

## RESEARCH

# Lexical case marking affects the processing of animacy in simple verbs, but not particle verbs: Evidence from event-related potentials

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In case-marking languages like German, nonstandard nominative-dative verbs lead to enhanced processing costs. So far, it is unclear if these case-marking effects reflect the special syntax or semantics of nominative-dative verbs. We present the results of two ERP experiments aimed to disentangle semantic and syntactic contributions to lexical case-marking by manipulating object animacy and case-marking for two verb types: simple verbs (nonstandard syntax and semantics for nominative-dative verbs) and particle verbs (nonstandard semantics only). Simple nominative-dative verbs show effects of case-marking, and no animacy effects. Particle verbs show no effects of case-marking, and animacy effects for nominative-accusative and nominative-dative verbs. Our findings suggest that lexical case-marking effects reflect the special syntax, rather than semantics, of simple nominative-dative verbs.

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## 1 Introduction

In sentence comprehension, the parser uses all kinds of cues to assign grammatical and thematic roles. Formal cues include word order, person and number congruency of subject and verb, and case marking on the arguments (Frazier & Flores d'Arcais 1989; Hemforth et al. 1993; Schriefers et al. 1995; Bader & Meng 1999; Pearlmutter et al. 1999; Schlesewsky et al. 2000; Frisch & Schlesewsky 2001; Carminati 2005). The relative importance of these cues varies for different languages. Semantic factors like argument animacy are also known to play a major role, a finding that seems to be relatively robust across languages (e.g., MacDonald et al. 1994; Trueswell et al. 1994; Weckerly & Kutas 1999; Frisch & Schlesewsky 2001; Paczynski & Kuperberg 2011; Czypionka 2014; see also Kuperberg 2007 for an overview).

Sentence comprehension in German relies heavily on case marking on the arguments, with subjects usually marked nominative and objects usually marked accusative. An interesting exception are lexical case marking verbs, i.e., two-place verbs that assign lexical dative instead of structural accusative to their objects. These verbs differ both semantically and syntactically from nominative-accusative-assigning verbs (Blume 2000; Bayer et al. 2001; McFadden 2004; Grimm 2010), and elicit different processing effects (Hopf et al. 1998; Bader et al. 2000; Bayer et al. 2001; Hopf et al. 2003; Bornkessel et al. 2004).

In this paper, we pursue the question if these processing differences reflect the syntactic or semantic differences of nominative-accusative and nominative-dative verbs. We present data from two ERP experiments, using object animacy effects as a tool to gain a better understanding of the role of structural and lexical case marking in the comprehension of German sentences.

We will set out by providing background information on the processing of argument animacy in sentence comprehension. This will be followed by an overview of the literature on the processing of lexical as opposed to structural case marking in German sentence comprehension. We will continue with an explanation how we can use argument animacy to better understand the processing of lexical case marking. We will show how we can disentangle semantic and syntactic contributions to the processing of lexical case marking by using the distinction between separable and non-separable German verbs.

## 2 Background

### 2.1 Argument animacy

The animacy of a noun's referent is a semantic (and possibly conceptual) property that is expressed differently across languages. Animacy is reflected, for example, in the choice of interrogative pronouns (English *who* or German *wer* for animates, but English *what* or German *was* for inanimates), number marking (Croft 1990; Corbett 2000; Haspelmath 2013) or case marking (in Differential Object Marking languages, in which morphologically overt object marking is obligatory for one semantic class of objects, but not for another one – the semantic property requiring overt marking often being animacy or humanness; see, e.g., Bossong 1985; 1991; Næss 2004). Based on observations from corpus linguistics and typology (Silverstein 1976; Bossong 1985; Comrie 1989; Dixon 1994; Aissen 2003; Jäger 2004; Dahl 2008; Malchukov 2008), sentences with an animate subject and an inanimate object are often considered the “most natural” transitive constructions in psycholinguistics.

In sentence production and comprehension, argument animacy is known to play a crucial role. In production, argument animacy influences word order and the assignment of syntactic function (Bock & Warren 1985; Bock 1987; Bock & Loebell 1990; McDonald et al. 1993; Ferreira 1994; Branigan & Feleki 1999; Prat-Sala & Branigan 2000; Branigan et al. 2008), interacting with processes of thematic role assignment (Ferreira 1994; van Nice & Dietrich 2003, see Verhoeven 2009; 2014 for the interplay with other factors like case marking in a variety of languages).

In sentence comprehension research, argument animacy has been used even earlier (e.g., Frazier & Rayner 1982) to assess the relative timecourse of the processing of semantic and syntactic information, with mixed results. While some studies support syntax-first approaches to parsing, with semantic information like animacy only being used during second-pass parsing (e.g., Ferreira & Clifton 1986; Clifton et al. 2003), other studies show that argument animacy is processed immediately, and influences structure building from the beginning of the parsing process (MacDonald et al. 1994; Trueswell et al. 1994). Over time, argument animacy manipulations have turned out to be different from many other semantic properties, in that contrasts in subject and object animacy seem to play an important role in the assignment of subject and object roles. In general, sentences with animate objects increase processing costs relative to sentences with inanimate objects, especially so for structures that are challenging to process, like relative clauses or ungrammatical clauses (Trueswell et al. 1994; Weckerly & Kutas 1999; Frisch & Schlesewsky 2001, but see Paczynski & Kuperberg 2011; Czypionka 2014; Czypionka et al. 2017, for object animacy effects with comparatively simple, grammatical sentences). For German, Frisch & Schlesewsky (2001) monitored the comprehension of embedded verb-final transitive sentences with inanimate and animate objects, using ERP measurements. Both arguments were marked nominative, making the sentences ungrammatical in German. With animate-inanimate argument sequences, they found a P600 on the clause-final verb. With animate-animate sequences, they found an N400 in addition to the P600, although the verbs' semantic selectional restrictions concerning animacy were not violated. The authors suggest that the assignment of thematic roles can proceed either

via morphosyntactic information or via argument animacy contrasts, and that the N400 arises only when neither is possible.

In EEG studies on the comprehension of English transitive sentences, object animacy has also been shown to affect processing, even in the absence of violations. For grammatical sentences without violations of semantic selectional restrictions, Paczynski & Kuperberg (2011) report an enhanced N400 component at centroposterior sites for postverbal animate compared to inanimate objects. The authors argue that this finding suggests that animacy effects in sentence comprehension are not caused by the higher conceptual accessibility of animate objects (as this should have attenuated, not enhanced, an N400). In their second experiment, Paczynski & Kuperberg (2011) find no difference for animate objects that are assigned patient and experiencer roles, suggesting that animacy effects are not caused by semantic matches or prototypicality (as this would have attenuated an N400 for animate experiencers, but not for atypically animate patients), at least in SVO languages like English. The authors interpret their findings as showing that animacy hierarchies are mapped directly on syntactic hierarchies during sentence comprehension.

The special role of argument animacy in sentence comprehension is further supported by observations collectively referred to as *semantic illusions* (see Hoeks et al. 2004, for Dutch, and Kuperberg et al. 2003; Kim & Osterhout 2005; Kuperberg et al. 2007, for English, among others). This term refers to the results of a number of studies monitoring the effects of different types of semantic violations of verb-argument-relationships. The general pattern reported in these studies is the following: For subject-verb relations that violated world knowledge and for weak lexico-semantic associations between subjects and objects, an N400 is reported. However, for violations of subject animacy restrictions, no N400, but a P600 is reported. The animacy restriction violation even causes a P600, but no N400, when there is no close lexico-semantic relationship between subject and verb (Kuperberg et al. 2007). These findings lend further support to the idea that argument animacy contrasts are used to assign subject-object relationships, and are processed in a different way from other types of semantic processing like world knowledge or lexico-semantic associations.

Findings like the ones outlined above have informed different models of sentence comprehension that focus on the assignment of grammatical and thematic roles. The comprehension model proposed by Kuperberg (Kuperberg 2007) distinguishes between semantic and formal processing pathways. Two formal processing pathways operate in parallel, one using morphosyntactic information like subject-verb-agreement, the other using lexical-thematic information like argument animacy. According to Kuperberg, processing difficulties in the semantic pathway are reflected in enhanced N400 components, whereas processing difficulties in one of the formal pathways are reflected in enhanced P600 components. Therefore, argument animacy is one of the formal cues for sentence comprehension, although semantic (and possibly conceptual) in nature. In the extended Argument Dependency Model, (eADM, Bornkessel-Schlesewsky & Schlewsky 2006; 2009; 2013), animacy is one of the contributors that help calculate a potential argument's prominence in the "compute prominence" step. Increased processing load during this step is linked to an enhanced N400, whereas the P600 is related to processing steps involving agreement and syntactic reanalysis.<sup>1</sup>

In sum, argument animacy is one of the relevant cues in sentence comprehension, and the processing of argument animacy contrasts is different from other types of semantic processing (like, e.g., the checking of semantic appropriateness, see Paczynski & Kuperberg

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<sup>1</sup> See Paczynski and Kuperberg 2011 for a discussion of the more recent *semantic illusion* literature with respect to the eADM.

2011, outlined above). Animate-animate argument sequences cause a higher processing load than animate-inanimate sequences, usually reflected in enhanced N400 components.

In the following, we will refer to the increased processing cost of two animate arguments relative to animate-inanimate argument combinations as the *object animacy effect*. We will use this well-established effect as a tool to understand more about the processing of different types of verbs in German, and to better understand another factor in the comprehension of German sentences, namely, case marking.

## 2.2 Case marking

In German, case is morphologically marked on arguments. Due to widespread case syncretism, many nouns and some pronouns are case-ambiguous, so that case-ambiguous, but grammatical sentences are still possible. In the comprehension of German sentences, case marking is one of the main cues for assigning grammatical roles: Subjects are marked with nominative, direct objects are marked with accusatives, and indirect objects are marked with dative. However, a small group of German two-place verbs assign dative instead of nominative to their *direct* objects. In the following, we will refer to these verbs assigning noncanonical case as *lexical case marking verbs* or NOM-DAT verbs; the verbs assigning canonical case will be called *structural case marking verbs* or NOM-ACC verbs.

Lexical case marking verbs occur in different case-marking languages, and encode a special type of argument semantics (Blume 2000): The situations encoded by German NOM-DAT verbs are not prototypically or maximally transitive (Dowty 1991; Grimm 2010). This means that they do not describe situations with a prototypical agent doing something to a prototypical patient; the semantic features associated with the proto-agent role (in the sense of semantic properties contributing to these roles, see Dowty 1991) are usually more evenly distributed among the participants. A rough way of putting this would be to say that their objects in general are more agentive relative to their subjects than in prototypically transitive situations.<sup>2</sup> It is important to mention that although the role of animacy is discussed in this part of the literature, animacy is not included in the list of semantic properties making up the agent and patient proto-roles in Dowty's account, and neither in the set of properties defining prototypical agents in Grimm (2010). Some of the semantic properties that contribute to Dowty's agent proto-role strongly imply animacy (e.g., *sentience* and *volitional involvement*). However, the semantic property of *affectedness*, which is associated with the patient proto-role, could also be argued to be linked to animacy. Therefore, it cannot be said that lexical case marking signals a preference for animate objects; if anything, it signals a deviation from prototypical transitivity (which only roughly matches an animate-inanimate argument pattern).

