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# The Interplay of Morpho-Phonology and Semantics in the Processing of Plural Subject-Verb-Number Agreement with Collective Noun Constructions

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## 1 Introduction

This study aims at comparing two major models of dependency formation, the *cue-based retrieval* model (Lewis & Vasishth 2005) and the *marking and morphing* (Bock et al. 2001) model, respectively focusing on number retrieval and number representation. The models main assumptions are tested against the influence of different modifier-types on the processing of *conceptual* (plural) subject-verb number agreement with collective noun constructions in German.

The cue-based retrieval model posits that the agreement-target sets retrieval cues during dependency formation, initiating a process of spreading activation to all items in working-memory whose specifications at least partly match the retrieval cue. For subject-verb agreement in language processing, a plural verb sets the retrieval cues +nominative and +plural, spreading activation to all items with features matching the retrieval cues. Typically, the retrieval process enables accessing the subject head-noun leading to successful subject-verb agreement even in the presence of a local distractor noun in the same DP.

The marking and morphing paradigm suggests that a subject-DP's number valuation (SAP-value) is continuous and determined by the interaction between the referent's notional number, the subject-head noun's number morphology and the number specification of local nouns. Successful agreement is established if the subject's SAP-value during dependency formation aligns with the verb's number specification.

In German, plural subject-verb-number agreement can occur between collective nouns that show a discrepancy between notional plurality and grammatical singularity although it is mostly limited to collectives like *Vielzahl* that denote numerosity and cooccur with modifiers like *der Schüler* to form a collective construction (Löbel 2012).

(1) [Eine Vielzahl [Fem, Nom, Sg.] der Lehrer]      haben [Pl.] Bier getrunken.  
      'A multitude                                      of the teachers      have              beer drunk.'

Compared to English, German allows for a variety of different modifier-types in collective constructions that can be described by the binary factors  $\pm$ Prepositional and  $\pm$ Definiteness, resulting in four different constructions (Tab. 1).

[ + DEF, -PP]	[ + DEF, + PP]	[ -DEF, -PP]	[ -DEF, + PP]
DPNom[Eine Vielzahl DPGen[der Lehrer]]	DPNom[Eine Vielzahl <sub>PP</sub> [von DPDat[den Lehrern]]]	DPNom[Eine Vielzahl DPGen[Ø Lehrer]]	DPNom[Eine Vielzahl <sub>PP</sub> [von DPDat[Ø Lehrern]]]

Table 1: Modifier-Types for Collective Constructions in German.

Although all of these modifications are mostly interchangeable and can be found in analogous contexts in corpora, I assume that the conceptualization differs slightly depending on the modifier type, following Goldberg's principle of no synonymy (1995).

Specifically, the degree of *partitivity*, i.e. the salience of the superset-implicature triggered by the modifier indicating that the main predication of the sentence does not hold for all entities denoted by the modifier-phrase of the collective construction is assumed to be higher when the variables  $\pm$ Definiteness and  $\pm$ PP take positive values (Lindauer 1995).

## 2 Study 1: Modifier-Type and Partitivity

The current study examined whether the theoretically postulated differences in the degree of partitivity are cognitively real, using a probability-judgement study. In a 2x2 repeated measures design with the binary factors  $\pm$ PP and  $\pm$ DEF, the participants were orally presented with sentences containing collective constructions (2) manipulated by modifier type. Participants were instructed to determine the probability of the existence of other entities as those denoted by the collective construction but not referred to by it.

- (2) Eine Vielzahl der pinken Lehrer fliegt über dem Dorf.  
,A multitude of (the) pink teachers fly above the village.'

48 participants, prescreened for German as native language, were recruited via Prolific. Each participant provided responses to four items per condition.

The results (Fig. 1) provide evidence that supports the hypotheses. The data was analyzed using a linear mixed-effects model with random intercepts for participants, predicting the probability rating as a function of the factors  $\pm$ PP,  $\pm$ DEF and their interaction. The model indicates significant main effects  $\pm$ PP and  $\pm$ DEF ( $p = 0.001$ ;  $p = >0.001$ ), with positive values increasing partitivity.

