



## SPEAKERS' ERRORS IN THE USE OF THE 'COUNT FORM' IN BULGARIAN NUMERAL PHRASES: POSSIBLE SOURCES OF THE DISTANCE EFFECT

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### ARTICLE INFO

#### Article history:

Received 31 August 2023

Received in revised form

14 November 2023

Accepted 20 November 2023

Available online 23 November 2023

### ABSTRACT

*In Bulgarian, numerals such as pet ('five') assign a special 'count form' feature to the noun: this assignment takes place across any number of intervening modifier phrases, thus forming a long-distance syntactic dependency. In colloquial speech, speakers often erroneously substitute the count form for regular plurals. Previous corpus and psycholinguistic research established that the ratio of such errors correlates with the distance between numeral and the noun in terms of the number of intervening items. In this note we briefly review this line of inquiry and outline two possible explanations for the distance effect: (i) the cost of maintaining and/or retrieving the numeral in the working memory, and (ii) cumulative activation of the plural markings on the intervening adjectivals.*

#### Key words:

*Numeral, Syntactic dependency, Processing, Working memory, activation, Bulgarian*

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## 1. INTRODUCTION

Syntactic dependencies between words in a sentence located at a distance between each other with any number of elements intervening between them are a pervasive characteristic of natural language and a major grammatical factor contributing to the non-trivial character of human sentence processing. A common type of dependency involves subject-verb agreement whereby one or more intervening subject modifiers may separate the subject phrase and the verb, cf. *The senator {whom the reporters viciously blamed in yesterday's newspaper} is famous*. Agreement in the most general linguistic sense is a process of matching some features between the two sentential elements for instance, grammatical number in the above example. It is only natural that manipulation of formal syntactic features like person, number and gender is involved also in the speakers' real time processing of agreement: the sentence processing mechanism then must have a device for temporarily storing and maintaining the features of the agreement controller until the matching feature arrives. Computation of agreement in real time is a topic of much research in the psycholinguistic and neurolinguistic literature which produced a number of articulated models in the context of both sentence production and comprehension (see below for references).

Another type of grammatical featural manipulation is *feature assignment*. A prototypical case of feature assignment is Accusative case assignment by a transitive verb (e.g. *He saw her<sub>ACC</sub>*), but recent work suggests that a much richer empirical context for investigating psycholinguistic aspects of feature assignment process is provided by numeral phrases (NumPs). NumPs are phrases denoting quantities of countable objects as in *five old repainted wooden houses*. They consist of a number-denoting word and a countable noun, as well as any number of intermediate modifier phrases. In the English example above, the numeral *five* does not affect the plural morphological marking on *houses* so the connection between the numeral and the noun is not morphologically transparent. The situation is different in morphologically rich Slavic languages. In Bulgarian, the noun depending on the numeral receives a special exponent of 'count form' (*brojna forma*), while modifiers are marked plural, as in (1):

- (1)    pet        dârvên-**i**/\*a                    prozorec-**a**/\*-i  
       five    wooden,pl/count        window,count/pl(default)  
       'five wooden windows'

The number of modifiers intervening between the numeral and the noun can of course be indefinitely large, while modifiers themselves can have arbitrary structural depth (e.g. further modified by prepositional phrases or adverbials, some of which may themselves contain the count form), which increases the distance between the numeral and the noun, e.g.

- (2) Stopani-te    natorihâ **dva** [posadeni    mezhdu njakolko niski javor-**a**]    kesten-**a**  
       farmers-the fertilized two [planted,pl. between several low,pl. sycamores] chestnuts, count  
       'The farmers fertilized two chestnuts [planted between several low sycamores]'

From the syntactic perspective, the count form *-a* on the noun in (1)-(2) is assigned by the numeral. The latter is thus the obligatory feature licensor or controller. How feature assignment is treated in syntax depends largely on the theoretical framework adopted but it is

often seen as similar, though not entirely identical, to agreement: both are thought to involve some sort of matching or sharing of abstract syntactic features between the controller and the dependent (e.g. Adger 2003). Assigning a count form by the numeral to the noun is a case of syntactic dependency of a potentially unbounded distance (Stepanov and Stateva 2018). As regards the processing perspective, the topic of feature assignment in general, and processing assignment of count form in Bulgarian in particular, received surprisingly little attention in the psycholinguistic literature. In this short note, we discuss the processing aspects of count form assignment in the Bulgarian numeral phrase concentrating specifically on the distance effect as a potential window into relevant processing mechanisms that are at play in this case.