While there is no consensus on the syntactic structure of NOM-DAT verbs, many analyses suggest that their structure is different from NOM-ACC verbs. Dative for direct objects is considered to be an idiosyncratic or lexical case (Haider 1993; Czepluch 1996; Haider 2010; Woolford 2006) (in contrast to dative for indirect objects, see Woolford 2006; but see Meinunger 2007 for a different position outlined above). Some analyses hold that lexical datives need to be assigned by lexical heads like  $V^0$  (see Fanselow 2000 for lexical case marking verbs, and Woolford 2006 for datives assigned by lexical case marking verbs

<sup>2</sup> While NOM-DAT verbs never denote prototypically transitive situations, the reverse conclusion does not hold: Non-prototypically transitive situations can very well be encoded in NOM-ACC verbs. A well-known example is the verb pair *helfen* ('to help', assigning NOM-DAT) and *unterstützen* ('to support', assigning NOM-ACC). This verb pair has been cited both as an illustration that lexical case marking is predictable from verbal semantics (Meinunger 2007) and that lexical case marking is essentially idiosyncratic (Haider 2010). In this paper, we will assume that NOM-DAT verbs reliably signal non-prototypical transitivity, while NOM-ACC verbs don't.

and prepositions). Another suggestion is that dative is always assigned in the position of the indirect object, even for two-place verbs; however, this approach assumes that there are different base positions for indirect objects, depending on the verb (McFadden 2004). An approach that has already been tested psycholinguistically is the proposal that lexical case is assigned in an additional syntactic layer of projection called KP (for Kase Phrase, Bader et al. 2000; Bayer et al. 2001); outlined in more detail below).

In sentence comprehension, NOM-DAT verbs cause increased processing cost compared to NOM-ACC verbs, but only when morphological case marking on the arguments is ambiguous (see Bader et al. 2000 for data from speeded grammaticality judgments). In ERP studies on German sentence comprehension, the reassignment of dative instead of structural case is reflected in an enhanced N400 to clause-final NOM-DAT verbs relative to NOM-ACC verbs (Hopf et al. 1998; 2003), again only when case marking on the arguments is morphologically ambiguous.

Another effect of lexical case marking is that NOM-DAT verbs license noncanonical word orders. In contrast to NOM-ACC verbs, NOM-DAT verbs come with different unmarked argument orders; some occurring with unmarked subject-object, others with unmarked object-subject word orders.<sup>3</sup> Judgment studies show that while object-subject-structures cause garden path effects with accusative objects, these processing difficulties are attenuated for dative objects (Bader 1996). These findings are further supported by EEG evidence reported by Bornkessel et al. (2004). For NOM-ACC verbs, the authors found a P600 for OS word orders compared to SO word orders. The same contrast elicited no P600, but an N400 for NOM-DAT verbs with unmarked SO word order. Although no direct comparison between NOM-ACC and NOM-DAT verbs was offered in this study, these findings support the idea that NOM-DAT case marking licenses noncanonical word orders, irrespective of the argument order associated with the specific NOM-DAT verb.

The processing of NOM-ACC and NOM-DAT verbs differs in another respect, namely, the processing of argument animacy. In Czypionka et al. (2017), grammatical subordinate clauses with SOV word order showed an effect of object animacy in various behavioral and ERP measurements. ERPs to the clause-final verb were more negative-going with animate than with inanimate objects at left-posterior sites. This contrast was only visible with NOM-ACC verbs. With NOM-DAT verbs, there was no contrast between animate and inanimate objects, and waveforms for dative verbs were more negative-going than the inanimate-accusative condition, irrespective of the objects' animacy.

Case marking plays an important part for assigning grammatical and thematic roles in models of sentence comprehension; however, the underlying assumptions about structural and lexical case marking verbs differ between accounts. The eADM (Bornkessel-Schlesewsky & Schlewsky 2006; 2009; 2013) predicts a processing difference between NOM-ACC and NOM-DAT verbs: "(...) constructions including a dative argument should give rise to processing behaviour that is measurably distinct from that observable for nominative-accusative structures" (Bornkessel-Schlesewsky & Schlewsky 2006: 792). The explanations for this predicted processing difference center around the special semantic behavior of NOM-DAT verbs. While the accusative arguments of NOM-ACC verbs must always be mapped on the "undergoer" role, this relationship is more flexible with NOM-DAT verbs (Bornkessel-Schlesewsky & Schlewsky 2009: 43–44). It is assumed that the objects of NOM-DAT verbs are not associated with a specific type of thematic role or set of semantic

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<sup>3</sup> In general, German verbs have unmarked SO structures, and subject-initial orders are preferred for subject-object-ambiguous structures (Hemforth et al. 1993; Schriefers et al. 1995; Bader 1996). Corpus studies reveal that SO sentences are more frequent than OS sentences, and that objects in OS sentences are mostly dative (and, incidentally, animate, with a high proportion resulting from the passivization of ditransitive verbs, Bader & Häussler 2010).

properties (“GR”s in the eADM), and neither with a specific structural position.<sup>4</sup> In its current state, the model does not make any more specific predictions for the type of difference to be found between NOM-ACC and NOM-DAT verbs, and does not go into detail about possible effects of different types of dative-assigning structures on sentence comprehension measures.

Another proposal about the processing of NOM-ACC verbs assumes that upon encountering a NOM-DAT instead of a NOM-ACC verb, two additional processing steps are performed (Bader et al. 2000; Bayer et al. 2001). The first step is a mild reanalysis of the syntactic structure to insert an additional projection where lexical case can be assigned to the object (KP; Bayer et al. 2001 – unlike assumed in the eADM, there is a specific syntactic position for objects of NOM-DAT verbs in this proposal). The second is a reaccess to the lexical entry of the preverbal *object* to check if the morphology licenses lexical case (i.e., dative). It is this latter step that is assumed to cause an N400, as reported in Hopf et al. (1998; 2003). While this proposal does not tie in with any broader model of sentence comprehension, it makes falsifiable predictions for contrasts between NOM-ACC and NOM-DAT verbs, and takes into account syntactic differences between both verb classes.

In sum, the reassignment of lexical instead of structural case enhances processing load. This additional processing load is reflected in more negative-going waveforms, mostly an enhanced N400, rather than an enhanced P600 (as could be expected for a morphosyntactic process like case assignment to objects). At the same time, NOM-DAT verbs seem to license noncanonical word orders, and seem to attenuate object animacy effects.

What is it that makes the processing of NOM-DAT verbs special? Specifically, what is it that attenuates the object animacy effect with NOM-DAT verbs? Different possible lines of explanation could account for the case marking effects reported in the psycholinguistic literature, and more specifically for the absence of object animacy effects with dative verbs:

- i. The first is centered around the non-prototypically transitive semantics of NOM-DAT verbs. These verbs encode transitive situations where the arguments do not have the prototypically transitive distribution of semantic properties (e.g., objects that can be volitional or agentive because they are animate; or subjects that are affected or moved by the action denoted by the verb). It is possible that the non-prototypically transitive semantics associated with the NOM-DAT case marking pattern license the processing of noncanonical argument animacy patterns, i.e., the processing of two animate arguments, thereby attenuating the object animacy effect, irrespective of the specific verb’s semantic selectional restrictions (roughly parallel to the licensing of OS word orders by NOM-DAT verbs, even those with unmarked SO word orders). This explanation is in line with the eADM and its underlying assumptions for the processing of NOM-DAT verbs (Bornkessel-Schlesewsky & Schlewsky 2006; 2009).
- ii. The second is centered around the syntax of NOM-DAT verbs: Lexical case marking effects in general, and the interaction of lexical case marking and object animacy effects in particular, could be caused by the syntactic differences between NOM-ACC and NOM-DAT verbs. The effects of encountering a NOM-DAT verb (rebuilding the syntactic structure, recheck-

<sup>4</sup> In Bornkessel-Schlesewsky & Schlewsky (2009: 43–44), the authors briefly discuss the the relative influence of animacy and case marking in assigning prominence. However, this discussion is limited to the thematic-role aspects of lexical case marking verbs, and to inanimate-nominative – animate-dative argument sequences. There are no predictions for the processing of animate-animate sequences with lexical case marking verbs, and no discussion of different types of lexical case marking verbs and their potentially differing syntactic structures.

ing the dative morphology on the object) override the measurable effects of the processing of animacy contrasts; not because of an interaction between the verb's semantics and the object animacy, but simply because of the increased processing difficulty. This explanation is in line with the KP-based account of NOM-DAT verb processing (Bader et al. 2000; Bayer et al. 2001).

Currently, the studies cited above do not allow us to distinguish between these two explanations. To disentangle the semantic and syntactic contributions to lexical case marking effects, and to find an explanation for the interaction of lexical case marking and object animacy effects, we will use another distinction between different types of German verbs: simple and particle verbs. Both simple and particle verbs come with NOM-ACC and NOM-DAT case marking patterns. For simple verbs, NOM-DAT verbs signal non-standard argument semantics, and additional syntactic and lexical processing load when compared to NOM-ACC verbs. For particle verbs, we assume that NOM-DAT verbs also have non-standard argument semantics, but not necessarily higher syntactic processing load than NOM-ACC particle verbs.

In the following, we will give a short overview of our assumptions about case marking with particle verbs. After this overview, we will present our research question again, in more detail than above, outlining how the contrast between simple and particle verbs can help us to better understand the processing differences between NOM-ACC and NOM-DAT verbs.

### 2.3 Particle verbs

In addition to their case marking pattern, German verbs can be distinguished by their separability. Non-separable verbs (like simple *folgen*, 'to follow', or prefixed *verfolgen*, 'to pursue') are realized as the second constituent in main clauses, and in sentence-final position in subordinate clauses. Separable or particle verbs (*nachlaufen*, 'to run after') consist of a particle (*nach*), often homologous to a preposition, and a base (*laufen*). In subordinate clauses, particle verbs are realized as one word in the clause-final position: ... *dass Peter dem Hund nachläuft* ('... that Peter pursues the dog'; literally: ... that Peter the dog **after-runs**). In main clauses, however, the particle and the base are split. Only the base is moved to the second constituent position in the clause, while the particle remains behind in the sentence final position: *Peter läuft dem Hund nach* ('Peter pursues the dog'; literally: Peter **runs** the dog **after**). Particle verbs thus are compounds that are potentially realized as multiple words in the sentence (McIntyre 2007), but share one lexical entry (Jackendoff 2002; Cappelle et al. 2010). In the following, we will refer to separable verbs as particle verbs, and to simple and prefix verbs as simple verbs for the sake of readability. (See Olsen 1996 for a definition of particle verbs, and Dehé 2015 for an overview of particle verbs in Germanic.) Particle verb formation is highly productive in German (see Smolka et al. 2014: 32), meaning that there is no exhaustive list of German particle verbs, since speakers can always make up new ones.

Currently, there is no single agreed-upon syntactic analysis of German particle verbs. Different analyses can roughly be divided into two groups (see McIntyre 2007, and, more recently, McIntyre 2015, for an overview of some of the descriptions). One group of analyses holds that the objects of particle verbs are not objects of the verb, but of the particle (see, e.g., Zeller 2001: 21, for a syntactic description of this latter view). Another view holds that the objects of particle verbs are objects of the verb or of a complex predicate that includes the particle and the verb, not of the particle alone (see, e.g., Neeleman & Weerman 1993; Neeleman 1994, for Dutch, Stiebels & Wunderlich 1994, for German). While these views differ in many important respects, all of them describe particle verbs with structures that are more complex than those of simple, structural case assigning verbs.

Just like simple two-place verbs, two-place particle verbs come with both canonical NOM-ACC and noncanonical NOM-DAT case marking patterns. Importantly, although many particles are homologous to prepositions, the case marking pattern of particle verbs cannot be reduced to case assignment by incorporated prepositions (Zeller 2001: 219), for which case encodes spatial semantics, (see, e.g., Svenonius 2010), and neither to any case reliably assigned by a specific particle. The lexical differences between accusative and dative case marking seem to be the same for simple and particle verbs (e.g., lexical case like dative, but not structural case like accusative, being retained under passivization). The relationship between noncanonical case marking and non-prototypical semantic transitivity described above holds for both particle verbs and simple verbs; i.e., particle verbs assigning NOM-DAT are never prototypically transitive and never describe true agent-patient scenarios (Meinunger 2007).

