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Forms and features: The role of syncretism in number agreement attraction

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ABSTRACT

Many experiments have studied attraction errors in number agreement (e.g. 'The key to the cabinets were rusty'). It has been noted that singular heads with plural dependents (attractors) trigger larger attraction effects than plural heads with singular attractors, and that in languages with morphological case, morphologically ambiguous attractors trigger larger effects (accusative plural forms coinciding with nominative plural were compared to unambiguous case forms). In Russian, the nominative plural forms of some nouns coincide not only with their accusative plural forms but also with the genitive singular. In one production and two comprehension experiments, such genitive singular forms were found to trigger larger attraction effects than morphologically unambiguous genitive plural forms. Accusative plural forms coinciding with the nominative plural were shown to be the most effective attractors. These results have implications for different models of attraction and for other discussions in morphology concerning ambiguity processing, different approaches to syncretism and the problem of lexical insertion.

Introduction

Much work has been devoted to so-called attraction errors in subject–verb agreement, as in (1a). In (1a) the verb agrees not with the head of the subject NP *key* but with a dependent NP *cabinets* (I will hereafter call such NPs *attractors*).

(1) a. **The key to the cabinets were rusty.*
b. **The key to the cabinet were rusty.*

Across languages, such errors in number agreement have been shown to arise more frequently than errors of the type exhibited in (1b), where no attraction is possible (e.g. Bock & Miller, 1991; Eberhard, Cutting, & Bock, 2005; Franck, Lassi, Frauenfelder, & Rizzi, 2006; Franck, Vigliocco, & Nicol, 2002; Hartsuiker, Schriefers, Bock, & Kikstra 2003; Solomon & Pearlmutter, 2004; Staub, 2009; Staub, 2010; Vigliocco, Butterworth, & Garrett, 1996; Vigliocco, Butterworth, & Semenza, 1995). In comprehension experiments, attraction errors have been demonstrated to trigger more grammaticality judgment mistakes and to provoke less pronounced effects in reading time and EEG studies than other agreement errors (e.g. Clifton, Frazier, & Deevy, 1999; Dillon, Mishler, Sloggett, & Phillips, 2013; Pearlmutter, Garnsey, & Bock, 1999; Tanner, Nicol, & Brehm, 2014; Wagers, Lau, & Phillips, 2009). Attraction has also been observed in gender agreement, although it is studied much less frequently (e.g. Badecker & Kuminiak, 2007; Franck, Vigliocco, Anton-Mendez, Collina, & Frauenfelder, 2008; Slioussar & Malko, 2016; Vigliocco & Franck, 1999).

Two major approaches to agreement attraction can be identified in the literature: representational and retrieval approaches. According to the representational approach (e.g. Brehm & Bock, 2013; Eberhard et al., 2005; Franck et al., 2002; Nicol, Forster, & Veres, 1997; Staub, 2009; Staub, 2010; Vigliocco & Nicol 1998), agreement attraction takes place because the mental representation of the subject NP's number feature is faulty or ambiguous. Some authors assume that the number feature can "percolate" from the embedded NP to the subject NP, which normally receives its features from its head. Others, relying primarily on the Marking and Morphing model suggested by Eberhard et al. (2005), argue that the number value of the subject NP is a continuum, i.e. it can be more or less plural. The more plural the subject NP, the higher the possibility of choosing a plural verb. This plurality depends on properties of the subject NP as a whole and of its head, such as collectivity, distributivity etc.

The retrieval approach (e.g. Badecker & Kuminiak, 2007; Dillon et al., 2013; Solomon & Pearlmutter, 2004; Wagers et al., 2009) claims that the number feature on the subject NP is always represented unambiguously and correctly and attraction errors arise when the subject NP is accessed to determine the number of the agreeing verb because several nouns are simultaneously active. The authors adopting this approach typically assume that the agreement controller is found via cue-based retrieval (Lewis & Vasishth, 2005; McElree, 2006): we query

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the memory with a set of cues (e.g. “number: plural”, “case: nominative”, etc.) and select an element that matches the maximum number of cues. This process is not error-free, and a wrong element can sometimes be retrieved; in cases of attraction errors, the attractor NP is retrieved instead of the subject NP.

Many characteristics of attraction errors have been examined in the literature, so here I will focus on the one directly relevant for this study. In the languages with morphological case marking, syncretism has been found to play an important role in attraction. Consider, for example, German, which inflects nouns, adjectives, articles and pronouns into four cases: nominative, genitive, dative and accusative. When plural, many nouns have the same forms in all four cases or only the dative plural differs from the other forms. However, the case is always visible on the definite article, which has the forms *die, der, den* and *die*, respectively. All of these forms are morphologically ambiguous, or syncretic: *die* is used in the nominative and accusative plural as well as in the nominative and accusative singular with feminine nouns; *der* is used in the genitive plural, genitive singular with feminine nouns and nominative singular with masculine nouns; etc. Hartsuiker et al. (2003) found that the number of attraction errors was much higher when, due to syncretism, the form of the attractor coincided with nominative plural, like in the German example (2a), as opposed to (2b).

(2)	a.	*die*	*Stellungnahme*	*gegen*	*die*	*Demonstrationen*[1]
		$\text{the}_{\text{NOM.SG}}$	position	against	$\text{the}_{\text{ACC.PL(=NOM.PL)}}$	demonstrations
	b.	*die*	*Stellungnahme*	*zu*	*den*	*Demonstrationen*
		$\text{the}_{\text{NOM.SG}}$	position	on	$\text{the}_{\text{DAT.PL(≠NOM.PL)}}$	demonstrations

A similar observation was made for Slovak gender agreement (Badecker & Kuminiak, 2007): to produce a significant effect, an attractor should look like a nominative subject. Notably, the syncretism factor has never been examined separately from number: in (2a), the attractor is plural and morphologically ambiguous with nominative plural, and in (2b), it is plural and not ambiguous. In the present study relying on Russian, I added to this comparison attractors that are singular but syncretic with nominative plural in order to identify the independent influence of syncretism in attraction.

The present study

I report three experiments studying subject–predicate number agreement in Russian. Experiment 1 aimed to elicit agreement errors in production. Experiment 2 used the speeded grammaticality judgement method to examine which agreement errors tend to be overlooked more often in comprehension. Experiment 3 provided more information on comprehension using the self-paced reading method; it analyzed how subject-verb agreement (including agreement errors) is processed online.

Let me outline the properties of Russian nominal inflection that are relevant for the present study. Russian nouns are inflected into six cases and two numbers. They may have different sets of inflections depending on their gender, animacy and stem type. Several examples are provided in Table 1.

Two patterns of syncretism will be crucial for the present study. First, the accusative usually coincides with the nominative in inanimate nouns and with the genitive in animate nouns; this is true for all Russian nouns in plural and for the majority of nouns in singular (the two feminine nouns in Table 1 illustrate an exception). Second, in the paradigms of *vilka* ‘fork_{F}’ and *košk*a ‘cat_{F}’, the genitive singular coincides with the nominative plural. In the case of the inanimate *vilka*, the same form is also used in the accusative plural. This second type of syncretism is less widespread and is found in a group of nouns that do not have any other properties in common (e.g. being animate or inanimate, belonging to a particular grammatical gender or inflectional class etc.).

Most previous production and comprehension studies of number agreement attraction found the following asymmetry: attraction effects were much larger when the head was singular and the attractor was plural, as in (1a) above, than in the opposite configuration, as in (3). To explain this asymmetry, the singular feature is usually argued to be unmarked in some sense, which makes singular attractors less effective (e.g. Bock & Miller, 1991; Eberhard et al., 2005; Vigliocco et al., 1995).[2]

(3) ∗*The keys to the cabinet was rusty.*

Several experiments, however, did not reveal this pattern: for example, Franck et al. (2002) found it in English but not in French. Crucially, though, Lorimor, Bock, Zalkind, Sheyman, and Beard (2008) observed this pattern in a production study on Russian. Therefore, although examples with plural heads were included in the present study to have a full picture, I did not expect to find any significant attraction effects in such sentences, independent of the characteristics of the dependent nouns. Foreshadowing the results, this expectation was confirmed. It was therefore not crucial that the present study could not include plural dependent nouns syncretic with nominative singular (no Russian nouns have such forms).

The different types of noun phrases used as stimuli in the present study are exemplified in (4a-d)–(5a-d). In addition to indicating the number and case for all nouns, for singular heads in (4a-d), I show whether their dependent nouns are syncretic with nominative plural, and for plural heads in (5a-d), I show whether their dependents are syncretic with nominative singular.

