



Draw *mir* a Sheep: A Supersense-based Analysis of German Case and Adposition Semantics

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Abstract

Adpositions and case markers are ubiquitous in natural language and express a wide range of meaning relations that can be of crucial relevance for many NLP and AI tasks. However, capturing their semantics in a comprehensive yet concise, as well as cross-linguistically applicable way has remained a challenge over the years. To address this, we adapt the largely language-agnostic SNACS framework to German, defining language-specific criteria for identifying adpositional expressions and piloting a supersense-annotated German corpus. We compare our approach with prior work on both German and multilingual adposition semantics, and discuss our empirical findings in the context of potential applications.

Keywords Natural language understanding · Prepositions · Lexical semantics · Case · German

1 Introduction

German, like many other languages, uses adpositions (such words as *in*, *zu* (*to*), *wegen* (*because of*), ...) and case (genitive, dative, accusative) to mark specific relations between natural language phrases. And contrary to popular claims (or, none the better, tacit assumptions) in natural language processing (NLP) that these relations can or even should be ignored in computational language understanding because they are merely grammatical, they do indeed convey crucial bits of meaning that are worth investigating [17,51,61,65,71].

To make things more complicated, lexical adpositions (i.e., pre-, post-, and circumpositions) can interact with morphological case markers, as well as each other. For example, a preposition may—under certain contextual conditions—be

paraphrased with a different preposition (e.g., *over* ↔ *above*), a case-marked pronoun (*von mir* / *of me* ↔ *mein* / *my*), or a construction that does not involve any explicit relational signal, such as a noun-noun compound (*Schale für Obst* / *bowl for fruit* ↔ *Obstschale* / *fruit bowl*). But what sorts of patterns arise? What is the influence on the meaning of an utterance or the communicative intent when we choose one adposition, case, or idiomatic construction over another? Which patterns pertain only to German and which can we observe across languages?

To get a better idea of the meanings and interactions arising from adposition and case usage in German, consider Fig. 1. The first two sentences are roughly equivalent, despite using superficially diverging constructions (dative case vs. the preposition *für* + accusative case). They can also both be interpreted with respect to two different meaning nuances, one of which involves spatial transfer while the other one does not. The third example involves a possessive pronoun, which can be read as expressing either “true”, alienable possession or, alternatively, creatorship.

Since each one of the different adposition and case senses may have different real-world implications, being able to distinguish between them is imperative as we move towards more capable and immersive artificial intelligence (AI).

Many researchers have dealt with semantics of adpositions from various angles and proposed theoretical frameworks [51], dictionaries [52], and corpora [18,51] to facilitate their computational analysis and processing. Our goals for this

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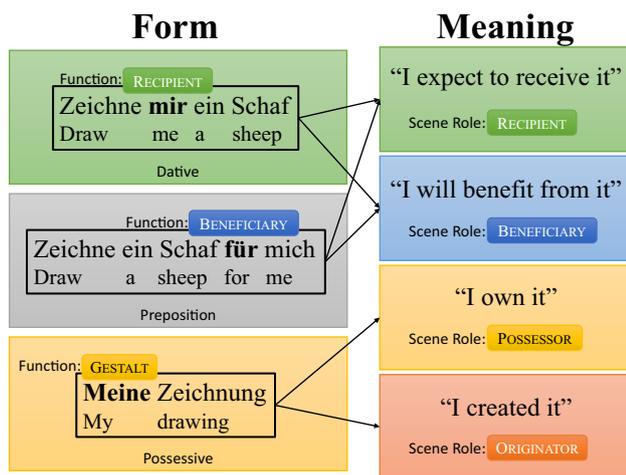


Fig. 1 : Illustration of adposition and case semantics in German by means of a form-meaning mapping and scene role and function supersenses assigned in our framework

article are to highlight the importance of this subfield of natural language understanding (NLU) for a wide range of AI applications, and to contribute guidelines, data, and empirical insights regarding a comprehensive semantic analysis of the German adposition and case systems.

We approach these goals by defining in a concise and replicable manner the scope of linguistic phenomena in German that fall within our notion of *adpositional expressions*, and by adapting and applying an existing annotation framework (the Semantic Network for Adposition and Case Supersenses, SNACS [61]) to a German corpus. Our specific contributions are as follows:

- We introduce a classification taxonomy for the semantics of German adpositions and case markers, building upon the SNACS framework and construal analysis. To the best of our knowledge, this is the most comprehensive and most practical analysis to date of German adpositions and case “in the wild”.
- We present a pilot annotation study to validate the task setup, measure its difficulty, and analyze the distribution of adpositions, case, and their semantics. We also discuss qualitatively a number of special and difficult constructions involving adpositional expressions and compare with SNACS analyses of other languages. The annotated data is available to the community at <https://github.com/nert-nlp/German-SNACS>.
- We situate our research in the fields of language technology and artificial intelligence, by walking through concrete application scenarios that are prone to errors stemming from improper handling of adposition semantics, and showing how our work can help resolve them.

2 Related Work

The problem of formalizing, marking up, and leveraging the meaning nuances signalled by grammatical markers is not a new one, neither in general nor for German in particular. In this section, we review various approaches from the last five decades, both establishing important background knowledge for the reader to be able to follow our assumptions and revealing the gap in the existing research landscape that we intend to fill. We begin by giving a short history of research on German adpositions and case semantics, before going over the fundamentals of Case Theory and Conceptual Metaphor, which inspire core aspects of our analysis. At that point it should become clear how the abstract and general theories of meaning relate to something as seemingly banal as “stop words”. We will then introduce the SNACS annotation scheme, which our work directly extends.