In the current study, we will not adopt a specific syntactic analysis of particle verbs, and will not answer the question whether the objects of particle verbs are best described as objects of the base verb, of the particle, or of a combination of both.

We will make the following assumptions:

- i. All particle verbs are morphologically and syntactically more complex than simple NOM-ACC assigning verbs.
- ii. Particle verbs assigning NOM-ACC and NOM-DAT do not differ from each other in syntactic complexity to the same extent as simple verbs assigning NOM-ACC and NOM-DAT differ from each other.<sup>5</sup>
- iii. The semantic differences between particle verbs assigning NOM-ACC and NOM-DAT are the same as for simple verbs, and, following the analysis of Meinunger (2007), NOM-DAT case assignment signals a deviation from prototypically transitive argument semantics.

We will discuss the implications of this assumption for sentence processing measurements below, when restating our research question.

Sentence comprehension research so far has mostly focused on the processing of separated base-particle combinations in Dutch and German (Urban 2001; 2002; Isel et al. 2005; Cappelle et al. 2010; Piai et al. 2013). An exception is the study by Roehm & Haider (2009), which directly compared the processing of nonseparable prefix verbs and complete particle verbs in the verb-second position of sentences. This study reports an N400 for particle verbs compared to prefix verbs at the position of the verb, suggesting enhanced processing cost for particle verbs. To our knowledge, no study so far has tested the influence of case marking patterns on the processing of particle verbs, and no model of sentence comprehension has made explicit predictions as to their processing.

To sum up the preceding paragraph, German two-place particle verbs come with canonical NOM-ACC and noncanonical NOM-DAT case marking patterns. Just like simple verbs, noncanonical case marking is a signal of non-prototypically transitive semantics with particle verbs. However, both NOM-ACC and NOM-DAT verbs are syntactically more complex than the standard structure of simple NOM-ACC verbs.

## 2.4 Research question

Because of their special syntactic and semantic characteristics, particle verbs allow us to disentangle semantic and syntactic contributions to lexical case marking effects in comprehension.

<sup>5</sup> By this assumption, we do not wish to suggest that the syntactic structure of NOM-ACC and NOM-DAT particle verbs is exactly identical. However, we believe that it makes sense to assume that the structures of both kinds of particle verbs are less distinct from each other than from the 'standard' structure of simple NOM-ACC verbs, and that this relative similarity should be reflected in measures of sentence processing.

- For simple verbs, effects of the processing of NOM-DAT verbs in contrast to NOM-ACC verbs could reflect one or more of the following properties: (1) They reliably signal non-prototypically transitive argument semantics, (2) their syntactic structure is more complex than the standard structure of NOM-ACC verbs, (3) and, according to the KP-analysis/lexical reaccess hypothesis proposed by Bayer et al. (2001), they cause lexical reaccess to the object entry to check for dative morphology.
- For particle verbs, effects of the processing of NOM-DAT verbs in contrast to NOM-ACC verbs could reflect the fact that (1) they signal non-prototypically transitive argument semantics, and (2) possibly cause lexical reaccess to the object. They are unlikely to reflect differences in syntactic complexity, given that both NOM-ACC and NOM-DAT particle verbs differ morphosyntactically from the “standard” structure of simple NOM-ACC verbs.

It is important to note that none of the earlier studies on the processing of NOM-DAT verbs cited above (for ERP, see Hopf et al. 1998; Hopf et al. 2003; Czypionka et al. 2017; Bornkessel et al. 2004) distinguished between simple and particle verbs. Both the sets of NOM-ACC and NOM-DAT verbs in those studies consisted of a mix of simple verbs and particle verbs that appeared as one orthographic unit in the clause-final position. Therefore, these earlier findings could theoretically reflect the semantic, lexical and syntactic effects of NOM-DAT in contrast to NOM-ACC verb processing.

To disentangle the semantic and syntactic contributions to effects of lexical case marking, we will focus on one of the effects of lexical case marking, namely, the attenuated object animacy effect (Czypionka et al. 2017). As outlined above, animate objects have been shown to cause higher processing costs than inanimate objects in transitive sentences. While this object animacy effect in general seems to be relatively stable, it is attenuated for NOM-DAT verbs – because of their special syntax, special semantics, or a mix of various factors.

Based on the previous studies, we expect a main effect of object animacy for NOM-ACC verbs, with more negative-going waveforms for animate than for inanimate conditions. This should reflect the slightly increased processing cost of animate-animate argument sequences when compared to animate-inanimate argument sequences. Based on the semantic and syntactic properties of different types of verbs, we make the following predictions:

- i. If the modulation of the object animacy effect for datives in previous studies was mainly due to the semantic differences between NOM-ACC and NOM-DAT verbs, or due to the lexical reaccess to the object necessary for NOM-DAT verbs, we predict an interaction of animacy and case marking for both simple verbs and particle verbs. Based on previous studies, we expect a reduced difference between animate and inanimate object conditions for NOM-DAT verbs compared to NOM-ACC verbs.
- ii. If, however, the source of the modulation in previous studies was mainly due to the increased syntactic processing cost caused by NOM-DAT verbs, we predict an interaction of animacy and case marking for simple verbs, but not for particle verbs. For particle verbs, we expect a main effect of object animacy that is not influenced by verbal case marking pattern.

In the following, we report the results of two EEG experiments. In the first experiment, we measure the interaction of the effects of object animacy and case marking patterns in sentences with simple verbs. In the second experiment, we measure the interaction of the same effects in sentences with particle verbs. For the sake of readability, the language material used in both experiments is described in detail in the next section, followed by the reports of the experiments.

### 3 Language material

#### 3.1 Simple verb stimulus set

The simple verb stimulus set (used in Experiment 1) consisted of 144 sentences, with 36 items in four different conditions. In each sentence quartet, we paired either NOM-ACC or NOM-DAT simple verbs with either inanimate or animate objects. All critical sentences were grammatical, verb-final embedded sentences with SOV word order, surrounded by a matrix clause. The two arguments were bare plural NPs. Because of case syncretism, the argument NPs do not carry overt morphological case marking in their plural forms, so neither case marking nor subject-verb number congruency allowed grammatical role assignment. Importantly, the sentences with animate objects are theoretically ambiguous because both arguments are animate and could be interpreted as the grammatical subject of the verb. However, an interpretation of these sentences as OSV would result in a dispreferred, pragmatically marked word order. NOM-DAT verbs were selected from a list of German dative-assigning verbs (Meinunger 2007), choosing only verbs with standard linking patterns like *folgen*, ‘to follow’ (no object experiencer verbs like *gefallen*, ‘to please’). All NOM-ACC and NOM-DAT verbs semantically allow inanimate and animate objects, so that all conditions are syntactically and semantically well-formed. An adverb was inserted between the object NP and the critical verb.

We constructed 36 critical sentence quartets using 33 animate subject NPs, 33 inanimate and 29 animate object NPs, 22 NOM-ACC and 16 NOM-DAT verbs. Due to the limited number of German NOM-DAT verbs, we repeated some verbs with different subject and object NPs. Animate and inanimate object NPs in a sentence quartet were controlled for length ( $t(60) = 1.49, p > .1$ ) and frequency ( $t(52.3) = -.35, p > .5$ ; frequencies unavailable for five objects) according to the dlexDB corpus (Heister et al. 2011). NOM-ACC and NOM-DAT verbs in a sentence quartet were also controlled for length ( $t(74) = -.18, p > .8$ ) and frequency ( $t(73) = 1.23, p > .2$ , frequency unavailable for eight verbs) according to the dlexDB corpus.<sup>6</sup>

A typical sentence quartet is given in Example 1. A full list of the simple verb stimulus set is given in the Supplementary Material.

#### 3.2 Particle verb stimulus set

The particle verb stimulus set (used in Experiment 2) was constructed in parallel to the simple verb stimulus set, consisting of 144 sentences, with 36 items in four different conditions. The structure of the sentences was identical to the ones in the simple verb stimulus set. However, there was one important difference to the simple verb stimulus set: The NOM-ACC and NOM-DAT verbs were particle verbs, not simple verbs. The particle verbs were presented as one orthographic word in the clause-final position. The NOM-DAT particle verbs were selected from the same list of German dative-assigning verbs as the NOM-DAT simple verbs (Meinunger 2007).

We constructed 36 critical sentence quartets using 34 animate subject NPs, 36 inanimate and 28 animate object NPs, 25 NOM-ACC and 21 NOM-DAT verbs. Just like in the simple verb stimulus set, we repeated some particle verbs with different subject and object NPs.

<sup>6</sup> The fact that the frequencies for some objects and verbs were unavailable in the corpus does not mean that the respective words do not exist, and does not even necessarily mean that this word is infrequently used. Some reasons for not finding an existing word in the corpus may be: The respective word is a compound that is not found in this specific constituent combination in the corpus (routinely formed in German, applies to objects only); the respective word has the feminine ending *-innen* (that conveniently is the same for all cases), but only occurs with generic masculine endings in the corpus (applies to objects only); the respective word is underrepresented in written language; the respective words will yield hits in the DWDS Kernkorpus, but has apparently not been annotated yet; the respective word only occurs in its separated form in the corpus (applies to particle verbs only). We omitted the words without corpus entries from the calculation of frequencies, rather than assume very low frequencies for them, because we simply do not have any information on their frequency.

A typical sentence quartet is given in Example 2. A full list of the particle verb stimulus set is given in the Supplementary Material. Animate and inanimate object NPs in a sentence quartet were controlled for length ( $t(58.05) = -.86, p > .3$ ) and frequency ( $t(51.3) = -1.19, p > .2$ ; frequencies unavailable for ten objects) according to the dlexDB corpus (Heister et al. 2011). NOM-ACC and NOM-DAT verbs in a sentence quartet were controlled for frequency ( $t(42.75) = -.96, p > .3$ , frequency unavailable for one verb) according to the dlexDB corpus and for length ( $t(37.9) = -2.64, p < .05$ ). The mean length of NOM-ACC assigning particle verbs was 9.1 letters, while the mean length of NOM-DAT assigning particle verbs was 10.7 letters. We chose to accept this descriptively small, but statistically significant difference in length, mostly because there is only a limited choice of NOM-DAT verbs in German, and stimulus construction is further restricted by the need to find argument-verb combinations that are meaningful and acceptable for accusative and dative conditions.

Please note that assessing the frequency of verbs in German corpora is problematic because of the separability of German particle verbs (see, e.g., Smolka et al. 2014: 33). Since particles and base verbs are separated in main clauses (present, simple past and imperative), the frequencies of potential base verbs are overestimated, and the frequencies of particle verbs are underestimated in German corpora like dlexDB (Heister et al. 2011). This means that lemma frequencies for particle verbs are unrealistically low, and both lemma and surface frequencies for simple verbs are unrealistically high. Therefore, the frequencies of simple and particle verbs cannot be used for direct quantitative comparisons in a meaningful way (the same holds for measures that are influenced by frequencies). Comparisons between different types of simple verbs, and different types of particle verbs, however, can still be informative.

**Example 1** Example of a typical sentence quartet with simple verbs. Note that case morphology is not marked overtly on the arguments.