(4)	a.	*ssylka*	*na*	*dokument*
		$\text{reference}_{\text{NOM.SG}}$	to	$\text{article}_{\text{ACC.SG(≠NOM.PL)}}$
	b.	*ssylka*	*na*	*dokumenty*
		$\text{reference}_{\text{NOM.SG}}$	to	$\text{article}_{\text{ACC.PL(=NOM.PL)}}$
	c.	*material*	*dlja*	*stat’i*
		$\text{material}_{\text{NOM.SG}}$	for	$\text{article}_{\text{GEN.SG(=NOM.PL)}}$
	d.	*material*	*dlja*	*statej*
		$\text{material}_{\text{NOM.SG}}$	for	$\text{article}_{\text{GEN.PL(≠NOM.PL)}}$
(5)	a.	*ssylki*	*na*	*dokument*
		$\text{reference}_{\text{NOM.PL}}$	to	$\text{article}_{\text{ACC.SG(=NOM.SG)}}$
	b.	*ssylki*	*na*	*dokumenty*
		$\text{reference}_{\text{NOM.PL}}$	to	$\text{article}_{\text{ACC.PL(≠NOM.SG)}}$
	c.	*materialy*	*dlja*	*stat’i*
		$\text{material}_{\text{NOM.PL}}$	for	$\text{article}_{\text{GEN.SG(≠NOM.SG)}}$
	d.	*materialy*	*dlja*	*statej*
		$\text{material}_{\text{NOM.PL}}$	for	$\text{article}_{\text{GEN.PL(≠NOM.SG)}}$

The factors manipulated in these examples are the number of the head and the dependent noun and the syncretism of the latter. I used only inanimate nouns because animate ones do not have plural forms syncretic with the nominative plural. Syncretism depends on case: in (4a-b) and (5a-b), the potential attractor is accusative, while in (4c-d) and (5c-d), it is genitive. This dependency cannot be avoided; in singular, only genitive forms can be syncretic with the nominative plural, and in plural, only accusative forms can be. However, this dependency does not seem problematic in the present design. If we take singular heads and treat the number and case of the dependent noun as factors, their interaction gives us syncretism. In

[1] The preposition *gegen* requires accusative, so the glosses show that *die* is an accusative form that coincides with nominative plural, unlike the dative plural *den* in (2b).

[2] This explanation is not uncontroversial: for example, some authors claim that the features of the head rather than of the attractor are of principal importance (Slioussar & Malko, 2016), but the present study does not bear on this question.

Table 1
Inflection of Russian nouns: examples.

	stol 'table$_M$'		*kot* 'cat$_M$'		*vilka* 'fork$_F$'		*koška* 'cat$_F$'	
	Sg	Pl	Sg	Pl	Sg	Pl	Sg	Pl
Nominative	*stol*	*stoly*	*kot*	*koty*	*vilka*	*vilki*	*koška*	*koški*
Genitive	*stola*	*stolov*	*kota*	*kotov*	*vilki*	*vilok*	*koški*	*košek*
Dative	*stolu*	*stolam*	*kotu*	*kotam*	*vilke*	*vilkam*	*koške*	*koškam*
Accusative	*stol*	*stoly*	*kota*	*kotov*	*vilku*	*vilki*	*košku*	*koški*
Instrumental	*stolom*	*stolami*	*kotom*	*kotami*	*vilkoj*	*vilkami*	*koškoj*	*koškami*
Locative	*stole*	*stolax*	*kote*	*kotax*	*vilke*	*vilkax*	*koške*	*koškax*

case of plural heads, teasing apart the case and syncretism of potential attractors would be more difficult, but, as I mentioned above, no significant attraction effects were observed with plural heads in the present study, so this does not become an issue.

Previous studies of number agreement attraction in Russian (Lorimor et al., 2008; Nicol & Wilson, 1999; Yanovich & Fedorova, 2006) looked only at production and did not focus on the role of syncretism—in particular, no authors considered syncretic genitive singular forms. As for comprehension, I could not find any published experiments examining the role of syncretism in agreement attraction in any language. Thus, based on the previous studies, attraction effects are predicted only with singular heads. As for the dependent nouns, different scenarios are possible.

First, attraction effects may be observed for all plural dependent nouns but may be smaller for non-syncretic genitive ones. This observation would indicate that syncretism boosts the effect of the plural feature. Second, attraction effects may be found only with syncretic accusative plural forms. This result would mean that syncretism is a gating factor: a plural feature on the dependent noun may cause attraction but only if this noun looks like a subject. Third, attraction effects may be observed for all syncretic forms: accusative plural and genitive singular. This outcome would demonstrate that syncretism is an independent factor and would undermine the assumption entertained by all current approaches to agreement attraction that effects are triggered by the plural feature on the dependent noun.

Foreshadowing the results, the third scenario was found in the production and comprehension experiments reported in this paper. The exact pattern that was observed (including the differences between syncretic conditions) is discussed in detail in the following sections. Neither representational nor retrieval approaches to agreement attraction can readily explain this outcome. As Badecker and Kuminiak (2007) note, in the representational approach we do not expect syncretism to play any role because it is not evident why feature percolation or the perceived plurality of the subject should depend on the form of the dependent NP. In the retrieval approach, it seems intuitively clear

(6)	a.	*byla*	*novoj* /	*byli*	*novymi*
		was$_{SG}$	new$_{SG}$ /	were$_{PL}$	new$_{PL}$
	b.	*trassa/trassy*	*čerez*	*pole/polja*	
		highway$_{NOM.SG/NOM.PL}$	across	field$_{ACC.SG(=NOM.SG)/ACC.PL(=NOM.PL)}$	
(7)	a.	*byla*	*prostornoj* /	*byli*	*prostornymi*
		was$_{SG}$	spacious$_{SG}$ /	were$_{PL}$	spacious$_{PL}$
	b.	*komnata/komnaty*	*dlja*	*večerinki/večerinok*	
		room$_{NOM.SG/NOM.PL}$	for	party$_{GEN.SG(=NOM.PL)/GEN.PL}$	

that looking like a subject may increase the chances of a dependent NP to be erroneously retrieved. However, formulating why precisely this should be the case is more difficult: it is assumed that we look for features rather than for actual word forms. In this respect, attraction with syncretic genitive singular forms is especially mysterious because they do not have a plural feature.

After presenting the experimental results, I will suggest a modification to the retrieval approach that explains the observed pattern, and I will discuss further implications of this pattern for certain aspects of ambiguity processing and for the theoretical and experimental approaches to syncretism.

Experiment 1

Participants

32 native speakers of Russian aged 18–29 took part in Experiment 1. All participants were naïve to the experimental hypotheses. No participant took part in more than one experiment. All experiments reported in this paper were carried out in accordance with the Declaration of Helsinki and the existing Russian and international regulations concerning ethics in research. All participants provided informed consent. They were tested at the Laboratory for Cognitive Studies of Saint-Petersburg State University.

Materials

I used a modified version of the method designed by Vigliocco et al. (1995). Participants were asked to produce sentences combining a predicate and a subject they saw on a computer screen. In half of the trials, predicates did not agree with subjects in number, and participants were instructed to change the predicate number to produce a grammatically correct sentence. Following Vigliocco et al. (1995), I call these trials *incongruent*, while the trials where predicates and subjects agree in number are called *congruent*.[3]

In all target stimuli, the predicates consisted of the verb 'to be' plus an adjective or a participle, and the subjects contained a head noun, a preposition and a dependent noun (a potential attractor), as shown in (6a-b)–(7a-b). [4]The head noun, the dependent noun and the predicate could appear in singular or plural. To explore the role of syncretism, I used prepositions taking accusative or genitive case. As I explained in the introduction, the forms of accusative plural and genitive singular nouns were ambiguous with the nominative plural. Accusative singular forms were syncretic with nominative singular.

[3] Like Vigliocco et al. (1995), I used predicates containing adjectives and participles, which do not have forms that are not marked for number, so they could not be provided in a neutral form that participants have to inflect.

[4] I opted for such predicates because I did not want them to contain any nouns and could not come up with single-verb predicates for all stimuli. As a result, two words inside the predicate were marked for number (I did not present number mismatches *inside* the predicate).

Table 2
Experimental conditions in Experiments 1, 2 and 3.