2.1 German Preposition and Case Semantics

When investigating the actual semantics of a specific linguistic class, the most obviously necessary first step is to define that class and to identify the phenomena that fall within it. In the case of adpositions, this task is, however, far from trivial, due to many similarities and overlaps with other parts of speech such as conjunctions (e.g., *und / and*, *weil / because*) and adverbs (e.g., *zusammen / together*, *hier / here*), or more broadly, particles. There is a rich literature on this problem in the Germanic and Romance languages dating back to the early and mid-twentieth century, which has been summarized quite brilliantly by Crössmann [13]. Crössmann concludes that logical and semantic criteria are—for the most part—superior to morpho-syntactic ones for drawing these boundaries, and generally agrees with Jespersen [31], Brøndal [7], and Ljunggren [43] that, based on these criteria, the traditionally separate classes of prepositions and subordinating conjunctions should be clustered together as ‘subordinators’.

The semantics of German prepositions have since been examined lexicographically [52], by means of cross-linguistic comparison [14,17,48,57], and in terms of their interaction with case, in particular the *two-way* prepositions, which express different meaning nuances depending on the case of their object [15,65,72,77,80]. They have also featured in computational analyses, e.g., using vector space semantics [35], and applications such as machine translation [74,75].

An approach that is closely related to ours is that of Müller et al [51], who developed a hierarchical annotation scheme containing 37 categories for the disambiguation of German prepositions in context. Multiple categories can be assigned to accommodate usages that systematically activate multiple meaning nuances at the same time [33]. They annotated a cor-

pus of news data, focusing on 22 prepositions that can engage in determiner-less preposition-noun constructions (PNCs).

2.2 Case Theory and Thematic Roles

Fillmore [19] has argued for a proper notion of functional—in addition to structural—relationships as first class citizens of any grammatical theory. This is because functional grammatical notions such as *subject* and *object* (in contrast to structural ones such as *noun phrase*) exhibit rather systematic correspondences with semantic relationships like AGENT and PATIENT or UNDERGOER called thematic *roles*. Case theory was succeeded by the more fine-grained¹ theory of *frame semantics*, which has been implemented in the FrameNet database [2] as well as the German SALSA corpus [8,18]. A good middle ground in terms of practicality, domain-independence, and granularity is VerbNet [32,41], whose thematic role inventory directly inspired the one we use in our semantic analysis. In contrast to case grammar, we take the position (spiritually consistent with FrameNet) that these roles are not atomic meaning primitives but rather high-level, prototype-based generalizations over a wide range of roles in more specific conceptual scenarios.

2.3 Conceptual Metaphor and Construal

Another linguistic theory that drives our investigation is that of *construal* in cognitive linguistics [30,38,40], which maintains that linguistic form is not arbitrary, but rather the words and constructions we choose to express any given state of affairs *construe* that state of affairs in a certain way. In order to articulate abstract relations in a target domain, we tend to choose words from a source domain that is grounded in *embodied* (i.e., frequently physically perceived) conceptual primitives. The process of construal can be obvious and intentional, like in carefully chosen metaphors (*they got into a heated argument about snakes*, EMOTION is TEMPERATURE), or more subtle and intuitive as in abstract or fictive motion (*she saw him from afar*, PERCEPTION is MOTION). With respect to adpositions specifically, linguists often make use of semantic networks encoding the breadth of available meaning nuances and the order in which they can be derived from one another [24,44,71]. Trott et al. [70] highlight the relevance of construal for the field of NLP, and establish a set of meaning dimensions along which the general phenomenon can be classified for practical applications.

¹ For example, the verb *zeichnen* ‘to draw’ may evoke the specific frame CREATE_PHYSICAL_ARTWORK with the frame elements CREATOR and REPRESENTATION, which are typically instantiated by the syntactic subject and object, respectively.

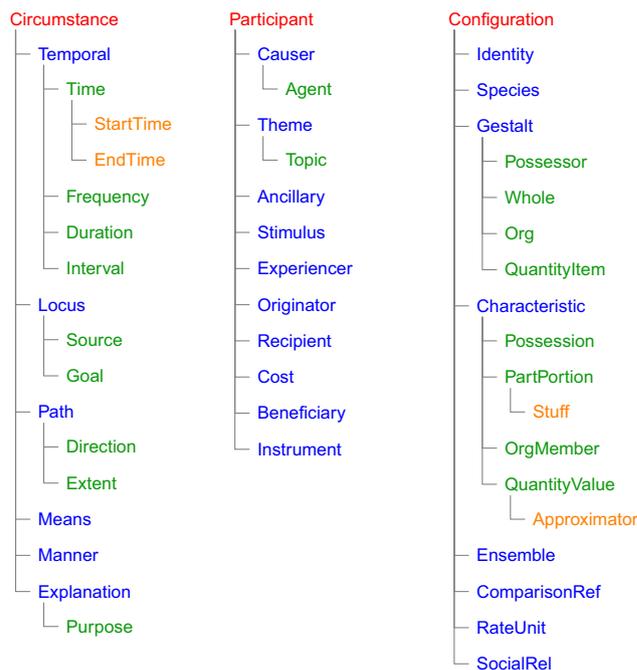


Fig. 2 : Hierarchically organized inventory of 50 SNACS supersenses. Replicated from Schneider et al. [62]

2.4 SNACS

The concrete framework we base our analysis on is the Semantic Network of Adposition and Case Supersenses (SNACS) [27,58,61], which consists of 50 hierarchically organized categories based on VerbNet thematic roles [32]. The SNACS inventory (Fig. 2) is broadly divided into senses pertaining to CIRCUMSTANCES, PARTICIPANTS of scenarios or scenes, and CONFIGURATIONS between entities.

SNACS is designed with typological universals and cross-linguistic applicability in mind. In addition to the English STREUSLE corpus [59,61], it has so far been adapted to and annotated in Mandarin Chinese [53], Korean [28], and Hindi [1]. Preliminary investigations are ongoing for Latin, Finnish, French, and Hebrew.