- (a) inanimate object, accusative-assigning verb:  
 Arno beklagt, dass Studentinnen Vorlesungen selten loben,  
 Arno deploras that student.FEM.PL(.NOM) lecture.PL(.ACC) rarely praise.3PL  
 und Uli beklagt es auch.  
 and Uli deploras it too  
 ‘Arno deploras (the fact) that students rarely praise lectures, and Uli deploras this, too.’
- (b) animate object, accusative-assigning verb:  
 Arno beklagt, dass Studentinnen Professoren selten loben,  
 Arno deploras that student.FEM.PL(.NOM) professor.PL(.ACC) rarely praise.3PL  
 und Uli beklagt es auch.  
 and Uli deploras it too  
 ‘Arno deploras (the fact) that students rarely praise professors, and ...’
- (c) inanimate object, dative-assigning verb:  
 Arno beklagt, dass Studentinnen Vorlesungen selten applaudieren,  
 Arno deploras that student.FEM.PL(.NOM) lecture.PL(.DAT) rarely applaud.3PL  
 und Uli beklagt es auch.  
 and Uli deploras it too  
 ‘Arno deploras (the fact) that students rarely applaud lectures, and ...’
- (d) animate object, dative-assigning verb:  
 Arno beklagt, dass Studentinnen Professoren selten applaudieren,  
 Arno deploras that student.FEM.PL(.NOM) professor.PL(.DAT) rarely applaud.3PL  
 und Uli beklagt es auch.  
 and Uli deploras it too  
 ‘Arno deploras (the fact) that students rarely applaud professors, and ...’

**Example 2** Example of a typical sentence quartet with particle verbs. Note that case morphology is not marked overtly on the arguments.

- (a) inanimate object, NOM-ACC verb:  
 Peter berichtet, dass Banditen Postkutschen häufig  
 Peter relates that bandit.PL(.NOM) post.coaches.PL(.ACC) often  
 ausrauben, und Ida berichtet das gleiche.  
 out.rob.3PL and Ida relates the same  
 ‘Peter relates that bandits often rob stage coaches, and Ida relates the same.’
- (b) animate object, NOM-ACC verb:  
 Peter berichtet, dass Banditen Postboten häufig  
 Peter relates that bandit.PL(.NOM) post.messengers.PL(.ACC) often  
 ausrauben, und Ida berichtet das gleiche.  
 out.rob.3PL and Ida relates the same  
 ‘... that bandits often rob postmen, and Ida ...’
- (c) inanimate object, NOM-DAT verb:  
 Peter berichtet, dass Banditen Postkutschen häufig  
 Peter relates that bandit.PL(.NOM) post.coaches.PL(.DAT) often  
 auflauern, und Ida berichtet das gleiche.  
 on.lurk.3PL and Ida relates the same  
 ‘... that bandits often waylay stage coaches, and Ida ...’
- (d) animate object, NOM-DAT verb:  
 Peter berichtet, dass Banditen Postboten häufig  
 Peter relates that bandit.PL(.NOM) post.messengers.PL(.DAT) often  
 auflauern, und Ida berichtet das gleiche.  
 on.lurk.3PL and Ida relates the same  
 ‘... that bandits often waylay postmen, and Ida ...’

### 3.3 Sentence completion task

To better characterize our stimuli, and to be able to interpret the results of the subsequent EEG studies, we ran a sentence completion tasks to assess the relative likelihood of different object-verb combination patterns in sentences parallel to our stimulus material. The aim of this study was to monitor which kinds of objects are expected to occur with NOM-DAT and NOM-ACC verbs.<sup>7</sup> This was necessary because the results of currently available data on object case and animacy (roughly: datives are animate more often than inanimate) cannot be transferred directly to the specific case of our stimuli.<sup>8</sup>

For the sentence completion task, participants saw the critical sentence printed until the final verb of the subordinate clause (i.e., minus the spillover region). The space of the object was left blank. The sentence completion task was prepared in two versions: For each sentence quartet, participants saw either the NOM-ACC or the NOM-DAT

<sup>7</sup> Since the main interest was on the pattern of argument animacy with specific case-marking patterns, we chose to analyze these patterns instead of the likelihood of completing the sentences with specific words, as would have been done in a Cloze task.

<sup>8</sup> In an extensive corpus study, Bader & Häussler (2010) found that datives are animate more often than inanimate. But the authors also remark on the fact that between 13% to 21% of the dative objects in their study were inanimate. This percentage is unexpectedly high, given that the prototypical thematic roles for dative objects are recipient and experiencers which usually have animate referents. In addition, their findings also show that the combination of two animate arguments (animate subject and animate object, as used in our stimulus material) is not more frequent with dative objects than with accusative objects. However, these findings cannot be transferred directly to our stimulus set for a number of reasons. One reason is that the datives investigated by Bader & Häussler (2010) included those in passivized ditransitive clauses. Another reason is that this study does not distinguish between dative objects of simple and particle verbs.

Therefore, the current literature can only provide very general predictions about the likelihood of finding animate or inanimate objects with the specific NOM-ACC and NOM-DAT verbs used in our stimuli.

conditions. In each version of the task, participants saw 36 sentences from the stimulus set with non-separable verbs, and 36 sentences from the set with separable particle verbs, leading to overall 72 sentences, with 18 sentences in each combination of conditions. Unlike in the EEG experiment, the separable and non-separable stimuli were presented in the same task.

The sentence completion task was performed as a pen-and-paper task as part of a course assignment at Constance University. Participants were instructed to fill in the blank with the first word that came to mind and that would complete the sentence in a meaningful way. Completions were coded as either “inanimate”, “animate” or “not applicable” (when the completion was not an argument, or when the space had been left blank). 28 participants successfully completed the task. 3 participants were male. Mean age was 23.3 years ( $SD = 2.0$ ).

Before data analysis, the responses coded as “not applicable” were removed from the data set. The majority of the completions were inanimate or animate arguments (93% for simple verb conditions, 89% for particle verb conditions), suggesting that a second argument is natural in this position in our stimulus material. An overview of the completions per condition is given in Table 1.

The results of the sentence completion task were analyzed in R (R Development Core Team 2005) with a binomial generalized linear mixed model, using the packages *lme4* (Bates et al. 2015, *glmer* function for binomial data) and *LMERConvenienceFunctions* (Tremblay & Ransijn 2015, *summary* function); the packages *plyr* (Wickham 2011) and *reshape* (Wickham 2007) were used for data preparation. For the first model, we specified the main effects and interactions of CASE and SEPARABILITY as fixed effects. Participants and items were specified as random intercepts. In addition, random slopes were defined for participants (main effects of CASE and SEPARABILITY) and items (main effects of CASE). A full table of the statistical results for the fixed effects of the first model (prepared using the *summary* function) is given in Table 2. There was a statistically significant main effect of CASE ( $p < .05$ ), with more animate completions for dative verbs than for accusative verbs. There was no interaction of CASE and SEPARABILITY, suggesting that this effect of case marking did not differ systematically between simple and particle verbs.

Since the two stimulus sets were to be run in separate EEG experiments and analyzed separately, we performed planned comparisons for simple and particle verbs. The planned comparisons were performed with a second model. For the second model, we specified the main effect of CASE as fixed effect. Participants and items were specified as random intercepts, and random slopes were defined for participants and items (main effects of CASE). A full table of the results for the fixed effects of the second model is given in Table 3.

For simple verbs, there was a statistically significant main effect of CASE on the likelihood of choosing an animate object ( $p < .05$ ). Overall, participants chose more animate than inanimate objects. This tendency was more pronounced for dative than for accusative

**Table 1:** Sentence completion task: Means of completion proportions over participants per condition. Means are given as % of the sentences per condition completed with either animate or inanimate objects. SD in parentheses.

Verb type	Case marking	Percentage of completions	
		inanimate	animate
simple	NOM-ACC	37.1 (12.6)	58.1 (14.8)
	NOM-DAT	22.6 (13.4)	68.3 (15.5)
particle	NOM-ACC	45.4 (18.3)	46.2 (15.1)
	NOM-DAT	22.6 (12.6)	64.3 (16.0)

**Table 2:** Sentence completion task: Full table of statistical results, model 1, all verbs.

Factor	Estimate	Std. error	z-value	p-value
(Intercept)	-.32	.38	-.84	.40
CASE	-1.05	.46	-2.29	.02*
SEPARABILITY	-.37	.53	-.69	.49
CASE:SEPARABILITY	.19	.65	.29	.77

**Table 3:** Sentence completion task: Full table of statistical results, model 2.

Verb type	Factor	Estimate	Std. error	z-value	p-value
simple	(Intercept)	-.69	.43	-1.58	.12
	CASE	-.82	0.40	-2.04	.04*
particle	(Intercept)	-.29	.37	-.80	.43
	CASE	-1.11	.56	-1.98	.048*

conditions. For particle verbs, there was a statistically significant main effect of CASE on the likelihood of choosing an animate object ( $p < .05$ ). Participants chose more animate than inanimate objects for dative conditions. For accusative conditions, there was no marked preference for animate or inanimate objects.

The general pattern for simple verbs and particle verbs fits the findings in the literature: there are more animate completions for dative than for accusative verbs, and more inanimate completions for accusative than for dative verbs. However, animate accusative objects seem to be more likely in our stimuli than in larger corpora, and inanimate datives still make up over 20% of the completions.

We will briefly return to the results of the sentence completion task in the General Discussion, when discussing possible influences of expectation-based parsing on the outcome of later EEG experiments.

#### 4 Experiment 1

In the first experiment, we measured the interaction of ANIMACY and CASE for simple verbs assigning either NOM-ACC or NOM-DAT.

For the sake of readability, we repeat the predictions following the different hypotheses here:

- i. If the modulation of the object animacy effect for datives in previous studies was mainly due to the semantic differences between NOM-ACC and NOM-DAT verbs, or due to the lexical reaccess to the object necessary for NOM-DAT verbs, we predict an interaction of animacy and case marking for both simple verbs and particle verbs. Based on previous studies, we expect a reduced difference between animate and inanimate object conditions for NOM-DAT verbs compared to NOM-ACC verbs.
- ii. If, however, the source of the modulation in previous studies was mainly due to the increased syntactic processing cost caused by NOM-DAT verbs, we predict an interaction of animacy and case marking for simple verbs, but not for particle verbs. For particle verbs, we expect a main effect of object animacy that is not influenced by verbal case marking pattern.

This means that under both hypotheses, we expect to find an interaction of animacy and case marking in Experiment 1.

For the accusative conditions, we expected enhanced processing difficulties for the animate-accusative compared to the inanimate-accusative condition. In line with earlier studies (e.g., (Frisch & Schlesewsky 2001; Paczynski & Kuperberg 2009; 2011), we expected an N400-like component on the clause-final verb. We expected this negativity to be rather small because all stimulus sentences were syntactically and semantically well-formed. In addition, we expected an effect of lexical case marking, and an interaction of animacy and case marking effects. Since our stimuli are the first in the literature to separate simple and particle verbs, we were not able to make specific predictions with regard to the timecourse and shape of lexical case marking effects.

#### 4.1 Material and methods

*Participants.* 24 participants participated in the first ERP experiment. All participants spoke German as their only native language and reported no known reading or language-related problems. Participants had normal or corrected to normal vision, were not taking any psychoactive medication and reported no neurological or psychiatric disorders. All participants were right handed, scoring 70% or higher on the Edinburgh handedness test (Oldfield 1971). All participants gave written informed consent. The data of 3 participants were excluded from the data analysis because of poor data quality. The mean age of the remaining 21 participants (11 male) was 23 years (SD = 2.4). Participants received 16 Euros compensation.

*Stimulus Material.* The stimulus material used in Experiment 1 was the simple verb stimulus set, described in more detail in the Language material section. During the experiment, the critical sentences were interspersed with filler sentences. The final list consisted of 222 sentences and contained 144 critical sentences (36 per condition) interspersed with 78 filler sentences. Filler sentences were short main clauses beginning with animate or inanimate grammatical subjects. Representative examples of filler sentences are:

*Der Affe ist vom Baum gefallen.* ('The monkey fell off the tree'); *Die Säge hat einen roten Plastikgriff.* ('The saw has a red plastic handle.')