Condition	Case group	Head	Dependent	Predicate
Sg-Sg(acc) + Sg	Acc	Sg	Acc.Sg (=Nom.Sg)	Sg (congruent/grammatical)
Sg-Sg(acc) + Pl	Acc	Sg	Acc.Sg (=Nom.Sg)	Pl (incongruent/ungrammatical)
Sg-Pl(acc) + Sg	Acc	Sg	Acc.Pl (=Nom.Pl)	Sg (congruent/grammatical)
Sg-Pl(acc) + Pl	Acc	Sg	Acc.Pl (=Nom.Pl)	Pl (incongruent/ungrammatical)
Pl-Sg(acc) + Pl	Acc	Pl	Acc.Sg (=Nom.Sg)	Pl (congruent/grammatical)
Pl-Sg(acc) + Sg	Acc	Pl	Acc.Sg (=Nom.Sg)	Sg (incongruent/ungrammatical)
Pl-Pl(acc) + Pl	Acc	Pl	Acc.Pl (=Nom.Pl)	Pl (congruent/grammatical)
Pl-Pl(acc) + Sg	Acc	Pl	Acc.Pl (=Nom.Pl)	Sg (incongruent/ungrammatical)
Sg-Sg(gen) + Sg	Gen	Sg	Gen.Sg (=Nom.Pl)	Sg (congruent/grammatical)
Sg-Sg(gen) + Pl	Gen	Sg	Gen.Sg (=Nom.Pl)	Pl (incongruent/ungrammatical)
Sg-Pl(gen) + Sg	Gen	Sg	Gen.Pl	Sg (congruent/grammatical)
Sg-Pl(gen) + Pl	Gen	Sg	Gen.Pl	Pl (incongruent/ungrammatical)
Pl-Sg(gen) + Pl	Gen	Pl	Gen.Sg (=Nom.Pl)	Pl (congruent/grammatical)
Pl-Sg(gen) + Sg	Gen	Pl	Gen.Sg (=Nom.Pl)	Sg (incongruent/ungrammatical)
Pl-Pl(gen) + Pl	Gen	Pl	Gen.Pl	Pl (congruent/grammatical)
Pl-Pl(gen) + Sg	Gen	Pl	Gen.Pl	Sg (incongruent/ungrammatical)

Table 3
The distribution of responses in Experiment 1.[b]

Condition	Group	Head	Dependent	Correct	Agreement errors	Other errors
Sg-Sg(acc) + Sg/Pl	Acc	Sg	Acc.Sg (=Nom.Sg)	279 (147 + 132)	0	41 (13 + 28)
Sg-Pl(acc) + Sg/Pl	Acc	Sg	Acc.Pl (=Nom.Pl)	234 (137 + 97)	49 (8 + 41)	37 (15 + 22)
Pl-Sg(acc) + Pl/Sg	Acc	Pl	Acc.Sg (=Nom.Sg)	249 (134 + 115)	0	71 (26 + 45)
Pl-Pl(acc) + Pl/Sg	Acc	Pl	Acc.Pl (=Nom.Pl)	261 (143 + 118)	0	59 (17 + 42)
Sg-Sg(gen) + Sg/Pl	Gen	Sg	Gen.Sg (=Nom.Pl)	250 (133 + 117)	13 (3 + 10)	57 (24 + 33)
Sg-Pl(gen) + Sg/Pl	Gen	Sg	Gen.Pl	259 (135 + 124)	2 (0 + 2)	59 (25 + 34)
Pl-Sg(gen) + Pl/Sg	Gen	Pl	Gen.Sg (=Nom.Pl)	256 (135 + 121)	0	64 (25 + 39)
Pl-Pl(gen) + Pl/Sg	Gen	Pl	Gen.Pl	248 (128 + 120)	0	72 (32 + 40)

[b] Responses in congruent and incongruent conditions are shown both as sums and separately (in parentheses; the number of responses in the congruent condition is given first).

In sum, there were three within item factors and one between item factor yielding the 16 experimental conditions shown in Table 2. The number of the head, the dependent and the predicate could be varied using the same sets of stimuli, while the case factor could not: sentences with accusative and genitive dependent nouns contained different lexical material, as demonstrated in (6a-b) and (7a-b). The same four factors were used in comprehension Experiments 2 and 3 where participants read complete sentences, only instead of congruent and incongruent conditions, there were grammatical and ungrammatical ones where predicates agreed or did not agree with the subjects. However, as will become clear below, when analyzing the experimental data, I always took only three or two factors out of the four into account, because for every comparison, one or two factors were irrelevant.

There were 40 items in the accusative group and 40 items in the genitive group. I used inanimate nouns of different genders and declensions. Five native speakers of Russian who did not take part in the experiment read all target items primarily to check that resulting subject NPs sound natural in all four number combinations. All stimuli are listed in Appendix.

There were eight experimental lists with 80 target stimuli in one of the eight conditions (balanced across lists) and 140 fillers, which appeared in pseudo-random order (no more than two target items in a row). In the fillers, predicates were analogous to those in target items, and half of them did not agree with their subjects in number. However, different NPs were used as filler subjects: they contained a singular or plural noun preceded by an agreeing adjective, as in (8).

(8) *finansovyj* *uspex*
financial$_{NOM.SG}$ success$_{NOM.SG}$

Since the experimental design involves several factors, let me summarize what we can expect based on the results of previous studies and which comparisons are novel and crucial for the present study. First of all, Vigliocco et al. (1995) observed errors both in congruent and in incongruent conditions, with more errors of all types in the latter. This pattern has an evident explanation that is not directly relevant for agreement attraction, so, unless the results of the present experiment differ from Vigliocco et al.'s, I will not focus on the congruent versus incongruent distinction. Second, as I mentioned in the introduction, most previous number agreement attraction studies, including the ones conducted on Russian, found significant effects only with singular heads. If the results of Experiment 1 are similar, we can focus on the number and case of the dependent noun in our analysis. If we find that the interaction of these factors significantly influences the number of attraction errors, that would indicate that syncretism plays a role in agreement attraction.

Procedure

The experiment was run on a PC using *Presentation* software (www.neurobs.com). In every trial, the predicate appeared on the screen for 800 ms, and then the subject was shown for 800 ms. Participants were asked to produce a complete sentence as fast as possible. After the participant's response, the experimenter pressed a key to initiate a 300 ms interval before the next trial. All responses were recorded.

Results and discussion

All participant responses were assigned into one of the following categories: 'correct', 'number agreement errors' and 'other errors'. It turned out that number agreement errors were the only grammatical errors participants made, so the category 'other errors' included sentences where participants substituted or omitted words while repeating the subject or the predicate. The distribution of responses in each experimental condition (in raw numbers and in percentages) is shown in Tables 3 and 4. In case of self-corrections, only the first variant was counted.

Table 4
The percentage of each response type per condition in Experiment 1.

Condition	Group	Head	Dependent	Correct	Agreement errors	Other errors
Sg-Sg(acc) + Sg/Pl	Acc	Sg	Acc.Sg (=Nom.Sg)	87%	0%	13%
Sg-Pl(acc) + Sg/Pl	Acc	Sg	Acc.Pl (=Nom.Pl)	73%	15%	12%
Pl-Sg(acc) + Pl/Sg	Acc	Pl	Acc.Sg (=Nom.Sg)	78%	0%	22%
Pl-Pl(acc) + Pl/Sg	Acc	Pl	Acc.Pl (=Nom.Pl)	82%	0%	18%
Sg-Sg(gen) + Sg/Pl	Gen	Sg	Gen.Sg (=Nom.Pl)	78%	4%	18%
Sg-Pl(gen) + Sg/Pl	Gen	Sg	Gen.Pl	81%	1%	18%
Pl-Sg(gen) + Pl/Sg	Gen	Pl	Gen.Sg (=Nom.Pl)	80%	0%	20%
Pl-Pl(gen) + Pl/Sg	Gen	Pl	Gen.Pl	78%	0%	23%

Two initial observations can be made about the data above that guide my analysis. First, errors of all types were more frequent in incongruent conditions, but not limited to them, so I will look at congruent and incongruent conditions together.[5] Second, there were no number agreement errors in the conditions with plural heads, so I will focus on the sentences with singular heads. In these sentences, there were 49 errors (15.3% of responses in this condition) with accusative plural dependent nouns, 13 errors (4.1%) with genitive singular dependent nouns, 2 errors (0.6%) with genitive plural dependent nouns and no errors with accusative singular dependent nouns (where no attraction could be expected).

I modeled the data with a mixed-effects logistic regression in *R* software (www.r-project.org) using the *glmer* function from the *lme4* package (Bates, Maechler, Bolker, & Walker, 2015). The logistic regression evaluated the likelihood of an agreement attraction error (coded as 1) versus a correct response (coded as 0). The case and number of the dependent noun were treated as fixed effects. For the predictors I used contrast coding: accusative was coded as 0.25, genitive was coded as −0.25; plural was coded as 0.25, singular was coded as −0.25. Random intercepts and random slopes by participant and by item were also included in the model.

The coefficient for the intercept was significant, reflecting that most responses were correct ($\beta = -7.83$, $SE = 2.19$, $z = -3.58$, $p < 0.01$). The main effect of case did not reach significance, while the main effect of number did ($\beta = 17.76$, $SE = 8.83$, $z = 2.01$, $p = 0.04$), indicating that there were more errors with plural attractors, as in the previous studies. The interaction of the case and number factors was also significant ($\beta = 86.29$, $SE = 34.89$, $z = 2.47$, $p = 0.01$), showing that syncretism influenced the error rate even more strongly.

In addition to the modeling above, I also conducted a post-hoc analysis to make pairwise comparisons of the three conditions where agreement errors were observed. I used a Tukey test with Holm correction for multiple comparisons. Accusative plural attractors trigger significantly more errors than genitive singular and genitive plural ones ($\beta = 1.45$, $SE = 0.32$, $z = 4.50$, $p < 0.01$; $\beta = 3.36$, $SE = 0.73$, $z = 4.63$, $p < 0.01$, respectively), and genitive singular attractors trigger significantly more errors than genitive plural ones ($\beta = 1.91$, $SE = 0.76$, $z = 2.50$, $p = 0.03$).