## **2. DISTANCE EFFECT IN ASSIGNING 'COUNT FORM' IN REAL TIME**

In spontaneous speech, Bulgarian speakers often erroneously substitute the regular plural ending on the noun which agrees with the modifying adjective, for the grammatical count form, e.g. *pet dârvên-i prozorc- \*i* (cf. (1)). This tendency has been noted anecdotally in traditional and contemporary Bulgarian grammars (see a review of the relevant literature in Barkalova et al 2018). Furthermore, in Stateva and Stepanov's (2016) analysis of the Bulgarian National Text corpus, the likelihood of this substitution error was found to increase proportionally to the amount of intervening material between the numeral and the noun from about 3% for a simple adjective-free collocation (Num+N), to 22% with NumPs with a single intervening adjective (Num+A+N), followed by 47% for NumPs with two intervening adjectives (Num+A+A+N) up to 67% for NumPs with three intervening adjectives (Num+A+A+A+N). Hence, the core factor that seems to underlie the feature assignment error profile appears to be linear distance, independently of structural distance between the numeral and the target noun, since it is kept the same across these different cases.

Further evidence for the role of linear distance comes from Stepanov and Stateva (2013) who used a cloze-like sentence completion task whereby participants were presented, in an auto-paced reading mode, with a sentential preamble with a missing final noun (e.g. *kesten* in (2)) for which only a lemma was provided; the participants then had to produce a suitable form of the noun to complete the sentence. In one experiment, the authors manipulated the linear distance between the numeral and the noun in terms of number of intervening adjectives modifying the noun (cf. (4) below). They found a statistically robust distance effect which essentially was in line with the corpus study mentioned above, that is, an error rate that increases with the number of intervening adjectives. In another experiment, the authors compared participants' response patterns manipulating the number of syntactic nodes separating the numeral and the noun (see Fig. 1) while keeping the linear distance (number of intervening words between the numeral and the noun) constant. They found no effect of structural distance.

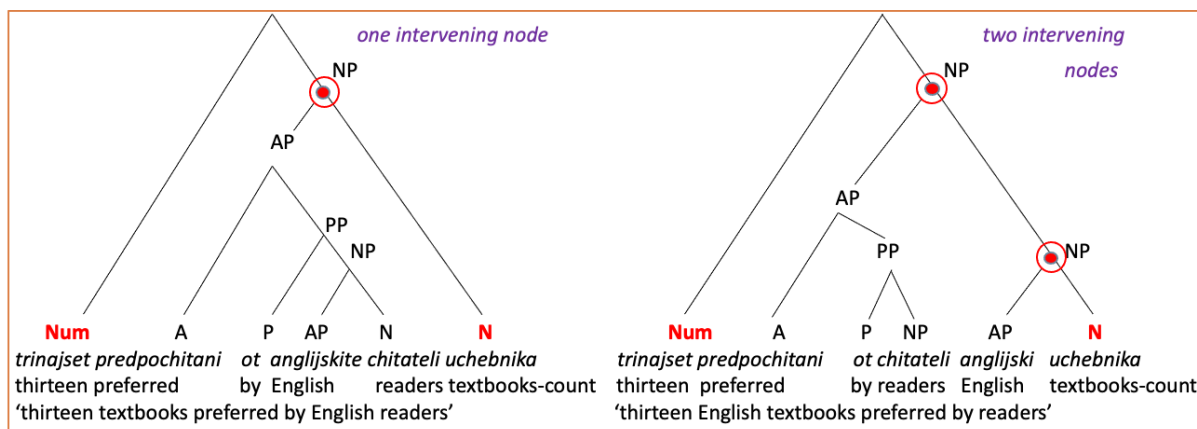


Figure 1. Stateva and Stepanov's (2013) examples of two manipulated structures of Bulgarian NumPs: the numeral and target noun are separated by a single syntactic node on the left, and by two syntactic nodes on the right. The erroneous production would be the plural form \*ucebniki.