Sentences were pseudorandomized before the presentations. Restrictions on the randomization procedure were the following: (1) two subsequent sentences should never belong to the same condition, (2) two sentences belonging to the same condition were to be separated by at least one sentence from another condition, (3) in any row of three sentences, at least one sentence does not belong to the same quartet.

To keep the participants' attention during the experiment, a comprehension question was asked after 24 of the critical sentences and after 12 of the filler sentences. Comprehension questions only had one correct answer. Questions like 'Do students rarely praise lectures?' were to be answered with 'yes', the other half were to be answered with 'no'. We did not systematically ask questions concerning the thematic relationship of the arguments in the critical sentences ('Did NP1 verb NP2 or vice versa?') to avoid drawing attention to the potential ambiguity in the animate object conditions.

*Procedure.* The participants were seated in a comfortable chair in front of a computer screen, with an average distance of about 180 cm, in an electrically shielded EEG recording chamber. The maximum visual angle on the critical verb was 4.3°, the minimum visual angle was 1.8°.

The experiment consisted of an instruction phase and the experimental phase. Participants were first instructed orally and then again in written form on the screen during the instruction phase. Words were presented visually in the center of a computer screen using the Presentation software by Neurobehavioral Systems Inc. (version 16.1).

Words were presented in white 40 pt Arial font on a black screen. The first two and last three words of the matrix sentence were presented together, while the remaining words were presented in a word-by-word fashion. This means that the embedded sentence and the first two postverbal words (*und* and a personal name) were presented as single words: *Tim glaubt, — dass — Tauben — Luftballons — gerne — mögen, — und — Tom — glaubt das auch*. Each word or string of words was presented for 700 ms, followed by a 200 ms blank screen. During the experiment, participants held a two-button response box in their hands. Participants answered the questions by pressing the left or right response button, respectively. The sides for answering ‘yes’ and ‘no’ were switched for half of the participants. Feedback was presented for 500 ms. After 72 sentences, participants were offered to take a short break, resulting in 2 breaks during the course of the experiment. Before the actual experiment, participants performed three practice trials.

*EEG recording.* The EEG was recorded with 61 Ag/AgCl sintered ring electrodes attached to an elastic cap (EasyCap, Herrsching) and connected to an Easy-Cap Electrode Input Box (EiB32). Electrodes were positioned in the equidistant 61-channel arrangement provided by EasyCap (see [http://easycap.brainproducts.com/e/electrodes/13\\_M10.htm](http://easycap.brainproducts.com/e/electrodes/13_M10.htm) for electrode layout). The EEG signal was amplified with a BrainAmp DC amplifier with a bandpass of 0.016–250 Hz (Brain Products, Gilching) connected to a computer outside of the EEG chamber (via USB2 Adapter, Brain Products, Gilching). The signal was recorded with a digitization rate of 500 Hz (Brain Vision Recorder, Brain Products, Gilching). Eye movements were monitored by recording the electrooculogram (IO1, IO2, Nz). The ground electrode was located on the left cheek.

*Data processing.* Data were processed using the Brain Vision Analyzer 2 software (Brain Products, Gilching). Raw data were inspected visually. Time windows including strong, visible artifacts and breaks were manually removed. Next, an ICA blink correction was performed for the remaining data, using the Slope Algorithm for blink detection. After blink correction, data were again inspected visually to monitor successful blink correction. A spline interpolation was performed for channels that showed long stretches of noisy data. Interpolation was only performed for electrodes with at least 3 surrounding non-interpolated electrodes. After the interpolation, all electrodes were re-referenced to average reference. An Automatic Raw Data Inspection was performed for the re-referenced data (maximal allowed voltage step: 50  $\mu\text{V}/\text{ms}$ ; maximal allowed difference: 100  $\mu\text{V}/200$  ms; minimal/maximal allowed amplitudes 200  $\mu\text{V}/-200$   $\mu\text{V}$ ; lowest allowed activity: 0.5  $\mu\text{V}/100$  ms). Before segmentation, the remaining raw data were filtered with Butterworth zero phase bandpass filters. The low cutoff frequency was 0.05 Hz (12 dB/oct), the high cutoff frequency was 70 Hz, (12 dB/oct).

After filtering, data were segmented into time windows time-locked to the onset of the critical verb. Time windows began at –2000 ms before the onset of the critical verb, and ended at 2000 ms after the onset of the critical verb.<sup>9</sup> A baseline correction was performed for the 2000 ms before the onset of the critical verb. Averages were calculated per participant for all four conditions. Participants with less than 23 trials in one of the four conditions were excluded from data analysis.

<sup>9</sup> We chose a longer baseline than the traditional 200 ms to allow for a more transparent view of the data. In this way, a fair evaluation of possible transmissions of ERP effects from preceding stimuli is possible for the reader, similar to data analyses without baseline correction (see, e.g., Bornkessel-Schlesewsky et al. 2011; Hung & Schumacher 2012). Given the ongoing debate about optimal filtering of EEG data (Tanner et al. 2015; Maess et al. 2016; Tanner et al. 2016), we chose to avoid a 0.3 Hz high-pass filter without baseline correction (since this can potentially evoke filter effects), and opted for a more conservative high-pass filter in combination with a longer baseline instead.

For the remaining 21 participants, on average 15 % of the data were rejected ( $SD = 7.5\%$ ), so that all condition means were calculated from 23 to 36 segments. The mean number of segments per condition were: inanimate accusative = 31 ( $SD = 3$ ), animate-accusative = 31 ( $SD = 3$ ), inanimate-dative = 31 ( $SD = 3$ ), animate-dative = 30 ( $SD = 3$ ). For data presentation, Grand Averages were smoothed with an additional 10 Hz low-pass filter.

*Parametrization and statistical testing.* Time windows were chosen based on visual inspection of the data, and when possible with reference to previous studies. The chosen time windows were 400–600 ms (verb-related; see, e.g., Paczynski & Kuperberg 2011; Czypionka et al. 2017 for reasons to expect effects during this time) and 1400–1700 ms (postverbal word-related, based exclusively on visual inspection). A subset of 25 electrodes was selected for the statistical data analysis. Electrode position was coded by assigning electrodes to five medial-lateral as well as five anterior-posterior positions. Medial-lateral positions were: lateral-left (front to back: AF7, FT7, T7, TP7, P7), lateral-medial-left (front-to-back: FP1, C3, P1, O1, F1), midline (front-to-back: FPz, Cz, Pz, Oz, Fz), lateral-medial-right (front-to-back: FP2, C4, P2, O2, F2) and lateral-right (front-to-back: AF8, FT8, T8, TP8, P8). Anterior-posterior positions were: anterior (left to right: AF7, FP1, FPz, FP2, AF8), medial-anterior (left to right: FT7, F1, Fz, F2, FT8); medial (left to right: T7, C3, Cz, C4, T8), posterior-medial (TP7, P1, Pz, P2, TP8), posterior (left to right: P7, O1, Oz, O2, P8).

For each chosen time window, we performed a repeated measures ANOVA of the mean voltages in the selected electrode sites, with within-subject factors MEDIAL-LATERAL position (with five levels going from LATERAL-LEFT to LATERAL-RIGHT), ANTERIOR-POSTERIOR position (with five levels going from ANTERIOR to POSTERIOR), CASE (with levels NOM-ACC and NOM-DAT) and ANIMACY (with levels INANIMATE and ANIMATE). Based on our initial hypothesis, we compared the effects of object animacy on two different verb classes, beginning at the presentation of the verb (the first point in time when verb class information became available). Statistical analyses were performed in a hierarchical fashion, i.e., only statistically significant interactions were pursued. Interactions were resolved if they included at least one of the factors ANIMACY and CASE. For the sake of readability, A Huyhn-Feldt correction was performed when the degree of freedom in the numerator was higher than 1. Original degrees of freedom and corrected probability levels are reported. Analyses were performed in R (R Development Core Team 2005) using the ezANOVA function of the ez package (Lawrence 2011).

## 4.2 Results

Mean answer accuracy was 83% ( $SD = 7\%$ ).

ERP results are reported for latency windows timelocked to the beginning of the presentation of the critical verb. Mapping views for selected time windows and curves for selected electrodes are given in Figures 1 and 2.

*400–600 ms:* There was a main effect of MEDIAL-LATERAL position ( $F(4,80) = 24.5$ ,  $\epsilon = .55$ ,  $p < .05$ ), ANTERIOR-POSTERIOR position ( $F(4,80) = 19.9$ ,  $\epsilon = .55$ ,  $p < .05$ ), an interaction of MEDIAL-LATERAL position and ANTERIOR-POSTERIOR position ( $F(16,320) = 8.3$ ,  $\epsilon = .42$ ,  $p < .05$ ) as well as an interaction of ANIMACY, CASE and MEDIAL-LATERAL position ( $F(4,80) = 3.3$ ,  $\epsilon = .66$ ,  $p < .05$ ).

To assess whether animacy effects were similar or different for accusative and dative conditions, we resolved the three-way interaction by calculating separate three-way ANOVAs for the two cases.

For the accusative conditions, there was a main effect of MEDIAL-LATERAL position ( $F(4,80) = 21.6$ ,  $\epsilon = .57$ ,  $p < .05$ ), ANTERIOR-POSTERIOR position ( $F(4,80) = 14.5$ ,  $\epsilon = .50$ ,  $p < .05$ ), an interaction of MEDIAL-LATERAL position and ANTERIOR-POSTERIOR

position ( $F(16,320) = 6.2, \epsilon = .47, p < .05$ ), and an interaction of ANIMACY and MEDIAL-LATERAL position ( $F(4,80) = 4.2, \epsilon = .62, p < .05$ ) as well as an interaction of ANIMACY, MEDIAL-LATERAL position and ANTERIOR-POSTERIOR position ( $F(16,320) = 2.7, \epsilon = .39, p < .05$ ).

To resolve which positions drove the three-way interaction, we calculated separate two-way ANOVAs of ANIMACY and ANTERIOR-POSTERIOR position for each MEDIAL-LATERAL position, and separate two-way ANOVAs of ANIMACY and MEDIAL-LATERAL position for each ANTERIOR-POSTERIOR position. This ANOVA revealed the following effects for medial-lateral positions:<sup>10</sup> lateral-right: ANIMACY ( $F(1,20) = 5.1, p < .05$ ), ANTERIOR-POSTERIOR position ( $F(4,80) = 8.6, \epsilon = .52, p < .001$ ); midline: ANIMACY ( $F(1,20) = 7.0, p < .05$ ), ANTERIOR-POSTERIOR position ( $F(4,80) = 7.7, \epsilon = .60, p < .001$ ); lateral-medial-left: ANIMACY ( $F(1,20) = 6.2, p < .05$ ), ANTERIOR-POSTERIOR position ( $F(4,80) = 12.61, \epsilon = .64, p < .001$ ).