Thus, the results of this experiment suggest that being syncretic with the nominative plural is more important for an attractor than having a plural feature. Out of the two syncretic attractor types tested, accusative plural attractors are more effective than genitive singular attractors. No existing approach to agreement attraction can explain these results. Before discussing possible solutions, however, let us turn to Experiments 2 and 3 to see whether the same pattern is found in comprehension.

Experiment 2

Participants

32 native speakers of Russian aged 25–39 took part in Experiment 2.

Materials

One set of 80 target stimuli was constructed for the comprehension Experiments 2 and 3. The full set of sentences appeared in Experiment 3, a self-paced reading study, while in Experiment 2, a speeded grammaticality judgment task, a selection of 64 stimuli was used. A reduced selection was used in Experiment 2, as feedback from a pilot experiment showed that the speeded grammaticality judgment method was perceived as relatively stressful, and I did not want to excessively overload the readers.

The target sentences were similar to those used in Experiment 1, but with four additional words at the end modifying the predicate (a preposition introducing a noun phrase). The design involved the same factors presented in Table 2 above: three within item factors (the number of the head, the dependent and the predicate) and one between item factor (the case of the dependent). Thus, half of the stimuli were ungrammatical due to a subject–verb agreement error. A sample sentence in two experimental conditions is shown in (9a-b). All stimuli are listed in Appendix A.

(9) a. Sg-Pl(acc) + Sg (grammatical)

Trassa	*čerez*	*polja*	*byla*	*novoj*	*po*	*merkam*	*mestnyx*
highway$_{NOM.SG}$	across	field$_{ACC.PL}$	was$_{SG}$	new$_{SG}$	by	standards$_{DAT.PL}$	local$_{GEN.PL}$

zitelej.
(of) people$_{GEN.PL}$
'The highway across the fileds was new by the standards of local people'.

b. Sg-Sg(acc) + Pl (ungrammatical)

Trassa	*čerez*	*pole*	*byli*	*novymi*	*po*	*merkam*	*mestnyx*
highway$_{NOM.SG}$	across	field$_{ACC.SG}$	were$_{PL}$	new$_{PL}$	by	standards $_{DAT.PL}$	localGEN.PL

zitelej.
(of) people$_{GEN.PL}$
'The highway across the fileds were new by the standards of local people'.

Sentences in different conditions were distributed across eight experimental lists. In addition to 32 grammatical and 32 ungrammatical target sentences, every list contained 140 fillers. Like the target stimuli, the fillers were nine words long. Half of the fillers were ungrammatical:

[5] The sentences participants had to produce in the relevant pairs of conditions were the same, and the congruent/incongruent distinction was introduced only to make the task of agreeing the subject and the predicate non-trivial.

Table 5
The distribution of responses to ungrammatical sentences in Experiment 2.

Condition	Group	Head	Dependent	Verb	Correct	Incorrect
Sg-Sg(acc) + Pl	Acc	Sg	Acc.Sg (=Nom.Sg)	Pl	120	6 (4.8%)
Sg-Pl(acc) + Pl	Acc	Sg	Acc.Pl (=Nom.Pl)	Pl	98	30 (23.4%)
Pl-Sg(acc) + Sg	Acc	Pl	Acc.Sg (=Nom.Sg)	Sg	117	9 (7.1%)
Pl-Pl(acc) + Sg	Acc	Pl	Acc.Pl (=Nom.Pl)	Sg	124	4 (3.1%)
Sg-Sg(gen) + Pl	Gen	Sg	Gen.Sg (=Nom.Pl)	Pl	106	18 (14.5%)
Sg-Pl(gen) + Pl	Gen	Sg	Gen.Pl	Pl	114	12 (9.5%)
Pl-Sg(gen) + Sg	Gen	Pl	Gen.Sg (=Nom.Pl)	Sg	114	10 (8.1%)
Pl-Pl(gen) + Sg	Gen	Pl	Gen.Pl	Sg	118	2 (1.7%)

Table 6
The distribution of responses to grammatical sentences in Experiment 2.

Condition	Group	Head	Dependent	Verb	Correct	Incorrect
Sg-Sg(acc) + Sg	Acc	Sg	Acc.Sg (=Nom.Sg)	Sg	122	6 (4.7%)
Sg-Pl(acc) + Sg	Acc	Sg	Acc.Pl (=Nom.Pl)	Sg	114	12 (9.5%)
Pl-Sg(acc) + Pl	Acc	Pl	Acc.Sg (=Nom.Sg)	Pl	119	9 (7.0%)
Pl-Pl(acc) + Pl	Acc	Pl	Acc.Pl (=Nom.Pl)	Pl	117	11 (8.6%)
Sg-Sg(gen) + Sg	Gen	Sg	Gen.Sg (=Nom.Pl)	Sg	121	5 (4.0%)
Sg-Pl(gen) + Sg	Gen	Sg	Gen.Pl	Sg	118	8 (6.3%)
Pl-Sg(gen) + Pl	Gen	Pl	Gen.Sg (=Nom.Pl)	Pl	111	11 (9.0%)
Pl-Pl(gen) + Pl	Gen	Pl	Gen.Pl	Pl	119	9 (7.0%)

they contained gender and case agreement errors. Every list started with four filler sentences, after which point target and filler sentences were pseudo-randomized (with at most two target sentences with errors in a row).

Procedure and analysis

The experiment was run on a PC using *Presentation* software (www.neurobs.com). I used the rapid serial visual presentation methodology (Potter, 1988). Sentences were presented one word at a time in the center of the screen at a rate of 500 ms per word.[6] At the end of each sentence, a response screen appeared for 2 s; participants were asked whether the sentence they read was grammatically correct and made a yes/no response by button press. Participants were instructed to read carefully and to make their response as quickly as possible.

I analyzed participants' judgment accuracy. Only in 34 trials (1.7% of all trials) was no response given in the 2 s window; these trials were excluded from analysis. On average, participants correctly answered 92.0% of the questions following target sentences. No participant gave more than 9 incorrect responses (14.1%) (here and below, I use the term *incorrect responses* rather than *errors* to prevent confusion between grammatical errors in the stimuli and errors in participants' grammaticality judgments).

Results and discussion

The distribution of correct and incorrect responses per condition is presented in Tables 5 and 6, for ungrammatical and grammatical target sentences respectively. When readers make an incorrect judgment about an ungrammatical sentence, this means that a particular error was missed—an agreement error we are interested in. On the other hand, when readers judge a grammatical sentence incorrectly, it is impossible to find out what happened; perhaps they misread one of the words, which were presented very quickly, or maybe they expected a different number or gender on the verb or a different case on one of the nouns. Grammatical and ungrammatical trials were therefore analyzed separately.

A preliminary overview of the results reveals that in this experiment, there were incorrect responses in all conditions. However, the largest percentages of incorrect responses are found in ungrammatical sentences with the same types of subject phrase as resulted in the most errors in Experiment 1: subject phrases with singular heads and syncretic accusative plural attractors (23.4%) and subject phrases with singular heads and syncretic genitive singular attractors (14.5%). In all other conditions, the number of incorrect responses was less than 10%.

In the statistical analysis, the factors of interest are the number of the head noun and the number and case of the dependent noun. I will start with ungrammatical trials. As in Experiment 1, I modeled the data with a mixed-effects logistic regression in *R* software (www.r-project.org) using the *glmer* function from the *lme4* package (Bates et al., 2015). The logistic regression evaluated the likelihood of an incorrect response (coded as 1) versus a correct response (coded as 0). The number of the head noun and the case and number of the dependent noun were treated as fixed effects. For the predictors I used contrast coding: plural was coded as 0.5, singular was coded as −0.5; accusative was coded as 0.5, genitive was coded as −0.5. Random intercepts and random slopes by participant and by item were included in the model.

The coefficient for the intercept was significant, reflecting the fact that most responses were correct ($\beta = -4.31$, $SE = 0.33$, $z = -13.12$, $p < 0.01$). The main effect of head number was significant ($\beta = -1.62$, $SE = 0.64$, $z = -2.55$, $p = 0.01$): there were more incorrect responses to sentences with singular heads than with plural heads (13.1% vs. 5.0% on average)—i.e. the data show the singular/plural asymmetry that was observed in Experiment 1 and in many previous studies on different languages.

The main effects of case and dependent number did not reach significance. The interaction between the head and dependent number was significant ($\beta = -5.20$, $SE = 1.36$, $z = -3.83$, $p < 0.01$): more incorrect responses were given when the head and dependent number did not match than when they were the same (12.0% vs. 6.0% on average). This pattern is characteristic of agreement attraction.