3 Annotation Scheme

We perform our analysis by means of annotating naturally occurring text. Our main assumptions are based on the ones described in the original SNACS guidelines for English [62]. This includes the inventory of categories (Fig. 2), the construal analysis, according to which annotations are split up into a *scene role* and *lexical function*, as well as the general annotation guidelines for the scene role, which is expected to be stable across translations. The high-level idea is to identify adpositional targets in the text, disambiguate the meaning

they express in their respective context (the scene role), and explicate how this meaning is lexically construed (the function). This is illustrated in Fig. 1.

When it comes down to the details, however, we need to define and handle a range of non-trivial phenomena that pertain to German in particular. We aim for an annotation scheme that is as comprehensive as possible, i.e., we are interested in all instances of prepositions, postpositions, and circumpositions—without cherry-picking, and yet with criteria for including certain word types and morphemes that may not traditionally be considered adpositions or for excluding ones that do not have a sufficiently independent semantics.

Furthermore, German is a fusional language, marking case morphologically in a way that is not clearly and unambiguously separable from lexical items (contrast, e.g., Korean, where case markers are always transparent suffixes, and English and Chinese, which have essentially no grammatical case). Since case may, depending on context, determine its governing adposition's meaning nuance, or carry its own semantics—which, in turn, may typologically correspond to a lexical adposition in another language—we want to analyze it in the same framework, to the extent possible.

Here we describe in detail the policies we have devised.

3.1 The Scene Role/Function Distinction

In our annotation, we apply the *Construal Analysis* as proposed by Hwang et al. [27]. This means that each annotation target is assigned up to 2 different semantic categories, the first one denoting the adpositional object's role within the scene described in the clause (the *scene role*, cf. § 2.2) and the second one denoting the prototypical meaning of the adposition or case marker, independently of the current context (the *function*, cf. § 2.3). Both scene role and function labels are drawn from the SNACS inventory (Fig. 2). The construal analysis is illuminating when the scene role conveyed in the current context diverges from the prototypical function(s) of the annotation target. We write, e.g., **POSSESSOR**→**LOCUS** and say “**POSSESSOR** construed as **LOCUS**” (e.g., *ich trage einen Schirm bei mir* ‘I am carrying an umbrella **with** (lit. **at/on**) me’). If the meaning conveyed in the current context is also a prototypical meaning of the annotation target, scene role and function are congruent. For simplicity, we write only a single category in this case (e.g., **TIME** rather than **TIME**→**TIME**), but annotators are always asked to make the function explicit even if it is congruent with the scene role.

When choosing the scene role, we consider the type of semantic relation the adpositional object engages in with respect to the governing scene, predicate, or entity in each specific context. This abstracts from surface forms and is expected to remain stable across paraphrases and translations.

The function, on the other hand, is tied to the concrete lexical item or construction chosen to express the abstract relation. Both the overall distribution of functions and which function label is chosen for a given target in context are thus sensitive to lexical, syntactic, and cross-linguistic variation.

Deciding what constitutes the set of prototypical functions for an adposition is not trivial. For annotation in German, we settled on the following order of priority:

1. We compiled an open-ended lexicographical list of individual adpositions and their possible functions, along with detailed examples, which should be consulted by annotators before moving on to the more general rules.
2. For prototypically spatial and spatio-temporal adpositions,² the function should always be spatial or temporal (i.e., from the **LOCUS**, **PATH**, or **TEMPORAL** sections of the hierarchy). Temporal meanings are generally considered as prototypical as spatial meanings, i.e., we never annotate a spatial function for a temporal scene role or vice versa. If the scene role is spatio-temporal as well, the function should match the scene role. Otherwise, we prefer to choose as the function the spatial category that most adequately describes the metaphor or origin of the extended meaning, except if a temporal category is clearly more salient.
3. Possible functions for genitive case and possessive pronouns are **GESTALT** and **POSSESSOR**, following Schneider et al. [62]. If and only if the scene role is **POSSESSOR**, i.e., the meaning in context is that of true, alienable possession, the function is also **POSSESSOR**. For all other scene roles, from general association meanings (e.g., **GESTALT**) to specific extended senses (e.g., **ORIGINATOR** or **SOCIALREL**), the function is **GESTALT**.
4. The function label for dative case and pronouns is always **RECIPIENT**, regardless of the scene role.
5. Since we aim for a comprehensive analysis of adpositions rather than a limited set of forms, it is possible that an annotator encounters a form that is not yet documented in our framework. In this case, the target will be examined and discussed by the project leaders and eventually added to the guidelines.

3.2 What Counts as Adpositional?

As tempting as it may be to simply assume that the terms “adpositions” and “case markers” are inherently well-defined, the question of which linguistic units we ought to include in our semantic analysis is far from trivial. One can draw from a wide range of morphological, syntactic, and semantic criteria in making this decision, and there is no one way that does not make any compromises. It all depends on what the goals of the investigation and their potential applications are.

² These are mostly closed-class; a list is provided to annotators.

In line with our main goal—broad-coverage exploration of the mapping between certain relational semantics and linguistic form, both within and across languages—we follow Crössmann [13], Huddleston and Pullum [26], and Schneider et al. [58–61] in using a mix of syntactic and semantic criteria for the inclusion of linguistic units. More concretely, we consider an expression adpositional and thus markable if and only if it denotes an **asymmetric, or directed figure-ground relation between two concepts**. This is in stark contrast to most prior annotation work, which typically focuses on a limited subset of forms [33,48,51]. Further, any form that can be used as a classic preposition (with an NP complement) is always considered an annotation candidate, even when it takes a non-NP complement (e.g., a clause) or no complement at all.

On the other hand, we want to formulate our task—at least for the time being—as strictly *lexical* disambiguation for practical reasons, thereby excluding from being annotation targets any bound morphemes that cannot be clearly separated from their lexical head, as well as any implicit or null-instantiated relations.