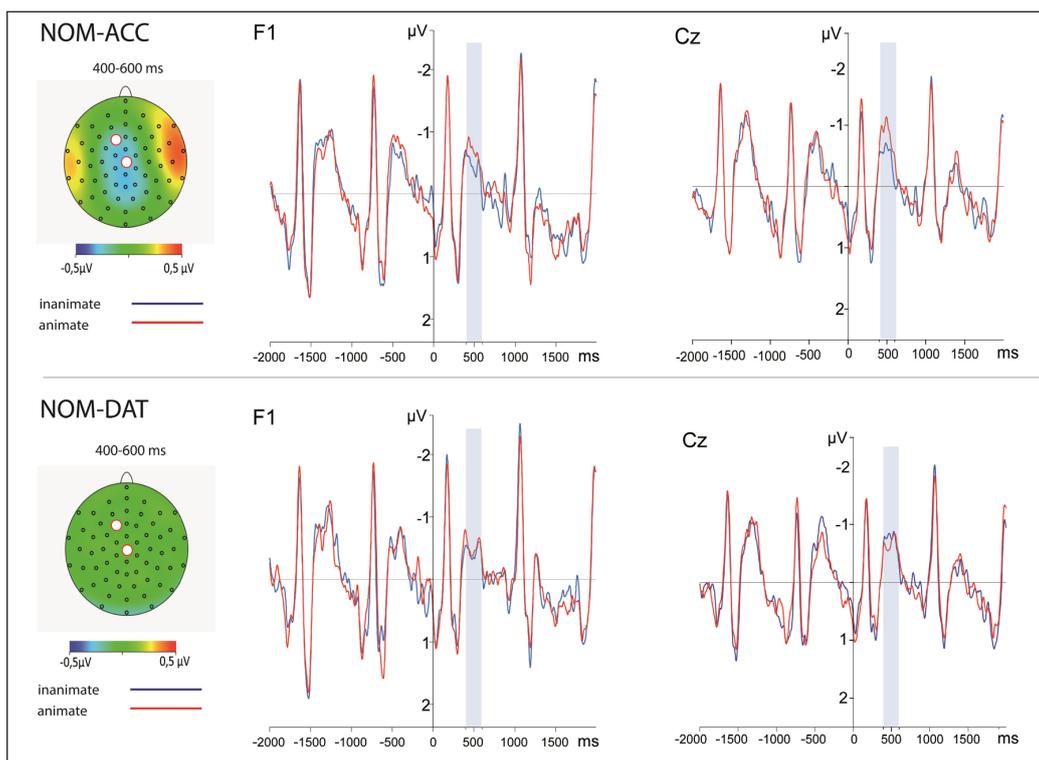
For anterior-posterior positions, this analysis revealed the following effects: medial-anterior: MEDIAL-LATERAL position ( $F(4,80) = 9.7, \epsilon = .65, p < .001$ ) and an interaction of ANIMACY and MEDIAL-LATERAL position ( $F(4,80) = 3.2, \epsilon = .61, p < .05$ ). *t*-tests for simple main effects of ANIMACY at individual electrode sites did not show significant effects of ANIMACY. medial: MEDIAL-LATERAL position ( $F(4,80) = 14.7, \epsilon = .64, p < .001$ ) and an interaction of ANIMACY and MEDIAL-LATERAL position ( $F(4,80) = 5.0, \epsilon = .61, p < .01$ ). Resolving the effect of ANIMACY for individual sites showed statistically significant effects at electrode sites Cz ( $t(20) = -2.4, p < .05$ ), T7 ( $t(20) = 2.4, p < .05$ ), and T8 ( $t(20) = 2.5, p < .05$ ). medial-posterior: MEDIAL-LATERAL position ( $F(4,80) = 18.7, \epsilon = .63, p < .001$ ) and an interaction of ANIMACY and MEDIAL-LATERAL position ( $F(4,80) = 3.9, \epsilon = .45, p < .05$ ). *t*-test for simple main effects of ANIMACY at individual electrode sites did not show significant effects of ANIMACY. posterior: MEDIAL-LATERAL position ( $F(4,80) = 33.9, \epsilon = .69, p < .001$ ).

For the dative conditions, there was a main effect of MEDIAL-LATERAL position ( $F(4,80) = 18.8, \epsilon = .46, p < .05$ ), of ANTERIOR-POSTERIOR position ( $F(4,80) = 13.8, \epsilon = .50, p < .05$ ), and an interaction of MEDIAL-LATERAL position and ANTERIOR-POSTERIOR position ( $F(16,320) = 7.8, \epsilon = .44, p < .05$ ). No statistically significant effects including the factor ANIMACY were found for dative conditions.

The original four-way ANOVA showed an interaction of ANIMACY and CASE. As illustrated in the difference maps of Figure 1, this was most clearly visible at central electrodes. In the time window from 400 to 600 ms, waveforms for central electrodes were more negative-going for the animate-accusative than for the inanimate-accusative condition. In contrast, waveforms for the two dative conditions did not differ from each other, and ran close to the waveforms for the inanimate-accusative condition.

*1400–1700 ms*: In the time window from 1400–1700 ms after the onset of the verb (which corresponds to 500 ms after the onset of the first postverbal word in the spillover region, *und*), there was a main effect of ANTERIOR-POSTERIOR position ( $F(4,80) = 18.4, \epsilon = .34, p < .05$ ), an interaction of ANTERIOR-POSTERIOR position and MEDIAL-LATERAL position ( $F(16,320) = 2.9, \epsilon = .46, p < .05$ ) as well as an interaction of CASE and ANTERIOR-POSTERIOR position ( $F(4,80) = 3.4, \epsilon = .46, p < .05$ ). To reveal which of the anterior-posterior positions drove the case effect, we performed *t*-tests for amplitudes cumulated across medial-lateral positions. The effect of CASE was statistically significant for anterior-posterior positions ANTERIOR-MEDIAL ( $t(20) = 2.5, p < .05$ ) and POSTERIOR ( $t(20) = -2.1, p < .05$ ).

<sup>10</sup> For the sake of readability, effects are only reported for conditions which showed a main effect or interaction of ANIMACY.



**Figure 1:** Experiment 1 (simple verbs): Grand average ERPs for selected electrode sites and difference maps are shown. Accusative conditions are depicted in the upper part, dative conditions are depicted in the lower part. Mean voltage difference maps (animate minus inanimate) for the marked time window from 400–600 ms are given on the left side. The electrodes selected for illustration are marked in the maps.

As seen in Figure 2, waveforms for dative conditions were more negative-going than for accusative conditions at left-anterior sites. Waveforms for animate and inanimate conditions did not differ visibly from each other. While the distinction between accusative and dative conditions looked slightly less pronounced for animate than for inanimate conditions, the interaction did not reach statistical significance.

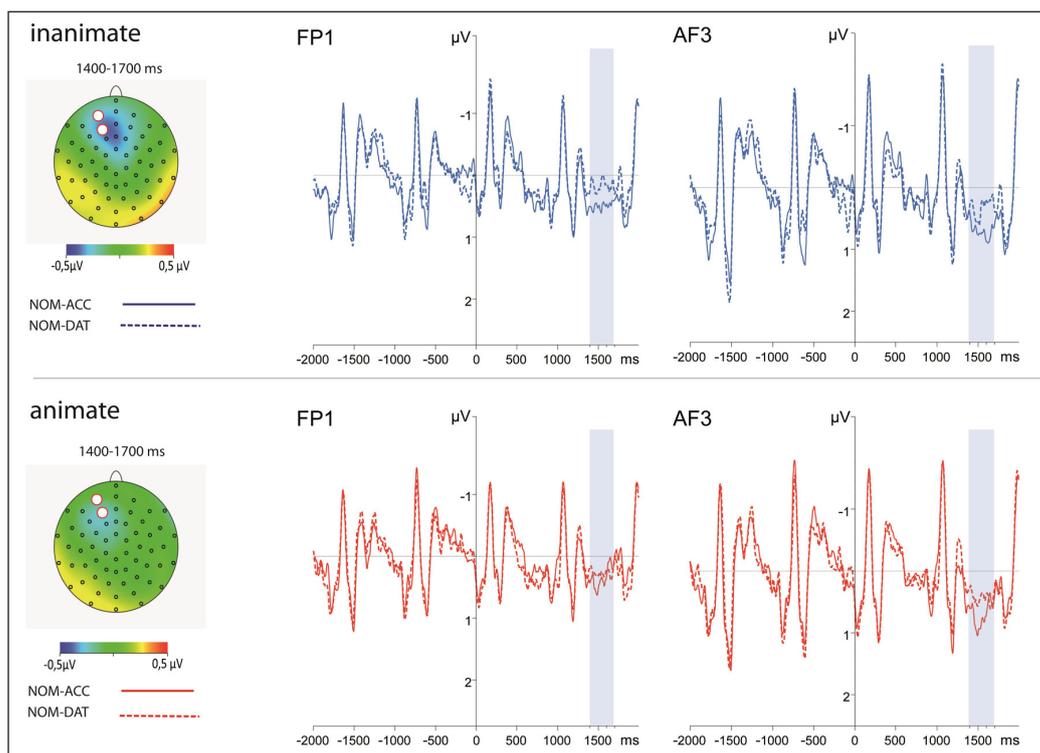
### 4.3 Discussion Experiment 1

In Experiment 1, we found an interaction of object animacy and verbal case marking on the verb, and a main effect of case marking on the first postverbal word, for the simple verb stimulus set.

Starting around 400 ms after the presentation of the verb, and continuing for about 200 ms, waveforms for the animate-accusative condition were more negative-going than waveforms for the inanimate-accusative condition, most visibly so at central electrodes. We interpret this finding as reflecting the slightly enhanced processing load caused by the animate compared to the inanimate objects, i.e., an object animacy effect. This fits earlier findings reporting enhanced N400 amplitudes to sequences of two animate arguments when compared to animate-inanimate argument sequences (Frisch & Schlesewsky 2001; Paczynski & Kuperberg 2011). Interestingly, this object animacy effect is visible even in the absence of semantic or syntactic violations.

On the contrary, for NOM-DAT verbs, no difference is visible between animate and inanimate objects. Waveforms for inanimate-dative and animate-dative conditions ran close together, and close to the inanimate-accusative condition.

At a general level, the object animacy effect for accusative, but not dative verbs fits earlier findings (Czypionka et al. 2017). However, there are a number of important differences relative to the previous study. In the earlier study, the animacy effect surfaced



**Figure 2:** Experiment 1 (simple verbs): Grand average ERPs for selected electrode sites and difference maps are shown. Inanimate conditions are depicted in the upper part, animate conditions are depicted in the lower part. Mean voltage difference maps (dative minus accusative) for the marked time window from 1400–1700 ms are given on the left side. The electrodes selected for illustration are marked in the maps.

as a longer lasting left-posterior negativity, while in the present study, negativities were constrained to latency windows close to those for an N400, and showed an N400-like topography. Another difference between the studies is that waveforms for the dative conditions were close to the animate-accusative condition in the earlier study, but close to the inanimate-accusative condition in the current study. A direct comparison of the outcomes of both studies would be difficult, since the stimuli of the earlier study mixed simple verbs and particle verbs, and therefore the stimuli were morphosyntactically more heterogeneous than the ones in the current study. The main pattern of results, however, is similar: In both studies, there are object animacy effects for accusative, but not dative conditions. If anything, the outcome of the current study is closer to earlier findings on animacy effects of Frisch & Schlesewsky (2001) or Paczynski & Kuperberg (2011) than the results of Czypionka et al. (2017).

In the spillover region, 1400 ms after the onset of the verb, there was a main effect of case, with more negative-going waveforms for dative compared to accusative conditions in the left-anterior and some central electrodes. This effect has not previously been described for NOM-DAT compared to NOM-ACC verbs. Interestingly, no N400-like dative effect was found, as could have been expected from earlier ERP studies on the processing of lexical case in German (Hopf et al. 1998; Hopf et al. 2003; Bornkessel et al. 2004). These earlier studies reported an N400 starting already on the verb, either for the direct comparison of accusative and dative conditions, (Hopf et al. 1998; 2003), or for OS in contrast to SO word orders (while the same contrast elicited a P600 for accusative conditions, Bornkessel et al. 2004). Data from the word directly following the critical verb are not reported in any of these studies.