Finally, the interaction between the dependent number and case was significant ($\beta = -4.88$, $SE = 1.31$, $z = -3.73$, $p < 0.01$). This interaction reflects the role of syncretism. Due to the high number of incorrect responses in the conditions with accusative plural and, to a lesser extent, genitive singular dependent nouns, there were fewer incorrect responses in conditions with a singular dependent noun in the accusative group and more incorrect responses in conditions with a singular dependent noun in the genitive group (on average, 6.0% vs. 13.5% and 11.1% vs. 5.6%, respectively).

Thus, Experiment 2 demonstrates that syncretism plays an important role for agreement attraction not only in production but also in comprehension. The fact that genitive singular forms are effective attractors shows that syncretism does not simply boost the effect of the plural feature on the attractor, but it is an independent factor. However, how precisely these two factors, number and syncretism, interact is not immediately clear from the data. More information on how sentences with agreement attraction errors are processed will be provided in Experiment 3, which offers a word-by-word reading time analysis.

[6] In most studies with English sentences, a rate of 300 ms is used, but a pilot study demonstrated that it would be too short for Russian participants – presumably because Russian words tend to be longer.

As in Experiment 1, I conducted a post-hoc analysis to compare the three conditions where the largest numbers of attraction errors (represented by the number of incorrect responses) were observed. These conditions were sentences with singular heads and three types of attractors: accusative plural (23.4% incorrect answers), genitive singular (14.5%) and genitive plural (9.5%). I used a Tukey test with Holm correction for multiple comparisons. Accusative plural attractors trigger significantly more attraction errors than genitive singular and genitive plural ones ($\beta = 1.05$, $SE = 0.38$, $z = 2.80$, $p = 0.01$; $\beta = 1.08$, $SE = 0.37$, $z = 2.92$, $p < 0.01$, respectively). The difference between genitive singular and genitive plural attractors did not reach significance.

Before looking at the grammatical sentences, let us consider the predictions made by the two major approaches to agreement attraction presented in the introduction. The representational approach assumes that attraction effects arise because the representation of the subject number may be incorrect or ambiguous. Therefore, symmetric effects are predicted in ungrammatical and grammatical sentences: relying on this representation, one should overlook errors in the former (resulting in a so-called grammaticality illusion) and reject correct predicate forms in the latter (a so-called ungrammaticality illusion). The retrieval approach is compatible with different outcomes, depending on how the cue-based retrieval is initiated (I will return to this topic in the general discussion section).

For the grammatical sentences, I used the same statistical tests I applied to the ungrammatical ones. The coefficient for the intercept was significant, reflecting that most responses were correct ($\beta = -2.96$, $SE = 0.16$, $z = -18.68$, $p < 0.01$). No main effects or their interactions reached significance. Thus, no evidence of ungrammaticality illusions was found (the consequences of this result are addressed in the general discussion section).

Now let us turn to Experiment 3 for more information on the processing of sentences with agreement attraction errors.

Experiment 3

Participants

40 native speakers of Russian aged 18–35 took part in Experiment 3.

Materials

Target stimuli used in this experiment were from the same set as in Experiment 2. 80 sentences in different conditions were distributed across eight experimental lists. In addition to the 40 grammatical and 40 ungrammatical target sentences, every list contained 150 fillers. All fillers were grammatically correct. The filler sentences were relatively diverse syntactically (containing different types of subjects and predicates), but, like the target sentences, they were always nine words long. Every list started with five filler sentences, after which point target and filler sentences were pseudo-randomized (with at most two target sentences with errors in a row).

Procedure and analysis

The experiment was run on a PC using *Presentation* software (www.neurobs.com). I used the word-by-word self-paced reading methodology (Just, Carpenter, & Woolley, 1982). Each trial began with a screen presenting a sentence in which the words were masked by dashes while spaces and punctuation remained intact. Each time the participant pressed the space bar, a word was revealed, the previous word was re-masked, and reading times (RTs) were measured. Comprehension questions with a choice of two answers, like the example in (10a-b), were asked after one third of randomly preselected sentences to ensure that the participants were reading properly.

(10)	a.	*Čto bylo novym?*	
		'What was new?'	
	b.	*trassa*	*tropka*
		highway	path

I analyzed participants' question-answering accuracy and reading times. On average, participants answered incorrectly to only 6.5% of questions (14.8% at most). Given the low number of mistakes, a breakdown of RTs into correct and incorrect question trials was not performed. Reading times that exceeded a threshold of 2.5 standard deviations, by region and condition, were excluded (Ratcliff, 1993). In total, 1.6% of the data was excluded (at most 3.8% per region and condition).

Results and discussion

Average reading times per region in different conditions are presented in Figs. 1–4.

It is a controversial question whether reading times for sentences in the accusative and genitive groups can be compared directly because these sentences contain different lexical material. Therefore, I first analyze these two groups separately before analyzing them together. For the first set of comparisons, the factors of interest are the number of the head noun, the number of the dependent noun and grammaticality (i.e. whether the number of the verb matches the number of the head noun).

I modeled the data with mixed-effects regressions in *R* software (www.r-project.org) using the *lmer* function from the *lme4* package (Bates et al., 2015). To obtain *p* values from the *t* values given by the

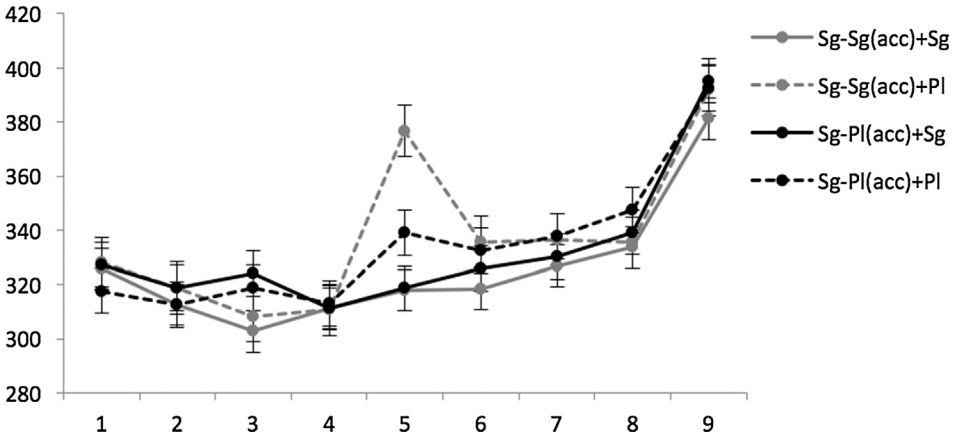

Fig. 1. Average RTs per region (in ms) in the conditions with singular heads in the accusative group in Experiment 3. Regions: N11 Prep2 N23 was/were4 Adj/Part5 + four words modifying the adjective or participle. Legend: solid lines are used for grammatical conditions, dashed lines for ungrammatical ones; black lines are used when heads and dependent nouns are matched in number, grey lines when they are not.

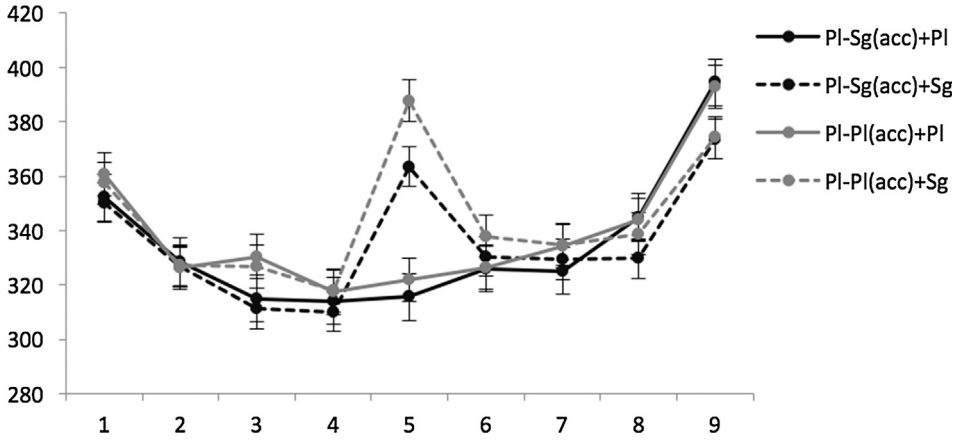

Fig. 2. Average RTs per region (in ms) in the conditions with plural heads in the accusative group in Experiment 3. Regions: N11 Prep2 N23 was/were4 Adj/Part5 + four words modifying the adjective or participle. Legend: solid lines are used for grammatical conditions, dashed lines for ungrammatical ones; black lines are used when heads and dependent nouns are matched in number, grey lines when they are not.