As a result, we annotate a range of linguistic units, from “classic prepositions” to prepositional adverbs (or pronominal adverbs), verb particles, multiword adpositional expressions, comparative conjunctions, purpose infinitivals, as well as possessive and dative pronouns. We discuss each phenomenon in detail below.

3.2.1 Classic Prepositions (PREP)

Unsurprisingly, the definition given above includes those words traditionally called prepositions, like *in*, *auf*, *über*, *nach*, and *zu*. They have in common, most notably, that they are (usually) morphological primitives and that they (usually) govern the case (accusative, dative, or genitive) of their object NP, which they precede. Semantically, they establish a relation between their syntactic governor as the more prominent trajector or figure, and their syntactic object as the anchoring landmark or ground.

Centered around this core set of “classic prepositional” word forms, we also include the following special cases, which are somewhat divergent in their morpho-syntactic properties but still share the same semantics:

- *Postpositions* Some prepositions, such as *nach* ‘after, according to’ and *wegen* ‘because of’, can also follow their object rather than preceding it. Apart from word order, these postpositions behave in the same way as prepositions and are thus included. We use the term *adpositions* to emphasize this.
- *P’s with non-NP complements* We annotate prepositional word forms, even when they are used with a non-NP complement. This could be, e.g., adjectives (*etw. für gut halten* ‘deem sth. (for) good’), or VPs/clauses, in which

case the marker would traditionally be assigned the part-of-speech of ‘subordinating conjunction’ (SCONJ; *bis/als wir ankamen* ‘until/when we arrived’).

- *P’s with implicit complements* While, in English, canonical prepositions can also occur without any explicit object (‘intransitive prepositions’ [26,61]), this kind of construction in German typically requires the preposition to undergo some form of morphological change into either pronominal adverbs or verb particles, which are discussed below in § 3.2.2 § 3.2.3, respectively.
- *P+D contractions*: When immediately followed by a determiner (usually a definite article), certain prepositions may (or even *must* in fluent, natural German) contract with that determiner to create a special form (*zu + der* → *zur*, *an + dem* → *am*). While there are constraints on when this can happen, and the contracted forms may have special semantics and/or pragmatics [11,25,56,76], these properties are finer-grained than what we aim to capture. We split them up in preprocessing and annotate the preposition part in the same way as uncontracted ones.

3.2.2 Pronominal Adverbs (PAV)

One of the multiple ways a German preposition can undergo a morphological process to end up intransitive (i.e., argumentless) is by combining with a locative particle (*da*, *wo*), as in the following examples:

- *da* ‘there’ + *für* ‘for’ → *dafür* ‘for that’
- *wo* ‘where’ + *mit* ‘with’ → *womit* ‘with what/which’

The resulting word class is called *pronominal adverbs* or *prepositional adverbs*. These are deictic expressions, encoding both the prepositional marker and a reference to the prepositional object in a single word form. The object referred to is usually an established discourse entity. We include in this class combinations of prepositions + emphatic demonstrative articles (*deswegen* ‘because of this’, *trotzdem* ‘in spite of this’), and prepositions + reciprocals (*miteinander* ‘with one another’). Additionally, we annotate all word tokens that are homographs with a pronominal adverb, even when they are used as clausal subordinators (e.g., *damit* with its purposive sense of ‘so that’).

3.2.3 Verb Particles (VPRT)

Another interesting class of words involving adpositional expressions is that of the particle verbs (PVs). Here, a verb combines with an adposition (or adposition-derived formative) to form a new verb whose semantics, and sometimes argument structure, is somewhat different from the base verb. This change in meaning can be more transparent, i.e., $[[PV]] \approx [[V]] + [[P]]$, or more opaque.

This is, however, not a clear-cut distinction that can always be easily made, but rather lies on a continuous scale. An

example for a highly transparent PV is *aufstehen* ‘to stand/get up’, a slightly less transparent one is *aufwachen* ‘to wake up’, and a highly opaque one is *unterhalten* ‘under+hold = to entertain’.

Orthogonally, German PVs can be divided into *trennbar* (separable) and *nicht trennbar* (non-separable). In V2-ordered main clauses, separable PVs leave their adpositional part in the clause-final position when moving³ the inflected verb part to V2, whereas non-separable ones move as a whole.

Because the dimensions of semantic transparency and morpho-syntactic separability do not align, we apply a rather crude preprocessing method to ensure high recall of our semantic annotation: we manually separate all PVs whose adpositional part matches a regular preposition (this does not include PVs beginning with, e.g., *hin-* or *her-*), make it available for annotation, and rely on annotators to determine its semantic content, if any.

3.2.4 Multiword Adpositional Expressions (MWE)

While we do not currently attempt to analyze subword units (except when they can be unambiguously isolated, as discussed above), annotation targets need not consist of only a single token. German has several constructions that we consider to be multiword adpositional expressions:

- *Purposive* ‘um zu’ *infinitivals* (INF): This combination of the preposition *um* and the infinitival marker *zu* expresses the purpose of an action, similar to the English (*in order to*). Potential direct and indirect objects as well as adjuncts of the complement VP intervene between *um* and *zu*, resulting in a discontinuous annotation target (**um_ es _zu finden** ‘(in order) to find it’). Similarly, when its complement is a separable PV, *zu* is embedded between the adpositional and verbal parts (**um_ auf _zustehen** ‘(in order) to get up’). The two can occur together, leading to even larger gaps (**um_ es auf _zuheben** ‘(in order) to pick it up’).
- *Circumpositions* These two-part adpositions surround their object and are thus always discontinuous (**von_ Kindesbeinen _an** ‘ever since childhood’, **um_ des Geldes _willen** ‘for money’s sake’). The second, postpositional part is usually derived from an adposition (*an*) or a nominal (*willen*) itself. Most circumpositions are not in frequent and productive use anymore and, in fact, none of them are attested in our data.
- *Genitive P’s with ‘von’* Certain prepositions governing genitive case can instead combine with *von* ‘of’ (which then governs dative case), with little to no change in meaning (**innerhalb_von** ‘within’) [10,16,63,66]. We consider

this a superficial variant of the main preposition rather than two separate annotation targets.