In general, a comparison of the current and earlier studies is difficult due to the many differences in the stimuli used. All of these three earlier studies used a syntactically heterogeneous mix of simple and particle verbs, whereas our own stimuli in Experiment 1 only contained simple verbs. In addition, dative effects in earlier studies were elicited using very different grammatical constructions (e.g., following embedded relative clauses with an accusative-assigning verb, Hopf et al. 2003, or object-subject-sentences, Bornkessel et al. 2004), and not always discussed in a direct comparison of accusative- and dative assigning verbs (Bornkessel et al. 2004, where verbal case marking pattern was a between-subjects factor that was not statistically pursued).

At this point, we cannot offer a conclusive interpretation of the late effect of case marking in our data. Therefore, we limit ourselves to the tentative interpretation that this effect of case in our results reflects the additional workload caused by NOM-DAT verbs.

The fact that we found an interaction between ANIMACY and CASE in the latency window from 400–600 ms supports our initial hypothesis, suggesting that the effect of object animacy is indeed different for simple verbs assigning NOM-DAT than it is for simple verbs assigning NOM-ACC. As we outlined in the Introduction, there are different possible explanations for the underlying linguistic causes of this interaction. The absent object animacy effect for dative verbs could reflect semantic differences (i.e., the non-prototypically transitive argument semantics); this explanation would be in line with the eADM. It could also reflect lexical differences (lexical reaccess to the object for NOM-DAT, but not NOM-ACC verbs) and syntactic differences (the increased processing load associated with the build-up of a more complex syntactic structure in the case of NOM-DAT verbs). This explanation would be in line with the KP-based account proposed by Bayer et al. (2001).

The first and the second, but not the third explanation should also hold for particle verbs.

## 5 Experiment 2

In the second experiment, we measured the interaction of ANIMACY and CASE for separable particle verbs assigning either NOM-ACC or NOM-DAT. We used the particle verb stimulus set described in the Language material section. This stimulus set is parallel to the one in Experiment 1 with respect to object animacy and case marking. The important difference is that the verbs are particle verbs instead of simple verbs. Therefore, the NOM-DAT verbs in the current stimulus set should signal the same non-prototypically transitive semantics as in Experiment 1. However, there should be no noticeable difference in syntactic complexity between NOM-ACC and NOM-DAT verbs.

Experiment 2 was designed to monitor the influence of object animacy and verbal case marking pattern on sentence comprehension for particle verbs, and to better understand the results of Experiment 1. Our predictions are:

- If the interaction of ANIMACY and CASE visible in Experiment 1 was caused by semantic differences between NOM-ACC and NOM-DAT verbs, then we expect an interaction of ANIMACY and CASE in Experiment 2, too, with small to absent object animacy effects for NOM-DAT assigning particle verbs.
- If the interaction of ANIMACY and CASE visible in Experiment 1 was caused by syntactic differences between simple NOM-ACC and NOM-DAT verbs, then we expect no effects of Case marking and no interaction of ANIMACY and CASE in Experiment 2. Instead, we expect a main effect of ANIMACY for NOM-ACC and NOM-DAT particle verbs.

## 5.1 Material and methods

**Participants.** 25 participants participated in the Experiment 2. All participants were right handed, scoring 70% or higher on the Edinburgh handedness test (Oldfield 1971). All participants spoke German as their only native language and reported no known reading or language-related problems. Participants had normal or corrected to normal vision, were not taking any psychoactive medication and reported no neurological or psychiatric disorders. All participants gave written informed consent. None of the participants had participated in Experiment 1. The data of 4 participants were excluded from the data analysis because of poor data quality. The mean age of the remaining 21 participants (10 male) was 24 years ( $SD = 3.7$ ). Participants received 16 Euros compensation.

**Stimulus Material.** The stimulus material used in Experiment 2 was the particle verb stimulus set, described in more detail in the Language material section. Filler sentences were the same as described for Experiment 1.

**Procedure.** The experimental procedure was the same as described for Experiment 1. The maximum visual angle on the critical verb was  $4.7^\circ$ , the minimum visual angle was  $2.5^\circ$ .

**EEG recording.** EEG recording was the same as described for Experiment 1.

**Data processing, parametrization and statistical analysis.** Data processing and analysis were the same as described for Experiment 1. On average 12 % of the data were removed during artifact removal, so that all condition means were calculated from a maximum of 36 and a minimum of 23 segments. The time window chosen was 400–600 ms. The time window from 1400–1700 ms was not analyzed because no differences between conditions were visible during visual inspection. The mean number of segments per condition were: inanimate-accusative = 31 ( $SD = 4$ ), animate-accusative = 31 ( $SD = 4$ ), inanimate-dative = 31 ( $SD = 4$ ), animate-dative = 31 ( $SD = 3$ ).

## 5.2 Results

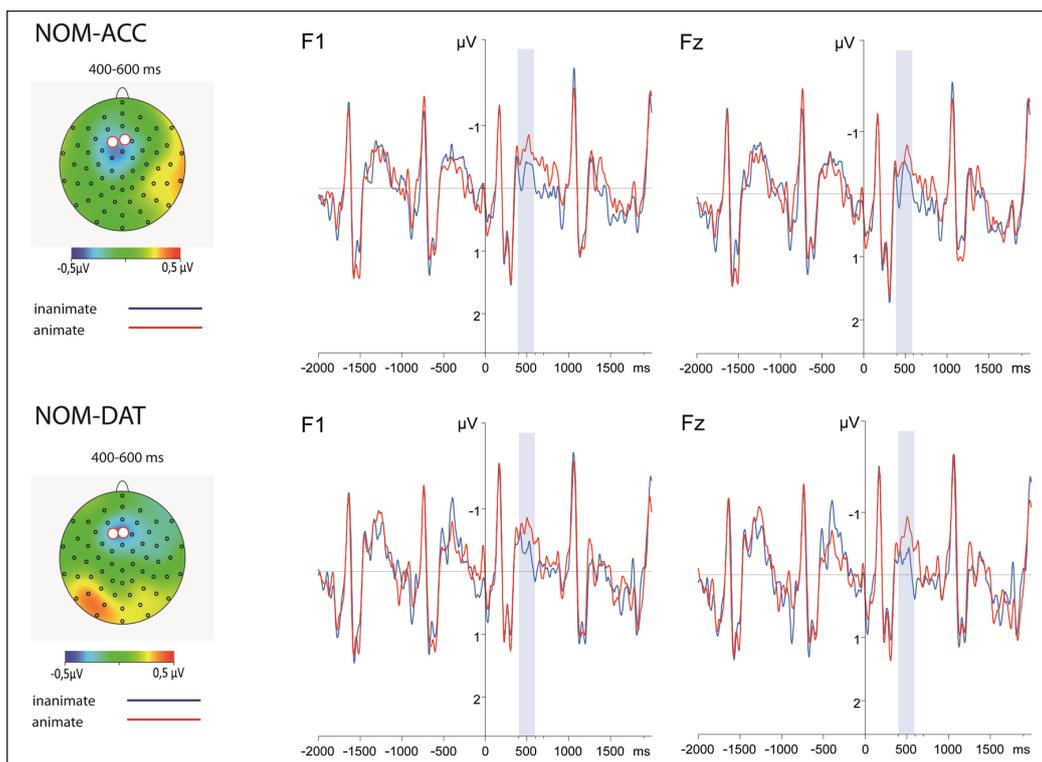
Mean answer accuracy was 86% ( $SD = 8\%$ ).

ERP results are reported for latency windows timelocked to the beginning of the presentation of the critical verb. Mapping views for selected time windows and curves for selected electrodes are given in Figure 3.

**400–600 ms:** In the time window from 400 to 600 ms, there was a main effect of MEDIAL-LATERAL position ( $F(4,80) = 37.6, \epsilon = .63, p < .001$ ), ANTERIOR-POSTERIOR position ( $F(4,80) = 14.9, \epsilon = .43, p < .001$ ), and an interaction of MEDIAL-LATERAL position and ANTERIOR-POSTERIOR position ( $F(16,320) = 6.6, \epsilon = .29, p < .001$ ). In addition, there was also an interaction of ANIMACY and ANTERIOR-POSTERIOR position ( $F(16,320) = 3.6, \epsilon = .50, p < .05$ ) and an interaction of ANIMACY, MEDIAL-LATERAL position and ANTERIOR-POSTERIOR position ( $F(16,320) = 2.3, \epsilon = .45, p < .05$ ).

To resolve which positions drove the three-way interaction, we calculated separate two-way ANOVAs of ANIMACY and ANTERIOR-POSTERIOR position for each MEDIAL-LATERAL position, and separate two-way ANOVAs of ANIMACY and MEDIAL-LATERAL position for each ANTERIOR-POSTERIOR position. This ANOVA revealed the following effects for medial-lateral positions:<sup>11</sup> lateral-left: ANTERIOR-POSTERIOR position ( $F(4,80) = 19.8, \epsilon = .38, p < .001$ ) lateral-medial-left: ANTERIOR-POSTERIOR position ( $F(4,80) = 9.9, \epsilon = .58, p < .001$ ) and an interaction of ANIMACY and ANTERIOR-POSTERIOR position ( $F(4,80) = 4.2, \epsilon = .78, p < .01$ ). Resolving the effect of ANIMACY for individual sites showed a statistically significant effect of ANIMACY at O1 ( $t(41) = 2.1, p < .05$ ). midline: ANIMACY ( $F(1,20) = 4.4, p < .05$ ; ANTERIOR-POSTERIOR position ( $F(4,80) = 6.1, \epsilon = .61, p < .001$ ) and an interaction of ANIMACY

<sup>11</sup> For the sake of readability, effects are only reported for conditions which showed some effect of ANIMACY.



**Figure 3:** Experiment 2 (particle verb stimulus set): Grand average ERPs for selected electrode sites and difference maps are shown. Accusative conditions are depicted in the upper part, dative conditions are depicted in the lower part. Mean voltage difference maps (animate minus inanimate) for the marked time window from 400–600 ms are given on the left side. The electrodes selected for illustration are marked in the maps.

and ANTERIOR-POSTERIOR position ( $F(4,80) = 4.3, \epsilon = .70, p < .01$ ). Cz ( $t(41) = -2.1, p < .05$ ), Fz ( $t(41) = -3.3, p < .01$ ) lateral-medial-right: ANTERIOR-POSTERIOR position ( $F(4,80) = 8.2, \epsilon = .63, p < .001$ ) and an interaction of ANIMACY and ANTERIOR-POSTERIOR position ( $F(4,80) = 3.5, \epsilon = .79, p < .05$ ). sites: F2 ( $t(41) = -2.8, p < .01$ ). lateral-right: ANTERIOR-POSTERIOR position ( $F(4,80) = 17.9, \epsilon = .30, p < .001$ ).

For anterior-posterior positions, the following effects were found: medial-anterior: ANIMACY ( $F(1,20) = 12.1, p < .01$ ); MEDIAL-LATERAL position ( $F(4,80) = 14.9, \epsilon = .61, p < .001$ ), and an interaction of ANIMACY and MEDIAL-LATERAL position ( $F(4,80) = 6.6, \epsilon = .56, p < .01$ ). Resolving the effect of ANIMACY for individual sites showed a statistically significant effect of ANIMACY at F1 ( $t(41) = -3.0, p < .01$ ), Fz ( $t(41) = -3.3, p < .01$ ) and F2 ( $t(41) = -2.8, p < .01$ ). posterior: ANIMACY ( $F(1,20) = 4.6, p < .05$ ); MEDIAL-LATERAL position ( $F(4,80) = 19.2, \epsilon = .59, p < .001$ ).