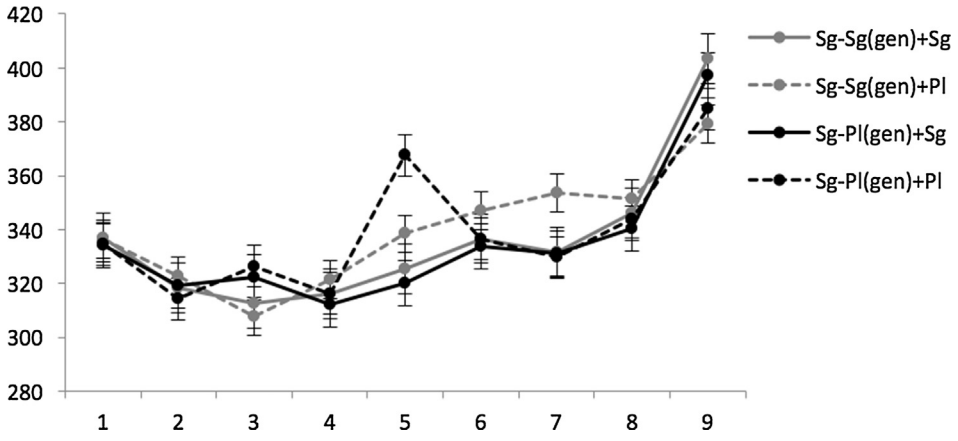

Fig. 3. Average RTs per region (in ms) in the conditions with singular heads in the genitive group in Experiment 3. Regions: N11 Prep2 N23 was/were4 Adj/Part5 + four words modifying the adjective or participle. Legend: solid lines are used for grammatical conditions, dashed lines for ungrammatical ones; black lines are used when heads and dependent nouns are matched in number, grey lines when they are not.

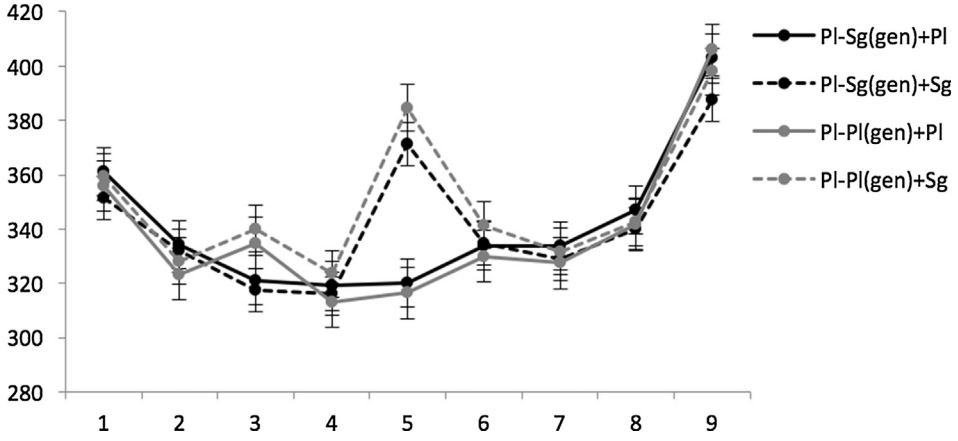

Fig. 4. Average RTs per region (in ms) in the conditions with plural heads in the genitive group in Experiment 3. Regions: N11 Prep2 N23 was/were4 Adj/Part5 + four words modifying the adjective or participle. Legend: solid lines are used for grammatical conditions, dashed lines for ungrammatical ones; black lines are used when heads and dependent nouns are matched in number, grey lines when they are not.

model, I used the *lmerTest* package (Kuznetsova, Brockhoff, & Christensen, 2015). Random intercepts and random slopes by participant and by item were included in the model. RTs were scaled and centered. For the predictors I used contrast coding: plural was coded as 0.5, singular as −0.5; grammatical was coded as 0.5, ungrammatical as −0.5.

In the region 1 (head noun), the head number factor was significant in both groups (accusative group: singular mean 325 ms, plural mean 355 ms; $\beta = 0.25$, $SE = 0.04$, $t = 6.01$, $p < 0.01$; genitive group: singular mean 335 ms, plural mean 357 ms; $\beta = 0.18$, $SE = 0.04$, $t = 4.33$, $p < 0.01$). No factors were significant in the very short region 2 (preposition). In the region 3 (dependent noun), the dependent number was significant in both groups (accusative group: singular mean 309 ms, plural mean 325 ms; $\beta = 0.15$, $SE = 0.04$, $t = 3.51$, $p < 0.01$; genitive group: singular mean 315 ms, plural mean 331 ms; $\beta = 0.16$, $SE = 0.04$, $t = 3.63$, $p < 0.01$). These results replicate previous findings showing that plural nouns take longer to be processed; in the agreement attraction literature, this phenomenon is discussed in detail

by Wagers et al. (2009). The region 4 (verb 'to be') is where the number agreement error appears in ungrammatical conditions. However, no factors reached significance in this short region.

The region 5 (adjective or participle, which is also inflected for number) showed a main effect of grammaticality in both groups (accusative group: grammatical mean 318 ms, ungrammatical mean 367 ms; $\beta = 0.41$, $SE = 0.04$, $t = 9.90$, $p < 0.01$; genitive group: grammatical mean 321 ms, ungrammatical mean 365 ms; $\beta = 0.37$, $SE = 0.04$, $t = 9.37$, $p < 0.01$). Notably, while average reading times for ungrammatical sentences vary between different conditions, for grammatical ones they virtually coincide. Thus, as in Experiment 2, I did not see any evidence of the ungrammaticality illusions predicted by the representational approach to agreement attraction.

Now let us turn to different results in the accusative and genitive groups. In the accusative group, the interaction of head number and dependent number was significant ($\beta = 0.27$, $SE = 0.08$, $t = 3.30$, $p < 0.01$): sentences where they did not match had longer reading times compared to those where they were the same. This pattern is characteristic of agreement attraction. The three-way interaction of grammaticality, dependent number and head number was also significant ($\beta = 0.47$, $SE = 0.17$, $t = 2.82$, $p < 0.01$): the error-related delay in reading times in the ungrammatical condition with a singular head and a plural dependent noun was much smaller than in the other three. This result is a manifestation of the singular/plural asymmetry in agreement attraction; similar results were obtained in many previous comprehension studies of number agreement.

In the genitive group, the interaction between the head number and grammaticality was significant ($\beta = 0.25$, $SE = 0.08$, $t = 3.20$, $p < 0.01$): ungrammatical conditions with singular heads were read faster than ungrammatical conditions with plural heads. This result can be explained by attraction from genitive singular dependents syncretic with nominative plural and genitive plural dependents. The interaction between the dependent number and grammaticality also reached significance ($\beta = 0.20$, $SE = 0.08$, $t = 2.51$, $p = 0.01$): ungrammatical conditions with singular dependents were read faster than ungrammatical conditions with plural dependents. This outcome indicates that genitive singular forms are more effective attractors than genitive plural ones.

Regions 6–9 contained a four-word prepositional phrase modifying the adjective or participle. In the accusative group, no differences were significant in these regions. In the genitive group, no differences were significant in the short region 6 (preposition) and in the two final regions, but in the region 7, the interaction of the three experimental factors was significant ($\beta = 0.25$, $SE = 0.12$, $t = 2.13$, $p = 0.03$); the ungrammatical condition with a singular head and a syncretic genitive singular dependent noun was read slower than all other conditions.

No similar results have been previously reported in the literature. Delays in reading times caused by agreement errors were observed to be larger or smaller depending on attraction, but they were always local. Sentences in the accusative group in the current experiment are not an exception. I hypothesize that the puzzling pattern found in the genitive group might be an indication of revision. In the other cases, if we miss an agreement error due to attraction, we never come back to it. However, the situation may be different in the sentences with syncretic genitive singular attractors; these nouns do not possess a plural feature, which might trigger a revision of our initial decision about their grammaticality.

The results of Experiment 2 are compatible with this hypothesis but cannot categorically confirm it. In their grammaticality judgements of ungrammatical sentences with singular heads, participants gave significantly more incorrect answers to stimuli with accusative plural attractors than to those with genitive singular ones (23.4% vs. 14.5%). Ungrammatical sentences with genitive singular attractors were judged incorrectly more often than sentences with genitive plural ones (14.5% vs. 9.5%), but this difference was not statistically significant. Further research is necessary to find a better way to test this hypothesis.

Finally, I compared sentences with accusative and genitive dependents directly. I performed this comparison using conditions with singular heads because attraction effects are much more pronounced in these conditions, both in this experiment in addition to Experiments 1 and 2. Thus, the factors of interest for the comparison were the number and case of the dependent noun and grammaticality. I used the same statistical tests as in the comparisons reported above. For the predictors I used contrast coding: plural was coded as 0.5, singular as −0.5; accusative was coded as 0.5, genitive as −0.5; grammatical was coded as 0.5, ungrammatical as −0.5.