- *Idiomatic P+P combinations and PNCs* Following Schneider et al. [61], we also include a number of lexicalized, highly idiomatic expressions consisting either of multiple prepositions (*nach_und_nach* ‘little by little’, *bis_auf* in the sense of ‘except’) or of prepositions and incomplete nominals or adverbs (*auf_gut_Glück* ‘haphazardly’, *von_Zeit_zu_Zeit* ‘from time to time’, *auf_einmal* ‘suddenly’).

Yet other types of frequently collocated prepositional expressions or phrases are semantically transparent enough that we annotate each adpositional constituent separately, as described in § 3.2.1, rather than the expression as a whole:

- *Transparently stacked P’s*: In contrast to the idiomatic *bis_auf* meaning ‘except’ as pointed out above, *bis* ‘until’ can also compositionally stack with a number of spatial (GOAL-type) preposition like *zu* ‘to’ and *an* ‘at/on(to)’. Here, the respective second GOAL preposition retains its usual meaning, while *bis* profiles the EXTENT of the PATH taken to reach the GOAL. We therefore annotate both prepositions separately.
- *Conventionalized transitive PPs*: German has many other conventionalized PP types which, because their nominal part often has relational semantics and thus takes a genitive or PP complement itself, in a way act as complex prepositional units (*im_Laufe* ‘in (the) course (of)’, *mit_Hilfe* ‘with (the) help (of)’, *in_Folge* ‘following/as (a) result (of)’). There are certainly arguments to be made that these expressions are on the verge of being grammaticalized, perhaps most tangibly by means of the contracted orthographical variants *mithilfe* and *infolge*. However, since it is still possible to derive their meaning compositionally, we treat them as normal, transparent PPs in our annotation.

3.2.5 Comparatives: *als*, *wie*, and *zu*

Since comparative constructions fall within the range of our COMPARISONREF and EXTENT senses, we include the comparative markers *als* ‘than’, *wie* ‘as/like’, and *zu* ‘too’ in our annotation, even though they are not traditionally recognized as prepositions. *Als* and *wie* are often called ‘comparative conjunctions’ and can otherwise also function as the adverbial subordinators ‘when’ and ‘how’, respectively. We follow our policies established above in annotating all of these adpositional, i.e. asymmetric-relational, usages that share a word form with a classic NP-complement preposition.

3.2.6 Possessive (POSS) and Dative (DAT) Pronouns

Motivated by the observation that, cross-linguistically, morphological case shares much of the semantics of adpositions—

³ In a purely illustrative sense. We are agnostic with respect to the formal syntactic notion of movement or any other syntactic paradigms.

in fact, adpositions can be seen as a finer-grained and more flexible extension of the case system [19]—we want to include case markers in our annotation, whenever they are easily accessible as lexical items.

The practice to annotate possessives has a precedent in English SNACS annotation, as piloted by Blodgett and Schneider [5], who found, e.g., that the meaning relations signaled by possessive constructions are often much broader and more abstract than just concrete alienable possession. The English possessive markers are *of*, the clitic *'s*, and possessive pronouns, all of which are ‘lexical’ in the sense that they can easily be tokenized and annotated. Possessive, and generally case-marked pronouns are similar to pronominal adverbs (§ 3.2.2) in that they encode both the case marker and a reference to its object within a single form. Due to German fusional morphology, genitive case marking on articles and nominals is not as easily accessible as *'s* in English. Thus, apart from the preposition *von* ‘of’, we only include possessive *pronouns*.

By the same logic, we are interested in German dative case, whose semantics we anticipate to span a variety of concrete and abstract TRANSFER, PERCEPTION, POSSESSION, as well as general ASSOCIATION frames [44]. To our knowledge, this is the first empirical investigation of its kind to cover the semantics of the German dative together with possessives and adpositions, all within the same framework. We analyze the arising form-meaning interactions in § 4.6.1.

3.3 What does NOT Count as Adpositional?

Conversely, we decided a priori on several phenomena we do not aim to capture in the current version of our framework. For the most part, these decisions are again based on semantic criteria, i.e., we rule out specific kinds of case marking with systematically less salient or even rather bleached semantics. This includes any nominative and accusative case marking, certain reflexive pronouns, any case governed directly by a lexical adposition, and any adjectives and participles (even when their semantics resembles that of an adposition).

3.3.1 Nominative and Accusative Case

Subjects and direct objects, marked in German with nominative and accusative case, are not annotated in the current version of our framework for the main practical reason that they are much more frequent than adpositions and would substantially increase annotation effort. However, as Shalev et al. [64] demonstrated for English, the SNACS senses can in principle be applied to core-syntactic arguments. We plan to adopt this for German in future work.

3.3.2 Reflexives

The syntactic argument structure of certain verbs demands reflexive objects, i.e., pronouns in accusative or dative case that corefer with the subject (e.g., *sich* ‘oneself’). While we do not currently annotate any accusatives, as explained in the previous section, we distinguish two types of dative reflexives: those that denote an additional semantic relation between the subject and the verb, and those that are purely grammatical. We include the former but not the latter. To test which class a given dative pronoun belongs to, we ask annotators to try to substitute the pronoun with a non-reflexive one (e.g., *er kocht sich etw.* vs. *er kocht ihr etw.* ‘he is cooking sth. for himself/her’). If the result is grammatical and the meaning still revolves around the same type of event, just with a different participant, the target is included. Otherwise (e.g., *er stellt es sich vor* ‘he imagines it’ vs. *er stellt es ihm vor* ‘he introduces it to him’), it is discarded.

