

Processing complexity in Slavic numeral phrases

Penka Stateva and Arthur Stepanov

penka.stateva@ung.si arthur.stepanov@ung.si

University of Nova Gorica

Agreement/attraction errors (Bock&Cutting 1992, a.o.) provide an important clue concerning the interface between the mental systems of grammatical knowledge and language production, about which little is known. Existing studies on number agreement errors typically discuss errors found in “symmetrical” agreement whereby the number feature values on two phrases (e.g. subject-verb) have to match (1). Those have argued that agreement errors are a function of computational complexity which, in turn, can be measured in terms of distance. We focus on a previously unnoted “asymmetrical” pattern of agreement errors within Slavic numeral phrases (NumP) to further explore the manner in which complexity affects the computation of agreement in both language production as well as language comprehension. We concentrated on Bulgarian and Russian.

In Bulgarian (which has no overt Cases), Num assigns a special [+count] feature to the noun, morphologically visible as “-a” in the masculine inanimate form, whereas the simple plural/SP (e.g. “-i”) on the adjective reflects the number feature on the entire NumP (2a). Building on the initial observations (Pashov 1989) that speakers are prone to make errors such as (2b), by producing SP forms instead of “-a”-forms in spontaneous speech, especially when more material intervenes between Num and the noun, we conducted a series of offline and online experiments, with the goal of investigating the strength and patterns of processing complexity involved in this phenomenon.

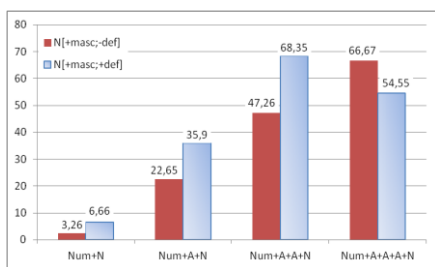


Fig. 1. Agreement errors in %, Bulgarian

In Experiment 1, a corpus study ([Bulgarian National Corpus](#), 240000 text samples, 1.2 billion tokens), we analyzed the patterns of NumP with one, two and three intervening adjectives, each in indefinite and definite form. About 4% and 15% of all such NumPs, respectively, were erroneously SP-marked. Furthermore, we found a robust correlation between the error ratio and the number of intervening adjectives (Pearson’s $r=0.999$ for indefinite, $r=0.85$ for definite NumPs), as well as across both adjectives and determiners (Pearson $r=0.92$ overall).

Addition of an adjective always has a greater effect than addition of a determiner (Fig.1).

We then asked whether the [+count] feature assignment rule is indeed part of the speakers’ mental grammar or, rather, speakers perceive both forms on the noun as doublets, regulated mostly by prescriptive grammar. In Experiment 2, an online comprehension study, subjects (N=27) read 24 target sentences as in (2), ending in a NumP with the masculine noun either in the correct “-a” form or SP form, and two adjectives always separating Num and the noun. Subjects read the sentences in the auto-paced mode (400 msec per word), whereby only one word appeared in the center of the screen at a time. Subjects then had to evaluate whether the morphological ending on the final noun is appropriate or not by choosing a “yes” or “no” answer. Additional 48 sentences of a similar kind ending on a feminine and neuter noun were constructed as fillers. The results showed that subjects are sensitive to the noun morphology, reliably indicating “-a” as the appropriate and SP as inappropriate (Pearson $\chi^2(2)=10.9$, $p=0.004$). This shows that the [+count] assignment rule is a productive part of the speakers’ knowledge of language and cannot be attributed to prescriptive factors.

In Experiment 3, an online sentence completion study, we explored the complexity issues further. Experiment 3 was designed as a 2x2 study crossing factors Distance (1 or 3 intervening adjectives) and Definiteness (+def, -def) of NumP. In each trial, an incomplete sentence as in (2) with NumP as a final constituent with a missing end noun appeared in the auto-paced (400ms per word) reading mode, followed by the unmarked (nom. sg.) form of the target noun. Subjects (N=47, excluded 9) were asked to read the auto-paced input and type in the appropriate form of the noun to complete the sentence. The ratio of erroneous SP forms was the dependent variable. Results: rANOVA with Distance and Definiteness as within-subject factors showed a main effect of Distance ($F(1,36)=8.55$, $p=0.006$); no main effect of Definiteness ($F(1,36)=1.912$, NS); and no interaction between Distance and Definiteness ($F(1,36)=0.192$,

NS). This corroborates the results of the corpus study in the online setting for the Distance factor, but diverges from those for Definiteness. We tentatively attribute the divergence to the different presentation modalities of Num in Experiments 1 and 3: production in the former, comprehension in the latter.