In the regions 1–4 (subject phrase and verb 'to be'), there were no significant results. The region 5 (adjective or participle) showed a main effect of grammaticality ($\beta = 0.35$, $SE = 0.06$, $t = 6.07$, $p < 0.01$). The interaction of dependent number and case was significant ($\beta = 0.27$, $SE = 0.08$, $t = 3.27$, $p < 0.01$): with accusative dependents, reading times were smaller when they were plural, while with genitive ones, reading times were smaller when the dependents were singular. The three-way interaction of grammaticality, dependent number and case was also significant ($\beta = 0.62$, $SE = 0.16$, $t = 3.82$, $p < 0.01$). The influence of grammaticality depended both on the case and on the number of the attractor.

No results were significant in the regions 6, 8 and 9. In the region 7, the interaction of grammaticality, dependent number and case reached significance ($\beta = 0.08$, $SE = 0.04$, $t = 2.04$, $p = 0.04$). This result reflects the reading time delay in the ungrammatical sentences with genitive singular attractors that was discussed above; this delay was hypothesized to reflect reanalysis of the initial decision about grammaticality. We can see that accusative plural attractors do not trigger similar effects.

General discussion

The goal of the present study was to explore the role of syncretism in agreement attraction. Prior to the present study, the role of syncretism had not been studied in comprehension, while in the previous production studies, it was demonstrated to be an important factor,[7] though its influence was difficult to tease apart from other factors. For example, Hartsuiker et al. (2003) compared plural attractors that were or were not syncretic with the nominative plural in German and found that only the former triggered significant effects. Badecker and Kuminiak (2007) studied gender agreement attraction in Slovak. Their stimuli were noun phrases with singular heads and dependent nouns of different genders (in Slovak, predicates show gender agreement only in singular); significant attraction effects were observed only if dependent nouns were syncretic with nominative singular.

In these experimental designs, it is impossible to isolate the influence of syncretism and to distinguish between several possible scenarios. First, syncretism, which essentially makes the attractor 'look like a subject', may boost the effect of the relevant number or gender feature. Second, syncretism may be a prerequisite for attraction in the languages with morphological case marking. Third, syncretism may be an independent factor. The results of the present study support the third scenario.

In one production and two comprehension experiments, I compared stimuli in which the head of the subject phrase and the dependent noun could be singular or plural, and the case of the dependent noun could be accusative or genitive. Russian, like many other languages, demonstrates the singular/plural asymmetry in number agreement attraction, so attraction effects were visible only in the sentences with singular heads. In these sentences, four types of attractors could be compared:

[7] No exceptions have been reported for the structures in which potential attractors are dependent nouns inside the subject noun phrase. However, Franck, Soare, Frauenfelder, and Rizzi (2010) found significant attraction with accusative plural object clitics that are not syncretic with nominative plural.

accusative plural and genitive singular forms syncretic with the nominative plural as well as genitive plural and accusative singular forms not syncretic with the nominative plural. Accusative singular forms were syncretic with nominative singular.

I found that genitive singular forms triggered significant attraction effects. Moreover, they were more effective attractors than genitive plural forms. Thus, syncretism does not simply modulate the effect of the plural feature; being syncretic with nominative plural was shown to be more important than possessing this feature. At the same time, accusative plural forms were the most effective attractors. To offer an explanation for these findings and to explore their implications, let me first consider the nature of syncretism.

Systematic and accidental syncretism

There is a wide range of approaches to syncretism in theoretical morphology (e.g. Baerman, Brown, & Corbett, 2005; Blevins, 1995; Bobaljik, 2002; Müller, 2011; Stump, 2001; Zwicky, 1991). Importantly, almost all theories draw a distinction between systematic and accidental syncretism. The syncretism of nominative and accusative plural forms in Russian is regarded as an example of the former, whereas the syncretism of nominative plural and genitive singular forms is considered an example of the latter (e.g. Baerman et al., 2005; McCreight & Chvany, 1991; Müller, 2004; Wiese, 2004; Wunderlich, 2004).

Nominative plural and accusative plural forms of inanimate nouns always coincide in Russian. Different approaches have different ways to account for this phenomenon: underspecification may be used, accusative plural forms may be defined through the reference to nominative plural etc. In any case, every approach has a mechanism to treat such forms as interconnected, and, clearly, this may be relevant for processing.

The syncretism of genitive singular and nominative plural forms, on the other hand, is found in a group of nouns that do not have any other properties in common (e.g. being animate or inanimate, belonging to a particular grammatical gender or inflectional class etc.). On the level of features, morphologists also do not see any connection. Thus, the fact that these forms are syncretic in some nouns is considered to be a matter of historical coincidence.[8]

The fact that syncretic genitive singular forms trigger attraction effects means that they activate the nominative plural feature set. Given the views on this type of syncretism, this activation can happen only through the phonological form; there is no deeper connection. It is interesting that the surface connection between the two forms turns out to be strong enough to influence syntactic processes.

This observation may also have more profound implications. I found attraction with genitive singular forms not only in comprehension but also in production, where we start out with features and not with forms. This finding can be taken as an argument against non-lexicalist frameworks assuming that syntax operates with sublexical units and actual words forms are glued together or inserted in the structure only at the last stage—i.e. against so-called late insertion. In order for the observed attraction to be possible, one can conclude that the form must be inserted relatively early and be allowed to play a role in subsequent syntactic processes: alternative feature sets associated with it should be at least marginally accessible.

Nonetheless, there is an important caveat to this argumentation. In all of the experimental methods used to study agreement attraction in production, subject nouns phrases are provided to the participants. In other words, all production tasks involve a comprehension component, and one may argue that genitive singular forms activate the nominative plural feature set at this stage. This scenario is compatible with late insertion, but makes the influence of accidental syncretism especially surprising; it implies that the effects of initial processing of syncretic forms are persistent enough to affect production later on. To appreciate this, let us consider my findings in the context of the literature on morphological ambiguity processing.

Morphological ambiguity processing

For many decades, locally and globally ambiguous sentences have served as a testing ground for parsing models (Clifton & Staub, 2008; Frazier & Fodor, 1978; Frazier & Rayner, 1982; McDonald, 1994; Swets, Desmet, Clifton, & Ferreira, 2008; van Gompel, Pickering, Pearson, & Liversedge 2005; van Gompel, Pickering, & Traxler 2001, among many others). The sources of ambiguity could be different, but in many cases, it was created by morphologically ambiguous forms, as in the classic example in (11).

(11) *The horse raced past the barn fell.*

Notably, almost all studies in this domain analyze constructions where, at least locally, two interpretations are possible; for example, (11) remains ambiguous until the reader reaches the verb *fell*. The goal is to determine which interpretation is chosen in different constructions depending on various factors, how ambiguity resolution proceeds, how reanalysis is implemented, if it is necessary etc. In the sentences used in the present study, no viable alternative interpretations can be constructed; the ambiguity should be resolved immediately because the preposition directly preceding the dependent noun requires a certain case. Still, the ambiguity was shown to play a role.

There are several examples reported in the literature in which syntactically illicit alternatives are demonstrated to influence processing. First, syntactic parses that were initially considered but subsequently discarded were shown to linger in examples like (11) (e.g. Christianson, Hollingworth, Halliwell, & Ferreira 2001; Christianson, Williams, Zacks, & Ferreira 2006; Ferreira, Christianson, & Hollingworth, 2001; Lau & Ferreira, 2005; Levy, Bicknell, Slattery, & Rayner, 2009; Slattery, Sturt, Christianson, Yoshida, & Ferreira, 2013; Staub, 2007; Sturt, 2007; van Gompel, Pickering, Pearson, & Jacob, 2006). Second, Tabor and colleagues (Tabor, Galantucci, & Richardson, 2004; Tabor & Hutchins, 2004) studied so-called local coherence phenomena, comparing examples like (12a) and (12b).

(12) a. *The coach smiled at the player tossed a frisbee by the opposing team.*
b. *The coach smiled at the player who was tossed a frisbee by the opposing team.*

Tabor and colleagues suggested that locally coherent syntactic fragments, like *the player tossed* in (12a), could lead to the construction of syntactic analyses that are inconsistent with the global syntactic context. Such errant local parses were hypothesized to distract readers and to slow them down. Indeed, the morphologically ambiguous form *tossed* and the following words were found to be read slower in (12a) than in (12b), where this form does not belong to a locally coherent syntactic fragment.

Prima facie the materials analyzed in the present study are very similar to the examples studied by Tabor and colleagues. For example, the sentence in (13a) with a syncretic genitive singular attractor contains a locally coherent fragment *večerinki byli prostornymi*, which literally means '(the) parties were spacious'. This fragment is semantically odd, but syntactically well-formed. The same is true for the fragment *polja byli novymi* in (13b), which literally means '(the) fields were new'.

[8] The model by Stump (2001) exemplifies a rare exception. In his model, syncretic genitive singular forms ending in *–i* are defined through the reference to the nominative plural, while the opposite is true for syncretic genitive singular forms ending in *–a*: nominative plural forms are defined through reference to the genitive singular. Both forms were used in the present study, and no differences can be detected in the attraction effects they produced, so my findings do not support this approach.