The linear distance effect found in 'count form' assignment errors stand in an interesting contrast with the wide literature on *agreement attraction* in language production. Attraction errors arise when the verb agrees with an element from the sentence that carries agreement features (= 'attractor') rather than with the head of the subject phrase as would be expected by grammatical rules, as in *The key to the cabinets #are lost*. According to some authors, errors are due to the percolation of the attractor's feature within the subject phrase resulting in an erroneous feature specification on the entire subject constituent affecting the choice of the verb form (Bock and Cutting 1992, Bock and Eberhard 1993, Vigliocco and Nicol 1998, Franck et al. 2002). Experimental work showed that more errors were found in production of sentences like *The computer with the programs of the experiment #are...* than in sentences like *The computer with the program of the experiments #are...*. Since the plural feature on *programs* in the former sentence is located structurally closer to the root node of the subject phrase than *experiments* in the latter sentence, this structural distance effect was argued to support the percolation hypothesis (Franck et al. 2002, but see Gillespie and Pearlmutter, 2011). However, elements situated outside the subject phrase were also found to trigger attraction, like moved objects, either preverbal or fronted (e.g., *\*These are the patients that the doctor cure*, Franck et al., 2006; 2010; 2020). Such findings cannot be accounted for by the percolation account. Rather, cross-linguistic experimental evidence from English, French, Italian and Farsi supports the hypothesis that it is the structural intervention of the attractor (or its intermediate trace) on the agreement dependency that is responsible for the erroneous copy of its features on the agreement target, and subject to structural factors like the type of syntactic relation between the intervener and the verb (c-commanding interveners triggering more attraction than preceding ones, see Franck et al. 2006; 2010; Franck, 2017; Franck et al., 2020). These findings on agreement stand in contrast to the finding of what appears as a more superficial distance effect in the assignment of the count feature in Bulgarian. In the next two sections, we underline two potential factors explaining these differences: the first one lies in the assumption that different memory mechanisms underlie the processing of the two syntactic dependencies, while the second one highlights a potential confound in the feature assignment test cases, and the possibility that morphological priming is actually responsible for the linear distance effect reported.

### **3. A MEMORY ACCOUNT OF DISTANCE EFFECTS**

In the late 90', Dependency Locality Theory (DLT) appeared as an influential model of the role of memory in sentence processing (Gibson 1998, 2000). This theory assumed that partially interpreted linguistic material is temporarily stored and maintained so that incoming material may be integrated with it (Chomsky and Miller 1963, Miller and Chomsky 1963) and that integration of a predicted item into the structure currently built incurs a processing cost that is a function of the amount of material intervening between the predictor and that item. Processing cost is measured in terms of linearly intervening 'new discourse referents', specifically nouns and verbs (note that the theory is focused predominantly on the clause-level processing). Hence, distance in that theory was counted in terms of new discourse referents. More recently, the content-addressable, cue-based approach of memory (e.g., McElree 2000, McElree et al. 2003 Lewis & Vasishth 2005) was argued to provide a relevant framework to account for key experimental findings on agreement processing in sentence comprehension (e.g., Badecker and Kuminiak, 2007; Wagers et al. 2009; Villata et al. 2018; Villata and Franck 2020, Franck and Wagers 2020). Research indeed showed that participants manifest similar agreement attraction effects in language comprehension whereby in cases where they are likely to produce an agreement error they also have less difficulty in processing an agreement error (e.g. Pearlmutter et al. 1999, Wagers et al. 2009). Exploring these deviations, researchers suggested that agreement in language comprehension involves a process of reaccessing the subject on the basis of cues available at the verb. This account was naturally couched within a memory model that assumes that the temporarily stored agreement source (the subject of the verb, in most of these studies) has to be retrieved based on subject cues. Although cue-based retrieval is efficient because direct (in contrast to a search mechanism), it is sensitive to similarity-based interference from other elements temporarily stored carrying syntactic features that are similar to those of the subject head. In line with the prediction of this memory model, studies conducted on various languages have reported slower processing of the agreement target when the intervener has the same case or agreement feature as the controller (e.g. Badecker and Kuminiak, 2007; Wagers et al. 2009; Franck and Wagers 2020) or when it bears some semantic similarity to it (Smith et al., 2018; 2021).