Building on the important findings in the previous literature on agreement errors (e.g. Franck et al. 2002), we inquired whether the main complexity factor of distance should be measured in linear (number of words), or rather, structural terms, that is, number of intervening syntactic nodes. To test this, we have conducted an additional corpus search for error patterns Num+[Adv+A]+N (see (3)) and compared them with both Num+A+N and Num+A+A+N. Since an adverb modifies only the adjective, the number of intervening syntactic nodes between Num and N is not increased, though linear distance is. Importantly, our results show that the error ratio in the adverbial pattern (26.98%) is not significantly different from the pattern involving just a single adjective (Pearson $\chi^2(1)=0.42$, NS), but reliably differs from the pattern involving two adjectives (Pearson $\chi^2(1)=9.05$, $p=0.003$), showing that structural distance indeed plays a role. A corresponding online sentence completion experiment is currently underway.

If the errors in Bulgarian NumPs are due to either processing complexity or interaction of the mental grammar and processor, then we should see similar processes -and find similar kinds of errors- in other languages, all else equal. Russian presents an excellent ground for testing this prediction because the structure of its NumPs is maximally similar to Bulgarian, modulo the productive Case system. While for numerals between 2-4 agreement is “paucal” (morphologically similar to gen.sing., see (4a)), for 5 and beyond agreement is gen.pl. (4b). We hypothesized that a) Russian speakers may make errors producing paucal morphology in place of gen.pl. (“false paucal”, FP) as well as gen.pl. morphology in place of paucal (“false genitive”, FG) in the course of processing NumPs under the similar kind of memory tax caused by the auto-paced mode of stimulus presentation, and b) distribution of both errors types should be about equal (50% each). In Experiment 4, we manipulated the length of the NumP (1, 2 or 3 intervening adjectives), and numeral type (≤ 4 and > 4 in equal proportions). 48 incomplete target sentences ending in NumP with missing Noun were presented to subjects in auto-paced mode followed by the unmarked (nom. sg.) form of the target noun (5). Subjects (N=64, excluded 18) were asked to read the input and type in the appropriate form of the noun. We found that Russian speakers indeed make errors under the design conditions, in quantities comparable to those observed in our Bulgarian experiments as well as in the previous studies on agreement errors (around 7%). The distribution of these errors, however, was quite unexpected: the ratio of FPs to FGs was 4:1. Complexity (number of intervening adjectives) affected the error ratio in FG, but not as much as in FP. We interpret these results as to suggest that there is a latent systematic factor favoring the paucal assignment rule in NumPs. In our view, this is the same factor that led to the spread of the [+count] assignment rule in Bulgarian over NumPs headed by numerals larger than 4 in the earlier stages of historical development, the details of which will be made precise.

Overall, our results show that 1) agreement errors in NumP is a Slavic phenomenon, independent of the presence of a productive Case system. 2) because of their dependence on complexity, a processing factor, the origin of feature assignment errors in Bulgarian and Russian must lie in the processing mechanism, or its interaction with the grammatical system of the respective language.

(1) *The son of the neighbours always *come* back late.

(2) a. V ezeroto pluvaha [dvanajset(te) krasiv-i (bel-i) lebed-a]
in lake-the swam twelve-(def.) beautiful-pl. white-pl. swan-count.
'Twelve beautiful swans swam in the lake.'

lebed swan-nom.

b. *V ezeroto pluvaha [dvanajset(te) krasiv-i (bel-i) lebed-i]
in lake-the swam twelve-(def.) beautiful-pl. white-pl. swan-pl.

(3) a. [_{NumP} pet [_{AP} mnogo prašasali] [_{NP} prozoreca]] b. [_{NumP} pet [_{AP} stari [_{AP} prašasali [_{NP} prozoreca]]]
five very dusted windows five old dusted windows

(4) a. dva / tri/ chetyre kuska / b. pjatj/odinnadcatj/sorok kuskov /
two three four pieces-masc.pauc. five eleven forty pieces-masc.pl.

(5) Na beregu reki paslisj pjatnadcatj krasivyx belyx ...
On bank river grazed fifteen beautiful white
“Fifteen beautiful white ... grazed on the river bank”

konj horse-nom.

References: Bock,K., and Cutting,J.C.1992. Journal of Memory and Language 31:99-127. Franck,J.,Vigliocco,G., and Nicol,J. 2002. Language and Cognitive Processes 17:371-404. Pashov, P., 1989. *Prakticheska bălgarska grammatika/Practical Bulgarian grammar*. Sofia: Narodna prosveta.