3.3.3 Adposition-Governed Case

Most German prepositions govern the case of their object. Some always take objects of the same case (accusative, dative, or genitive), and others are more flexible. Dubbed ‘two-way prepositions’ and generally situated in the locative semantic domain, these markers can either combine with datives to denote a stative location, or with accusatives to denote the endpoint of a (not necessarily physical [65]) motion or change. The case governed by a particular two-way preposition in a specific context can thus be used by annotators to disambiguate its semantic function (either LOCUS or GOAL) and evoked scene role. However, we do not consider adposition-governed morphological case markers annotation targets in their own right.

3.3.4 Adjectives and Participles

As an exception to our strict adherence to semantic inclusion/exclusion criteria, we also rule out adjectives and participles although they sometimes signal relations that overlap with adpositional semantics and may even govern case. The criterion for ruling out such an item is that it still follows, in a productive way, the morpho-syntactic behavior of its respective part-of-speech class (adjectives can be compared, verbs that participles are derived from can be conjugated).

4 Annotated Corpus

In order to test out the framework and guidelines as well as empirically evaluate their quality and difficulty, we annotated a pilot corpus of natural language data. Annotation was carried out over multiple rounds, with two different sets of

annotators, and in reciprocal alternation with refinements to the guidelines based on empirical analysis of the annotation quality and feedback from the annotators.

Throughout all iterations, annotators were presented with continuous stretches of text containing adpositional and case markers naturally embedded in context. The annotation targets had been manually identified by the first author of this paper, according to the criteria outlined in § 3.2 and § 3.3, and highlighted in the text for annotators to disambiguate.⁴

Below we provide details on the data, annotators, and inter-annotator agreement; discuss our overall findings as well as particularly interesting or difficult observations in depth; and point out crucial parallels and divergences between the case-adposition systems in German and other languages, based on a few selected examples.

4.1 Data and Preprocessing

We use a publicly available German translation of Antoine de Saint-Exupéry’s *Le Petit Prince* (“Der kleine Prinz”, translated from French by Romy Strassenburg, 2015, BUCH-FUNK Verlag). The top-left portion of Table 1 provides basic statistics. We choose this text for its availability in many languages and frequent appearance in linguistic and computational semantics research [e.g., 3, 4, 47, 68], and expect the SNACS-annotated German version to contribute to future comparative analyses and multilingual applications alike. It should be noted, though, that parts of the vocabulary and structure of this corpus are noticeably specific to the literary genre and the data can therefore not be considered representative of German as a whole. Moreover, translations (as opposed to text originally authored in a language) are known to exhibit certain tendencies such that ‘translationese’ is a distinctive style [36]. We thus hope that the methods piloted on *Der kleine Prinz* will be repeated for German texts covering a wide range of genres and styles to better reflect the language as a whole.

Our preprocessing steps were as follows: We first automatically extracted the raw text from the pdf; then tokenized it with Stanford CoreNLP [46], version 3.8.0; normalized abbreviated and article-contracted prepositions using lookup tables; and finally cleaned up chapter headings and page numbers.

⁴ In order to efficiently gather supersense-annotated data on a larger scale, the target identification step may be automated. Schneider et al. [61] have demonstrated for English that this is possible, at least approximately, based on part-of-speech tags and syntactic dependencies. We expect their method to be applicable to German as well, but this still needs to be tested empirically.

Table 1 : General statistics of our corpus

Chapters	v0.1	v0.2	LexCats (of 1586 ann. v0.1 targets)			
Sentences	1509	228				
Tokens	18,600	2034	PREP	836	PAV	110
Candidates	1715	244	POSS	215	SCONJ	59
Annotated	1586	236	DAT	183	INF	31
Unique forms	184	59	VPRT	143	MWE	9

The discrepancy between *Candidate* and *Annotated* targets is explained in § 4.4

4.2 Training of Annotators

First, annotators were sensitized to the class of word forms and meanings introduced in § 3 (e.g., by asking questions like “In your own words, how would you describe the meaning of adposition p in sentence X ? How is it different from the meaning of p in sentence Y ? How is it different from preposition q ?”). Then the general annotation procedure with SNACS was demonstrated by means of individual and relatively simple examples. Finally, annotators were asked to self-learn how to apply the written guidelines to sample data. This was complemented with feedback from the first author (= annotator A) and discussions among the annotators.

4.3 Details on Annotators and Annotation Procedure

The annotation process so far has been divided into two main stages with distinct sets of annotators and different versions of the inventory and guidelines, which we call v0.1 and v0.2:

v0.1 Four trained annotators (A, B, C, and D) annotated all 27 chapters of the *Little Prince* in paid work over five months (January–May 2019). All four are fluent in German, though only A and B are native speakers. A and D have advanced training in computational linguistics and B is experienced in teaching German. Each adpositional target was annotated by two annotators independently, and disagreements were resolved (adjudicated) by a third, impartial annotator. There was no full-fledged German-specific guidelines document yet, so the English/general guidelines v2.0 [60] along with lists of German examples were used. Annotators were asked to translate the relevant text snippet into English and look for a matching or closely related example in the guidelines. The translation did not need to be literal, but it was required that the adposition’s object and governor also be mentioned in the English translation and reflect the same scenario and role as in the German sentence.

These instructions are obviously quite complicated and demanding, leading to rather low agreement among the annotators (~40% average raw pairwise agreement on both scene

role and function). We therefore made several changes to the workflow and started developing detailed German-specific guidelines. Independently, the SNACS sense inventory and general guidelines were updated multiple times [29,64]. In order for our analysis to reflect this more current and reliable version of the framework, we conducted another round of annotation.

v0.2 Three trained annotators (A, E, and F) annotated five chapters (1–3, 6–7) in voluntary, unpaid (E and F) / paid (A) work over one month (August 2020). All three are native German speakers and computational linguistics students. Each target was annotated by all three annotators independently in three explicit steps: (1) identifying the semantic argument and head of the adposition, (2) assigning the argument’s scene role with respect to the head, (3) assigning the adposition’s function. A German-specific guidelines document (in statu nascendi) was used, containing detailed explanations and examples of functions of German adpositions, and referring to the English/general guidelines v2.5 [62] for scene roles, which are expected to transfer across languages. This procedure resulted in much better agreement.