(13) a. ∗*Komnata* *dlja* *večerinki* *byli* *prostornymi.*
room$_{NOM.SG}$ for party$_{GEN.SG(=NOM.PL)}$ were$_{PL}$ spacious$_{PL}$
b. ⋆*Trassa* *čerez* *polja* *byli* *novymi.*
highway$_{NOM.SG}$ across field$_{ACC.PL(=NOM.PL)}$ were$_{PL}$ new$_{PL}$

However, I believe that some crucial details are different in Tabor and colleagues' experiments and in the present study. The sentences in (13a-b) are ungrammatical, while Tabor and colleagues studied grammatical examples and demonstrated that local coherence phenomena may slow down their processing. Therefore, let us identify grammatical sentences with locally coherent fragments in the present study and control cases they can be compared to. Examples of such sentences are given in (14a) and (15a) (unlike (13a-b), they have plural head nouns), while (14b) and (15b) can serve as control cases.

(14) a. *Komnaty* *dlja* *večerinki* *byli* *prostornymi.*
room$_{NOM.PL}$ for party$_{GEN.SG(=NOM.PL)}$ were$_{PL}$ spacious$_{PL}$
b. *Komnaty* *dlja* *večerinok* *byli* *prostornymi*
room$_{NOM.PL}$ for party$_{GEN.PL}$ were$_{PL}$ spacious$_{PL}$
(15) a. *Trassy* *čerez* *polja* *byli* *novymi.*
highway$_{NOM.PL}$ across field$_{ACC.PL(=NOM.PL)}$ were$_{PL}$ new$_{PL}$
b. *Trassy* *čerez* *pole* *byli* *novymi.*
highway$_{NOM.PL}$ across field$_{ACC.SG}$ were$_{PL}$ new$_{PL}$

Experiment 3 demonstrated that average reading times were virtually the same in all grammatical conditions, i.e. no influence from locally coherent fragments could be detected.

So why is the influence of local coherence observed in some examples (such as (12a-b)) but not others (like (14a-b))? Local coherence phenomena are not studied well enough to give a definitive answer, but the following difference seems crucial. In Tabor and colleagues' examples, the second form in the locally coherent fragments is ambiguous, so different syntactic analyses are considered, at least briefly. In my examples, the first form is ambiguous, so when the verb arrives, this form, which is directly preceded by the preposition that determines its case and thus resolves ambiguity, already occupies its proper place in the syntactic tree.

I conclude that the findings from the present study cannot be explained by local coherence effects. Similarly, they cannot be explained by lingering discarded parses—for any alternative parses to linger, they must be constructed in the first place, and no evidence for that can be detected.

The explanation I would like to suggest relies on the assumption that morphologically ambiguous forms activate all feature sets associated with them, and, even after disambiguation takes place, alternative sets remain at least marginally accessible for certain syntactic processes. Prima facie, nothing is novel in this assumption: we can process various sentences with morphological ambiguity and, if necessary, resort to reanalysis, like in (11), so it is evident that we can activate different feature sets and come back to the sets that have initially been discarded. The new idea I would like to introduce is that alternative feature sets may be accessed when no parallel syntactic parses are considered and no reanalysis is attempted. This idea is developed in the next subsection, in which I explore the implications of my findings for agreement attraction models.

Agreement attraction models

Two major approaches to agreement attraction, representational and retrieval, were outlined in the introduction. It is difficult to account for the role of syncretism in agreement attraction in the different versions of the former; it is unclear why syncretism should influence number feature percolation or the conceptual plurality of the subject, which is crucial for the Marking and Morphing model. This difficulty seems especially true for syncretic genitive singular forms, which do not have any plural feature of their own and yet were found to trigger significant attraction effects.

The retrieval approach is better suited to account for my findings, but the results of the present study call for several modifications. First of all, they show that retrieval cues can tap into alternative feature sets of syncretic forms. Second, previous descriptions of cue-based retrieval (e.g. Wagers et al., 2009) suggest that if no noun matches the cues perfectly, several imperfect matches are considered. For example, reading the Russian sentence in (16), we start looking for a nominative plural noun when we reach the verb. There is no perfect match, but the head is nominative and the attractor is plural, so they compete and a wrong noun may be retrieved.

(16) ∗*Trassa* *čerez* *polja* *opusteli.*
highway$_{NOM.SG}$ across field$_{ACC.PL(=NOM.PL)}$ emptied$_{PL}$
'The highway across the fields were deserted'.

The findings from the present study suggest a slightly different picture. In (17a), the head is nominative and the dependent noun is plural, but, as Experiments 1–3 demonstrated, there is virtually no attraction. This indicates that a "compound" cue is used (something like {nominative + plural}) instead of a set of individual cues. Alternative feature sets of syncretic genitive singular forms, like in (17b), and of accusative plural forms, like in (16), match this cue, so significant attraction effects are observed. Compound cues have not been previously discussed in the context of retrieving an agreement controller, although several authors studied how several cues can be used in combination: for example, what is expected to happen when one cue matches and the other does not (e.g. Parker & Phillips, 2016; Wagers, 2008). Compound cues have been discussed, for example, in the context of word-to-word priming (e.g. Ratcliff & McKoon, 1988).

(17) a. ∗*Komnata* *dlja* *večerinok* *opusteli.*
room$_{NOM.SG}$ for party$_{GEN.PL}$ emptied$_{PL}$
'The room for the parties were deserted'.
b. ∗*Komnata* *dlja* *večerinki* *opusteli.*
room$_{NOM.SG}$ for party$_{GEN.SG(=NOM.PL)}$ emptied$_{PL}$
'The room for the party were deserted'.

The fact that accusative plural forms triggered larger effects than genitive singular ones can be explained by the difference between systematic and accidental syncretism. The latter is a matter of surface coincidence, while the former reflects a deeper connection between the two forms. This distinction may also be relevant for the explanation of the pattern that was observed in Experiment 3. In all conditions, reading time delays related to agreement errors were local, although they could be larger or smaller depending on attraction. Only ungrammatical sentences with genitive singular attractors showed larger reading times in subsequent regions, which might indicate a revision of the initial decision about their grammaticality. Further research is needed to test this hypothesis—so far, I can only note that it is compatible with the results of Experiment 2. Though, if this hypothesis is on the right track, attraction effects triggered through accidental syncretism may not only be less pronounced but also short-lived.

An anonymous reviewer suggested that the asymmetry between accusative plural and genitive singular attractors may also be due to the

fact that accusative plural forms actually possess a morphosyntactic plural feature. However, although I would not exclude this possibility, it is not readily compatible with the fact that retrieval relies on compound cues demonstrated above. I showed that we do not look for something that has a nominative feature and a plural feature (otherwise non-syncretic genitive plural forms would cause some attraction), but for the combination {nominative + plural}. This makes the separate role of the plural feature on accusative plural nouns less plausible.

Another finding from the present study that is compatible with the predictions of the retrieval approach but not the representational one is the absence of any effects in grammatical sentences in the comprehension experiments. In brief, representational models assuming that attraction effects arise from a faulty or ambiguous representation of the subject phrase predict symmetrical effects in ungrammatical and grammatical sentences. The former should be subject to grammaticality illusions (when the reader misses an agreement error), while the latter should be subject to ungrammaticality illusions (when the reader rejects a correct predicate form relying on a misconstrued subject representation). However, we did not find the ungrammaticality illusions predicted by this approach in Experiments 2 and 3.

As Wagers et al. (2009) note, in the retrieval approach, two scenarios are possible both in production and in comprehension. On the one hand, cue-based retrieval may be initiated whenever we reach an agreeing verb form; on the other hand, we may predict the number of the verb relying on the subject NP and initiate the retrieval only when our expectations are violated. In comprehension, they would be violated in ungrammatical sentences, in production, this would be possible if a wrong verb form can sometimes be spuriously generated. In the latter scenario, no ungrammaticality illusions are expected, and this is what was observed in Experiments 2 and 3.

Conclusions

I presented one production and two comprehension experiments studying subject–predicate number agreement attraction in Russian. As in many previous studies on different languages, attraction effects were observed in the conditions with singular heads, where four attractor types could be compared: accusative plural and genitive singular forms syncretic with nominative plural as well as genitive plural and accusative singular forms not syncretic with nominative plural. Both in production and in comprehension, genitive singular forms triggered significant attraction effects that were larger than those in sentences with genitive plural forms but smaller than those with accusative plural forms.

These results show that syncretism does not simply boost the effect of the plural feature—it is an independent factor. I argue that the results cannot be explained as local coherence phenomena and suggest an explanation in terms of the cue-based retrieval approach to agreement attraction, with two notable modifications. First, the present study shows that retrieval cues can tap into alternative feature sets of syncretic forms. Notably, unlike in the previously discussed cases, this is possible although no parallel syntactic parses are considered and no reanalysis is attempted. Second, I demonstrate that retrieval should rely on compound cues such as {nominative + plural} instead of a set of individual cues.

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A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jml.2018.03.006.

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