As illustrated in the difference maps of Figure 3, waveforms at central-anterior sites were more negative-going for the animate than for the inanimate conditions, with no visible differences between waveforms for accusative and dative conditions. No main effects of CASE and no interactions of ANIMACY and CASE were found in this time window, and none were visible during the visual inspections of other time windows until the end of the presentation of the first postverbal word.

### 5.3 Discussion Experiment 2

The results of Experiment 2 show a clear main effect of object animacy, starting about 400 ms after the presentation of the verb, and persisting for about 200 ms. Waveforms for animate conditions were more negative-going than for inanimate conditions in central

elektrodes. We interpret our findings as reflecting the enhanced processing load in sentences with animate compared to inanimate objects. These findings fit earlier reports of enhanced N400 components to animate compared to inanimate objects in the literature (Frisch & Schlesewsky 2001; Paczynski & Kuperberg 2011), and also fits the findings for the accusative conditions in Experiment 1 of the current study. The findings of Experiment 2 again strengthen the point that object animacy effects are subtle, but visible even in grammatical sentences without syntactic or semantic violations. They also match the predictions made by the models of sentence comprehension outlined above (Bornkessel-Schlesewsky & Schlesewsky 2006; Kuperberg 2007; Bornkessel-Schlesewsky & Schlesewsky 2009; 2013).

No main effects of verbal case marking, and no interactions of verbal case marking with object animacy were visible in Experiment 2. Our interpretation is that the contrast between NOM-ACC and NOM-DAT verbs does not affect the processing of particle verbs; at least, not to an extent that is detectable with our current paradigm. This outcome is difficult to explain in the framework of the eADM, as the difference between NOM-ACC and NOM-DAT verbs is assumed to be caused by their semantic differences, and these differences should hold for particle verbs, too. They fit better with the predictions implicit in the KP-based account, since this account assumes that the reason for lexical case marking effects lies in lexical and syntactic differences, and the syntactic difference between particle verbs assigning NOM-ACC and NOM-DAT should be smaller than for simple verbs.

## 6 General discussion and conclusion

In this paper, we investigated the interaction of argument animacy and verbal case assignment in sentence comprehension. The goal was to disentangle the semantic and syntactic contributions to this interaction, and to better understand the effects of lexical compared to structural case marking in the comprehension of German sentences. To do so, we monitored the interaction of object animacy and case marking in the processing of sentences with either simple or particle verbs assigning NOM-ACC or NOM-DAT. While dative effects in simple verbs could be caused by syntactic, lexical and/or semantic differences from accusative verbs, dative effects in particle verbs should only be caused by semantic and/or lexical differences. To our knowledge, our studies are the first EEG studies on case marking effects in comprehension that separate simple and particle verbs, and the first EEG study on the processing of particle verbs that distinguishes between NOM-ACC and NOM-DAT assigning particle verbs.

A direct quantitative comparison of the outcomes of Experiment 1 and 2 is not warranted for a number of reasons. The two most important ones are the impossibility to assess realistic relative frequencies of simple and particle verbs, and the difference in morphological and syntactic complexity between simple and particle verbs. Therefore, we will treat them as two separate experiments, and only attempt a qualitative comparison of their outcomes. We will also discuss how the preparation of the language material and the pre-tests serve to control for confounds and alternative explanations of the outcomes.

On the verb, we found main effects of object animacy for the accusative (simple) condition in Experiment 1, and for accusative and dative (particle) conditions in Experiment 2. In both experiments, the effects started around 400 ms after the onset of the verb, and persisted for 200–300 ms. While descriptively, there are subtle differences between animacy effects in both experiments (slightly more frontal and longer-lasting effects for particle than for simple verbs), both Experiments support the existence of object animacy effects (Frisch & Schlesewsky 2001), even in the absence of grammatical violations (Paczynski & Kuperberg 2011). This supports the idea that animacy contrasts of arguments are routinely used in sentence comprehension, and that they influence processing even when they are not needed for thematic role assignment. In particular, this observation matches

the important role of animacy during the ‘compute prominence’ processing step proposed in the eADM, since the processing of arguments relies on maximal distinctness of the arguments in many dimensions (see, e.g., Bornkessel-Schlesewsky & Schlewsky 2009: 44).

The general direction of the animacy effects fits in with the models of sentence comprehension outlined above (Bornkessel-Schlesewsky & Schlewsky 2006; Kuperberg 2007; Bornkessel-Schlesewsky & Schlewsky 2009; 2013). (Not being a full-blown model of sentence comprehension, the KP-based account, Bayer et al. 2001, does not make any predictions about the influence of object animacy.)

With respect to the eADM (Bornkessel-Schlesewsky & Schlewsky 2006; 2009), our results match the general prediction that NOM-DAT verbs should be processed differently from NOM-ACC verbs. However, they do not match the predictions that can be drawn from the underlying assumptions for these processing differences. According to the eADM, the reason for predicting this difference is that NOM-DAT verbs encode non-prototypically transitive situations, and that role assignment works differently for the arguments of NOM-DAT verbs than for the arguments of NOM-ACC verbs. While the model in its current state does not make any explicit predictions about the processing of particle verbs, the special semantics of NOM-DAT verbs should affect the processing of both simple and particle verbs. Thus, the model gives no reason to assume the *absence* of differences between NOM-ACC and NOM-DAT particle verbs. Therefore, the findings of Experiment 1, but not Experiment 2, can be explained in the framework of the eADM.<sup>12</sup>

With respect to the KP-based analysis, the general direction of our results matches the predictions that are implicit in the account: Effects of lexical case marking are only found when NOM-DAT verbs are syntactically more complex than NOM-ACC verbs (i.e., with simple verbs, but not with particle verbs).<sup>13</sup> However, the effects do not fit in with the second part of the KP-based analysis, namely, with the proposal that encountering a NOM-DAT verb after a case-ambiguous object leads to lexical reaccess to check for morphological licensing of lexical case (Bayer et al. 2001). This lexical reaccess the object is assumed to be reflected in an N400. In Experiment 1, we found no N400 for NOM-DAT compared to NOM-ACC verbs; indeed, the interaction of object animacy and case on the verb surfaced in the form of an *absent* N400 for animate-dative compared to animate-accusative conditions. In addition, it could be argued that lexical reaccess should be necessary for the objects of all NOM-DAT verbs, irrespective of whether they are simple verbs (with a KP structure) or particle verbs. This would suggest that there could be a smaller, but not entirely absent N400 for the accusative-dative contrast with particle verbs, as well.

In addition, we found a late effect of case marking for simple verbs, but not for particle verbs. This effect started 1400 ms after the presentation of the critical verb, and persisted for 300 ms. No interactions with animacy were found for this effect. No similar effect has been reported for NOM-DAT compared to NOM-ACC verbs in the literature so far. As we outlined in the discussion of Experiment 1, it would be premature to offer a conclusive interpretation of this effect at this point. Therefore, we will limit ourselves to the general conclusion that it reflects an enhanced workload associated with simple NOM-DAT compared to simple NOM-ACC verbs. Given that this effect was not found in Experiment 2, it

<sup>12</sup> Importantly, our findings do not imply that there are no semantic or thematic differences between NOM-ACC and NOM-DAT verbs, or that they do not play a role in sentence comprehension. However, our results suggest that at least some effects of lexical case marking are driven by syntactic differences between NOM-ACC and NOM-DAT verbs; therefore, it may be fruitful to take both syntactic and semantic differences into account in future models of sentence comprehension.

<sup>13</sup> Our findings do not fit with syntactic accounts that assume similar positions for the objects of simple NOM-DAT and NOM-ACC verbs, e.g. Fanselow (2000). Under this account, we would have predicted similar outcomes for simple and particle verbs – either no case marking effects at all, or case marking effects caused by semantic rather than syntactic differences between NOM-DAT and NOM-ACC.

seems likely that this effect is linked to some aspect of the syntactic, rather than semantic, differences between simple NOM-DAT and NOM-ACC verbs. The late timepoint of this effect seems to suggest that it would reflect later syntactic reanalysis processes. However, current models of sentence comprehension are not focused on effects occurring this late, so a more specific interpretation is impossible here. In this paper, we will take this late effect as simply one more finding supporting lexical case marking effects for simple NOM-DAT verbs, but not for particle NOM-DAT verbs, leaving a more profound interpretation to future work.

The current study does not allow us to tell if there simply are no differences in the processing of NOM-ACC and NOM-DAT-assigning particle verbs, or if these differences are too subtle to surface in the comprehension of comparatively simple, grammatical structures. If the effect of lexical case marking is truly absent for particle verbs, the assumptions about lexical reaccess to objects in the processing of lexical case marking verbs (Bayer et al. 2001) need to be reassessed. If, however, lexical reaccess is in fact necessary for objects of dative-assigning particle verbs, there should be a subtle effect of case marking visible with particle verbs, reflecting only lexical reaccess to the object, but not the buildup of a more complex syntactic structure for NOM-DAT compared to NOM-ACC particle verbs. Future studies will have to reveal if any hints of lexical reaccess for dative, but not accusative objects of particle verbs can be found in more challenging constructions.

It would be possible that the different outcomes of Experiment 1 and 2 could reflect different frequencies of finding animate objects with simple and particle verbs. However, this interpretation is unlikely given the results of the sentence completion task. This pre-test suggests that simple and particle verbs do not differ with respect to object animacy preferences. For both simple and particle verbs, dative conditions were indeed completed more often with animates than with inanimates. However, for simple verbs, this tendency was the same for accusative conditions, albeit less pronounced than with dative conditions. Therefore, the interaction of ANIMACY and CASE found in Experiment 1 (simple verbs) is unlikely to reflect the participants' strong expectation of an inanimate object with accusative, but not dative verbs. In the sentence completion task, the contrast between accusative and dative conditions is descriptively more pronounced for particle verbs, with about equal proportions of animate and inanimate objects given for accusative, but not for dative conditions. Interestingly, there is no effect of CASE, and no interaction of ANIMACY and CASE in the corresponding EEG experiment (Experiment 2). Based on the results of the sentence completion task, we should predict an influence of case marking for both simple and particle verbs in the EEG experiments, and possibly an even stronger influence for particle verbs than for simple verbs, due to the more pronounced difference between accusative and dative preferences for animate objects (see Table 1). The results of the sentence completion task suggest that the results of the EEG experiments cannot be explained in a straightforward way as mere effects of frequency- or expectation-based processing.

Taken together, our experiments show that argument animacy influences sentence comprehension even in the absence of syntactic or semantic violations or processing difficulties, with slightly enhanced N400 components for animate compared to inanimate objects. For dative-assigning simple verbs, this animacy effect is absent; instead, we find main effects of case marking on the first postverbal word. For particle verbs, however, there are no effects of case marking at all, and animacy effects obtain for both accusative- and dative-assigning verbs.

In sum, our findings suggest that the effects of lexical case marking in German reflect the additional syntactic processing required by simple dative compared to simple accusative verbs. They match predictions from syntactic theory, arguing that simple verbs assigning NOM-ACC or NOM-DAT differ more from each other than particle verbs assigning

NOM-ACC and NOM-DAT. This shows that the theoretical distinction of different case marking verbs, and also the theoretical distinction between simple and particle verbs, are relevant also for sentence processing.

## Abbreviations

ACC = accusative, DAT = dative, NOM = nominative, NOM-ACC = nominative-accusative assigning (verb), NOM-DAT = nominative-dative assigning (verb), 3PL = third person plural

## Additional File

The additional file for this article can be found as follows:

- **Full Stimulus sets.** The additional file contains the full stimulus sets used in both experiments and their translations into English. DOI: <https://doi.org/10.5334/gjgl.313.s1>

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## Competing Interests

The authors have no competing interests to declare.

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