In Table 1 we give an overview of annotation targets—broken down by morpho-lexical categories (LexCats, as defined in § 3.2)—in the full corpus, most of which has not been updated to v0.2 yet. In the detailed analyses below, we focus on v0.2 as it uses the most current version of the SNACS inventory and annotations are more reliable.

4.4 Governed, Opaque, and Unresolved Targets

It turns out that not all of the targets made available for annotation carry equal amounts of semantic weight. At the lower end of this spectrum are two particular phenomena that are intentionally not fully captured by our current scheme:

- *Governed usages* These are core arguments of verbs whose adpositional marking does not add any additional semantics. We annotated them as **THEME** (64 in v0.1, 7 in v0.2).
- *Opaque targets* In order to achieve high recall, we make all verb particles and dative pronouns available for annotation and rely on annotators to filter out the false positives, such as semantically bleached VPRTs and purely grammatical reflexive DATs (67 in v0.1, 8 in v0.2).

Additionally, 62 targets in v0.1 could not be resolved even after adjudication. Opaque and unresolved cases are excluded from the set of annotated targets in the remainder of this section.

4.5 Inter-annotator Agreement

We show different measures of agreement between annotators in Table 2. We observe average Cohen’s κ values of .50 on the scene role and .64 on the function (“moderate”

Table 2 : Inter-annotator agreement rates in a v0.2 sample (chapters 6 and 7) consisting of 95 adposition tokens (28 unique lemmas)

	N	Avg. Pairwise IAA		≥ 2 Agree	
		Role (κ)	Fxn (κ)	Role	Fxn
Exact	47	.51 (.50)	.70 (.64)	.87	.96
Depth-2	24	.59 (.61)	.80 (.76)	.90	.99
Depth-1	3	.76 (.64)	.90 (.82)	.99	.99

We show both averages of pairwise agreement (raw and Cohen’s κ [12]) and the proportion of targets for which at least (any) two annotators agree, at different levels of supersense granularity (N is the number of available sense types at each level)

according to Landis and Koch [39]), which highlights the difficulty of the task and suggests that there are still improvements to be made to the scheme and/or annotator training. The hierarchical structure of SNACS allows us to conflate supersenses at different levels of granularity. Agreement is much higher with a coarsened sense inventory (up to .64, 0.82 with fully flattened hierarchy), showing that annotators generally understand the **CIRCUMSTANCE/PARTICIPANT/CONFIGURATION** trichotomy and disagreements tend to be on finer-grained and thus more difficult distinctions.

In the vast majority of cases, 2 out of 3 annotators agree. This is a good indicator for the general validity of our scheme. The discrepancy between this and pairwise agreement measures suggests minor but systematic individual differences between annotators’ interpretative tendencies, such that any one pair of annotators may have consistent disagreements.

Overall, our agreement numbers are comparable with those of Shalev et al. [64] (English, Wikipedia) and Müller et al. [51] (German, newswire), but substantially lower than the ones reported in Schneider et al. [61] (English, *Little Prince*) and Peng et al. [53] (Chinese, *Little Prince*). Potential reasons for this might be different levels of annotator expertise as well as logistical details and available resources in carrying out the annotation. Additionally, it is not inconceivable that the set of linguistic phenomena we include (e.g., datives, verb particles) or even certain properties of the German language itself (e.g., attachment ambiguity, inflection) are genuinely more difficult to disambiguate.⁵

4.6 Analysis

We show the most frequent adposition types among the v0.2 corpus in Table 3. Under ‘LexLemmas’ we conflate all morpho-lexical variants of a single adpositional lexeme (‘unique Forms’ column, e.g., inflection of POSS and

⁵ The moderate agreement also suggests that the task in its current form is likely too difficult for crowd workers without either a background in linguistics or close supervision by a project manager. Alternative task formulations that facilitate crowdsourcing have been proposed by Gessler et al. [20].

Table 3 : 10 most frequent adposition types in the v0.2 portion of our German corpus

LexLemma	Approx. transl.	#	unique...		
			Forms	Roles	Fxns
POSS		42	14	7	2
DAT		30	5	6	1
in	‘in, into’	19	1	6	3
von	‘from, by, of’	16	1	6	1
auf	‘on (top of), onto’	14	1	6	3
als	‘than, when, as’	13	1	4	3
mit	‘with’	12	1	7	4
an	‘on, at’	10	4	6	3
zu	‘to, too’	9	2	5	3
wie	‘like, as, how’	9	1	4	1
Total		236	59	31	25

DAT pronouns; PAV and VPRT versions of PREPs). All of the listed target types fill various different semantic roles, depending on context. Interestingly, LexLemmas that are traditionally classified under multiple syntactic categories, like *als* and *wie*, appear to be less semantically ambiguous (4 unique roles across 2 main branches: CIRCUMSTANCE and CONFIGURATION) than, e.g., POSS and *mit* (up to 7 unique roles across 2–3 main branches). Most lemmas can also bear different lexical functions.

In the left part of Table 4 we list the most frequent supersenses, separately for scene role and function annotations. Next to LOCUS and TIME, the adpositions in our corpus frequently mark the MANNER (*wie, in, als, auf, ohne*), EXPERIENCER (DAT, *für*), and TOPIC (*über, von*) of a scene.

4.6.1 Datives

Our inclusive approach to analyzing dative semantics together with adpositions and possessives in a single shared framework allows us to gain deeper insights into where the German

dative overlaps with other forms and meanings, as well as empirically confirm theoretical findings about case polysemy. This is a novelty, both compared to previous applications of SNACS and in the German-specific literature.