To the extent that cue-based retrieval takes place, it was argued that agreement in sentence comprehension can be seen as a 'backward-looking' dependency in a sense that the parser consults pieces of the (partial) structure already built in the time course of processing a sentence at the point of completing the dependency. In contrast to agreement, feature assignment implies 'projecting forward' a feature to-be-assigned by the feature controller without an overt cue for that feature (e.g. in (1)-(2) the numeral itself does not have the "count form" marker, just as the verb *kiss* itself does not come with an overt Accusative feature cue). The feature is first activated by processing the trigger itself, namely the numeral. This can be implemented by encoding the feature COUNT into the featural specification of the numeral's lexical item. Using a simplified notation reminiscent of the Head-driven Phrase Structure Grammar format (cf. Sag et al. 2003) we may represent the feature structure of numerals as follows:

- (3) [ NUM *pet*  
[ N num  
[ N noun [ COUNT + ] ] ] ]

The [COUNT +] specification in (3) is basically an open slot or morphological prediction for a countable noun. Feature assignment can therefore be seen as a 'forward-looking' search process seeking to complete a dependency by integrating the noun that conforms to the morphological specification of the predictor. A few sentence processing studies have explored test cases where temporal or spatial order of the elements in the sentence has to be retrieved, and concluded that in such cases a search mechanism, sensitive to linear distance, rather than a direct content-addressable, cue-based retrieval mechanism is at play (e.g., Oztekin and McElree 2007). Viewed this way, we suggest that feature agreement and feature assignment may differ in the type of memory mechanism involved in processing the syntactic dependency. In the agreement case, a backward-looking mechanism is triggered to retrieve the subject: such a mechanism is direct, structure-dependent, and based on retrieval cues available at the verb (Franck and Wagers 2020). In contrast, feature assignment relies on a forward-looking search mechanism, triggered by the abstract COUNT feature of the numeral to find the noun that links to it. This mechanism is sensitive to linear distance, as new elements entering the parse are being sequentially scanned for their potential suitability as syntactic dependent. The reasons why linear distance plays a critical role in feature assignment but not in feature agreement may have to do with the incremental character of sentence processing: at any intermediate point X of processing a sentence, the parser has constructed the (partial) syntactic structure consisting of the material before X, but not after X: hence a forward-looking process does not have access to the syntactic information in principle. Elaborating this conjecture further is beyond the scope of this brief note and we leave it for further research.

#### **4. A MORPHOLOGICAL PROCESSING ACCOUNT OF THE DISTANCE EFFECT**

One may also wonder if the distance effect in the error patterns within feature assignment may actually be due not to the processing cost of maintaining the numeral in memory, but rather because of a collateral effect arising due to the intervening morphological exponents on the intervening adjectives that are uniformly plural, since the plural is expressed with the same morpheme on the adjective and on the target noun, cf. (5):

- (5) Pet krasiv-i graciozn-i bel-i lebed-a/#-i  
Five beautiful,pl graceful,pl. white,pl. swan,count/pl  
'Five beautiful graceful white swans'

