency:

кенгуру	карамель	унюхала	и	завернула.
Kangaroo Acc/Nom	caramel Acc/Nom	sensed	and	turned.
(4.4)	(1.07)	(1.07)		(27.3)

C. Unambiguous case/unbiased agency:

пантера	газель	унюхала	и	завернула.
Panther Nom	gazelle Acc/Nom	sensed	and	turned.
(2.76)	(1.23)	(1.07)		(27.3)

D. Unambiguous case/biased agency:

кенгуру	карамель	унюхала	и	завернула.
пантера Nom	caramel Acc/Nom	sensed	and	turned.
(2.76)	(1.07)	(1.07)		(27.3)

Вопрос: Кто завернул?
Question: Who turned?

8.

A. Ambiguous case/unbiased agency:

Форель	сельдь	учуяла	и	уплыла.
Trout Acc/Nom	herring Acc/Nom	sensed	and	swam away.
(3.71)	(1.49)	(3.79)		(5.55)

B. Ambiguous case/biased agency:

Форель	трость	учуяла	и	уплыла.
Trout Acc/Nom	caneAcc/Nom	sensed	and	swam away.
(3.71)	(7.2)	(3.79)		(5.55)

C. Unambiguous case/unbiased agency:

треска	сельдь	учуяла	и	уплыла.
cod Nom	herring Acc/Nom	sensed	and	swam away.
(1.95)	(1.49)	(3.79)		(5.55)

D. Unambiguous case/biased agency:

треска	трость	учуяла	и	уплыла.
cod Nom	caneAcc/Nom	sensed	and	swam away.
(1.95)	(7.2)	(3.79)		(5.55)

Вопрос: Кто уплыл?
Question: Who swam away?

9.

A. Ambiguous case/unbiased agency:

теплоход	сухогруз	задел	и	взорвался.
Steam boat Acc/Nom	cargo ship Nom/Acc	touched	and	blew up.
(10.22)	(1.19)	(17.61)		(19.83)

B. Ambiguous case/biased agency:

теплоход	айсберг	задел	и	взорвался.
Steam boat Acc/Nom	iceberg Nom/Acc	touched	and	blew up.
(10.22)	(6.78)	(17.61)		(19.83)

C. Unambiguous case/unbiased agency:

подлодка	сухогруз	задела	и	взорвалась
Submarine Nom	cargo ship Nom/Acc	touched	and	blew up.
(1.65)	(1.19)	(17.61)		(19.83)

D. Unambiguous case/biased agency:

подлодка	айсберг	задела	и	взорвалась
Submarine Nom	iceberg Nom/Acc	touched	and	blew up.
(1.65)	(6.78)	(17.61)		(19.83)

Вопрос: Что взорвалось?
Question: What blew up?

10.

A. Ambiguous case/unbiased agency:

Комбайн	трактор	проехал	и	перевернулся.
combine	tractor	passed	and	turned upside down.
(5.63)	(54.78)	(30.55)		(14.82)

B. Ambiguous case/biased agency:

Комбайн	поворот	проехал	и	перевернулся.
combine	turn	passed	and	turned upside down.
(5.63)	(27.98)	(30.55)		(14.82)

C. Unambiguous case/unbiased agency:

машина	трактор	проехала	и	перевернулась.
car	tractor	passed	and	turned upside down
(575.42)	(54.78)	(30.55)		(14.82)

D. Unambiguous case/biased agency:

машина	поворот	проехала	и	перевернулась.
car	turn	passed	and	turned upside down
(575.42)	(27.98)	(30.55)		(14.82)

Вопрос: Что перевернулось?
Question: What turned upside down?

11.

A. Ambiguous case/unbiased agency:

фламинго	кенгуру	услышал	и	обернулся.
flamingo Acc/Nom	Kangaroo Acc/Nom	heard	and	turned.
(0)	(4.4)	(208.18)	(92.72)	

B. Ambiguous case/biased agency:

фламинго	вертолет	услышал	и	обернулся.
flamingo Acc/Nom	helicopter Acc/Nom	heard	and	turned.
(0)	(46.17)	(208.18)	(92.72)	

C. Unambiguous case/unbiased agency:

опоссум	кенгуру	услышал	и	обернулся..
opossum Nom	Kangaroo Acc/Nom	heard	and	turned.
(2.56)	(54.78)	(208.18)	(92.72)	

D. Unambiguous case/biased agency:

опоссум	вертолет	услышал	и	обернулся..
opossum Nom	helicopter Acc/Nom	heard	and	turned.
(2.56)	(46.17)	(208.18)	(92.72)	

Вопрос: Кто обернулся?
Question: Who turned?

12.

A. Ambiguous case/unbiased agency:

танкер	катер	вызвал	и	утонул.
tanker Acc/Nom	motor boatAcc/Nom	signaled	and	sank.
(2.49)	(21.29)	(161.97)		(18.95)

B. Ambiguous case/biased agency:

танкер	берег	вызвал	и	утонул.
tanker Acc/Nom	land Acc/Nom	signaled	and	sank.
(2.49)	(240.22)	(161.97)	(18.95)	

C. Unambiguous case/unbiased agency:

баржа	катер	вызвала	и	утонула.
bargeNom	motor boatAcc/Nom	signaled	and	sank.
(7.77)	(21.29)	(161.97)	(18.95)	

D. Unambiguous case/biased agency:

баржа	берег	вызвала	и	утонула.
barge/Nom	land Acc/Nom	signaled	and	sank.
(7.77)	(240.22)	(161.97)	(18.95)	

Вопрос: Что утонуло?

Question: What sank?