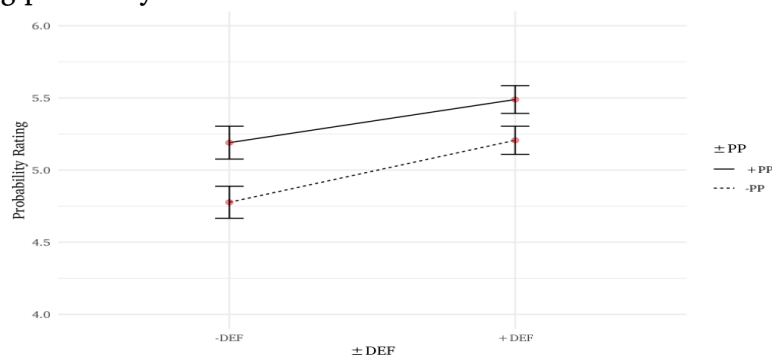


Figure 1: Interaction-plot for partitivity ratings by modifier-type

Following Brehm & Bock (2013), I assume that notionally more coherent sets of entities are perceived as less plural. Furthermore, a higher degree of partitivity of the modifier phrase decreases the coherence of the set of entities denoted by the collective construction due to the contrast with the not-included superset, increasing the notional plurality of the subject-denotation. When processing a sentence with a collective noun construction as the subject, the marking and morphing account predicts an increase in notional plurality to increase the competition between the singular- and plural values in the subject's number representation, increasing number ambiguity as reflected in differences in agreement-processing. The cue-based retrieval model on the other hand does predict any differences purely based on the notional plurality of the modifier as it is not considered relevant in the account.

The notional meaning component of the modifier type can, however, not be viewed in isolation as it is embedded in specific constructions that differ in terms of morpho-phonological factors. Specifically, the case-syncretism of the local noun may be considered relevant in this regard. While the embedding in the dative-controlling preposition *von* (+PP) causes the local noun *Lehrern* to be marked explicitly as not-nominative, genitive modifiers (-PP) contain case-syncretic local nouns *Lehrer* that have the same form as a nominative noun.

## 3 Study 2: Processing of Plural Agreement by Modifier-Type

According to the marking and morphing account, plural local nouns spread their plural number feature regardless of their morphological form, increasing the overall plural valuation

of the subject. The marking and morphing account consequently predicts the ambiguity in the number valuation and differences in the process of dependency formation to be solely determined by the notional meaning aspect of the modifier phrase. The local noun specified for plural will spread its features regardless of whether it is a noun like *Lehrern* (+PP), explicitly marked for dative case, or a noun like *Lehrer* (–PP) that is syncretic between nominative- and genitive case. The marking and morphing model consequently predicts differences caused by main-effects of  $\pm$ PP and  $\pm$ DEF.

Cue-based retrieval models assume that the plural local noun may be misretrieved during dependency formation due to a partial feature match of +plural with the retrieval cues set by the plural verb. Infelicitous retrieval is, however, significantly more likely if the local noun is case-syncretic to a nominative form as processing the syncretic form will activate the nominative function to some degree so that the local noun seemingly matches both retrieval cues of the verb. Differences in processing are consequently purely determined by the presence of a case-syncretism in the local noun. The cue-based retrieval consequently predicts differences caused by a main-effect  $\pm$ PP.

The study examines the hypotheses about different processing patterns using a speeded-grammaticality judgement procedure with rapid serial visual word presentation. Each word is sequentially displayed for 425ms before automatically disappearing. The design follows a 2x2 repeated measure design with the binary factors  $\pm$ PP and  $\pm$ DEF in the modifier as the manipulated variables. Each sentence consists of a matrix-clause, embedding a subordinate clause with a sentence-final plural verb establishing plural-agreement and a collective construction as its subject.

- (3) Peter | weiß, | dass | eine | Vielzahl | der | Lehrer | in | der | Pause | Bier | trinken.  
'Peter | knows | that | a | multitude | of (the) | teachers | during | break | drink | beer.'

The participant's task is to judge as quickly as possible whether the sentence is grammatical after the last word is presented. Both the judgements and the reaction times are measured as response variables. 70 participants, prescreened for German as native language, were recruited via Prolific. Each participant provided responses to four items per condition.