Processing of errors in number agreement between the noun and modifiers in morphologically rich languages has been studied extensively in the psycholinguistic (e.g. Gurjanov et al. 1985a, 1985b, Lukatela et al. 1983) and neurolinguistic literature (e.g. Barber and Carreiras 2005). Cross-linguistic studies have shown that subject heads with regular morphological or morphophonological number or gender markers (e.g., nouns ending in –o in Italian, which are usually masculine) are less prone to attraction than heads lacking these cues, while the presence of the same markers on the attractor tends to increase the chances of attraction (see Franck, 2017 for a review). Interestingly, morphological priming studies using the Lexical Decision task (in which the modifier with the matching or non-matching agreement feature primes the target noun) demonstrated that nouns preceded by feature-matching

adjectives were recognized faster than those preceded by feature-mismatching ones (Gurjanov et al. 1985a, 1985b). In cases such as (5), repeated activation of a plural morphological marker on an adjective may thus contribute to strengthening the tendency to erroneously produce the same marker on the target noun, in place of the count morpheme. This idea can be characterized in terms of activation-based models from cognitive psychology (Anderson et al. 2004, see also Vasishth and Lewis 2006). In our case, morphological plural number (which is not inherent to the adjective but must be retrieved and computed with each adjective separately) receives a greater activation level with each processed adjective. Thus the likelihood of an erroneous plural appearing on the target noun can be naturally expected to proportionally increase with the number of adjectives. Since the number of adjectives coincides with linear distance, the data do not allow distinguishing a morphological activation account from a memory decay account. A further possibility is that the error pattern observed in assignment of the count form in Bulgarian is a function of both the processing cost *and* the increased activation of the plural on the intervening adjectives. It is also possible that intervening *nouns* contribute to the activation level of the plural as well.

All these possibilities need to be taken into consideration when formulating a theory of processing feature assignment. It should be noted that it is not easy to tease apart these possibilities by constructing relevant experimental manipulations in which the dependency length (number of intervening material) is separated from the cumulative activation effect of repeated plurals, because of the structural constraints on the NumP: adjectival modifiers in Bulgarian (and Slavic languages more generally) must agree with the noun, so by adding more modifiers we simultaneously increase both the distance between the numeral and the noun *and* the plural activation level. This grammatical restriction could perhaps be circumvented by fine-tuning the experimental methodology, a track which we are currently pursuing in our research.

## **5. CONCLUSION**

To conclude, feature assignment is similar to agreement grammatically and to some degree also processing-wise: both contexts involve a syntactic dependency that can be interrupted by unlimited materials, and both must therefore involve a component of memory responsible for linking two elements temporally distant. We briefly reviewed the existing literature on the processing of these two dependencies, which suggests that errors in processing these two grammatical configurations are distinct: whereas agreement errors are sensitive to structural factors like hierarchical structure and c-command, feature assignment errors appear to rather depend on a surface factor that is the linear distance between the numeral and the noun. We proposed to (non-exclusive) hypotheses to account for that difference. The first one assumes that whereas a cue-based memory retrieval mechanism underlies agreement errors, a memory search mechanism would drive the errors observed in feature assignment. This hypothesis is currently ad-hoc, but it opens the way to new experimental research that could be designed to assess its predictions. The second hypothesis highlights the potential role of morphological priming in the feature assignment errors reported. We argued that this factor is actually confounded with linear distance, and that therefore a proper experimental design allowing to teased the two factors apart is necessary. Although much remains to be done in order to fully

grasp similarities and differences between feature agreement and feature assignment processing, this new line of research opens the way to new insights in the study of long-distance syntactic dependency processing.

## **ACKNOWLEDGMENTS**

This research has received financial support from the collaborative research project ‘Beyond agreement: How speakers assign syntactic features in real time’, funded by the Slovenian Research Agency (project no. N6-0156, Principal investigator: Penka Stateva) and the Swiss National Science Foundation (project no. 100015L\_192859, Principal investigator: Julie Franck).

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