The assumed main effect for  $\pm$ PP and  $\pm$ DEF from the marking and morphing account is predicted to reflect in more grammatical-judgements as well as longer reaction times when the factors  $\pm$ PP and  $\pm$ DEF take positive values. As notional plurality rises, the competition between singular- and plural number in the subject's SAP-value intensifies, increasing the probability of plural-agreement appearing grammatical. Concurrently, the intensified competition extends the time needed for number feature selection during dependency formation, increasing reaction time.

The cue-based retrieval model, on the other hand, predicts more grammatical-judgements as well as longer reaction times if the factor  $\pm$ PP takes a negative value and the modifier contains a case-syncretic local noun. For reaction times the spread of activation to items matching the verb's +nominative and +plural cue initiated during the retrieval process is distributed between the head noun and the local noun, increasing the retrieval time due to slower activation for either. Acceptance of plural agreement is additive and expected if either the conceptual number specification of the collective head noun – which in contrast to the notional plurality of the local noun can be assumed to influence agreement – is more strongly activated than the singular grammatical number feature during dependency is retrieved, or if the plural local noun is mistakenly retrieved creating an illusion of grammaticality.

The reaction time data (Fig. 2) was analysed using a linear mixed-effects model with random intercepts for participants, predicting the reaction time as a function of the factors

$\pm$  PP,  $\pm$  DEF and their interaction. The model indicates a significant main-effect for  $\pm$  PP ( $p = 0.013$ ), a significant main effect for  $\pm$  DEF ( $p = <0.001$ ) as well as a significant interaction effect ( $p = 0.004$ ). The Grammaticality-Judgement data (Fig. 3) was analysed using a generalized linear mixed-effects model with random intercepts for participants, predicting the probability of grammatical-judgements as a function of the factors  $\pm$  PP,  $\pm$  DEF and their interaction. The model indicates a significant main-effect of the factor  $\pm$  DEF ( $p = 0.017$ ).

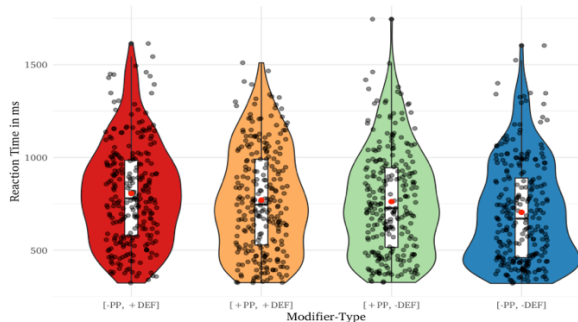


Figure 2: Violin-plot for reaction times

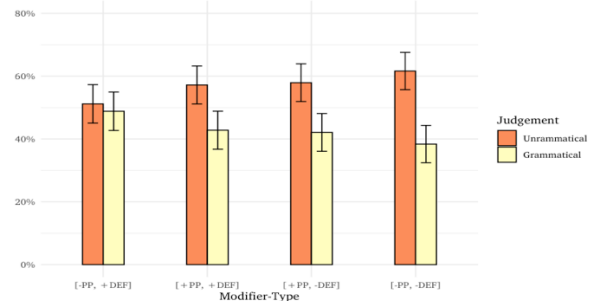


Figure 3: Bar-plot for grammaticality judgements

## 4 Discussion

The observed data cannot be fully explained by either the marking and morphing account nor by the cue-based retrieval account. The prediction of the cue-based retrieval account that only the morpho-phonological aspect of case-syncretism in the modifier influences agreement-processing can neither explain the increased reaction times for the positive value of the factor  $\pm$  PP for the reaction time, nor the increased reaction times and grammatical-judgements for the positive value of the factor  $\pm$  DEF. The predictions of the marking and morphing account fit the data better. Consistent with the predictions, a significant increase in reaction time is observed when the factors  $\pm$  PP and  $\pm$  DEF assume positive values. The factor  $\pm$  PP, however, does not significantly influence the grammaticality-judgements, contrary to expectations. The interaction effect in the reaction times can further not be straightforwardly explained by the marking and morphing model. Inclusion of additional parameters and some combination of the two models, increasing their flexibility, as proposed by Yadav et al. (2023), may yield a superior fit for the data.

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