Almost all of the 30 datives annotated in v0.2 of our corpus are split relatively evenly between the RECIPIENT (12), EXPERIENCER (9), and BENEFICIARY (6) scene roles. Examples are given below.

- (1) Sie haben **mir**:RECIPIENT geantwortet
they have me.DAT responded
‘They responded to me’
- (2) Dabei half **mir**:BENEFICIARY~>RECIPIENT die Geographie
at.that helped me.DAT the geography
‘Geography helped me with that’
- (3) So absurd es **mir**:EXPERIENCER~>RECIPIENT erschien
as absurd it me.DAT appeared
‘As absurd as it seemed to me’

This semantic domain overlaps with those of other forms, most prominently *für* (BENEFICIARY, EXPERIENCER), *zu/an* (RECIPIENT), and possessives (EXPERIENCER):

- (4) so sagte ich schlecht gelaunt **zu**:RECIPIENT dem Männchen
so said I bad tempered to the little man
‘so I told the little man, in a bad mood’
- (5) Dabei ging es **für**:EXPERIENCER~>BENEFICIARY mich
at.that revolved it for me
um Leben und Tod
around life and death
‘This was a matter of life and death for me’
- (6) **meine**:EXPERIENCER~>GESTALT Panne
my hitch
‘the failure [of my plane]’

These empirical findings are in line with Malchukov and Narrog’s [44] typological work on case polysemy. They point out that the dative has historically evolved from benefactive and directional cases. In argument structures corresponding to causal chains, such as transfer, the dative or indirect object is usually situated at the literal ‘receiving end’ of the chain. Haspelmath’s [24] semantic map for the dative domain thus

Table 4 Most frequent supersense types in our German corpus, the English STREUSLE corpus, v4.3 [61], and the Mandarin Chinese Little Prince corpus [53]

German				English				Chinese			
Role	%	Function	%	Role	%	Function	%	Role	%	Function	%
LOCUS	11.4	LOCUS	17.5	LOCUS	11.7	GESTALT	15.0	LOCUS	31.6	LOCUS	34.7
MANNER	6.8	RECIPIENT	12.9	PURPOSE	6.6	LOCUS	14.6	TIME	10.6	TIME	9.2
EXPERIENCER	6.8	GESTALT	12.5	TIME	6.5	PURPOSE	7.4	THEME	7.9	DIRECTION	8.4
TOPIC	6.4	SOURCE	7.9	POSSESSOR	5.9	GOAL	7.0	RECIPIENT	7.8	THEME	7.9
TIME	6.4	GOAL	6.7	GOAL	4.3	POSSESSOR	6.5	EXPLANATION	5.9	EXPERIENCER	6.3

Shaded cells indicate language-specific functions

includes DIRECTION, PURPOSE, RECIPIENT, EXPERIENCER, BENEFICIARY, the *dativus iudicantis* (e.g., *das ist mir zu warm* ‘this is too hot **for me**’, subsumed by EXPERIENCER in our scheme), as well as external and predicative POSSESSORS (e.g., in Russian and French).

Many languages (other than German) feature differential object marking, where a single ‘dative-accusative’ case is used for both RECIPIENTS and PATIENTS. This is the case, e.g., in English pronoun morphology, in alternation with the *to*-dative:

- (7) a. she gave **me** the drawing
b. she gave the drawing **to me**

Similarly, syncretisms between directional and (stative) locative adpositions can be found in French and several Altaic languages, or between dative and genitive case in Australian and Austronesian languages [44].

4.6.2 Cross-linguistic Comparison

In Table 4, we also contrast the head of the supersense distribution in our corpus with SNACS analyses of English [61] and Chinese [53]. Unsurprisingly, LOCUS and TIME are consistently in the top-5 scene roles across all three languages. LOCUS and similar senses such as GOAL and DIRECTION are also frequent function values cross-linguistically, but otherwise the distributions diverge quite a lot.

This is expected for the function, as grammatical constraints and lexical preferences are heavily language-dependent. Supersenses that only occur as function labels in a subset of languages are shaded in Table 4. In particular, these are the GESTALT and POSSESSOR functions of possessives in German and English, the RECIPIENT function of datives in German, and the EXPERIENCER function in Mandarin Chinese. That SOURCE occurs more often as a function in German than in the other languages is because this includes almost all uses of the frequent adpositions *von* (including passive subjects) and *aus*.

On the other hand, the diverging scene role distributions may be due to topical differences between the annotated text samples. And even when expressing the same or similar meaning relations, languages vary in when and how they rely on using adpositions, as can be seen in the following examples:

- (8) a. Riesenschlangen verschlingen ihre Beute **in** einem Stück
giant.snakes swallow their prey in one piece
b. Boa constrictors swallow their prey **whole**
- (9) a. **Sein** Heimatplanet ist der Asteroid B-612
his home.planet is the Asteroid B-612
b. The planet he came **from** is Asteroid B-612

5 Impact on AI Applications—Three Case Studies

With our adapted annotation scheme, annotated corpus, and newly gained empirical insight, we lay the groundwork for applying SNACS supersenses to a variety of downstream tasks in German-speaking environments. To illustrate potential use cases, we discuss below three concrete scenarios involving human-robot interaction, machine translation (MT), and computer-assisted language education.⁶

5.1 Human–Robot Interaction

Adpositions and case are hard to interpret and act upon! Reasoning and communicating about objects in the real world comes natural to us as human beings, as we intuitively acquire embodied representations of scenarios, which deeply affect our language (see § 2.3). In contrast, enabling a robot to engage in dialogue about its tasks, goals, and methods requires facilitating its symbolic and geometric reasoning about its environment first [22, *inter alia*]. Since a robot’s executive and communicative faculties are not inherently intertwined in the way a human’s are, its NLU representations and mechanisms need to be carefully engineered and tailored to its intended domain of application [45,79]. It should be able to recover from fail states [34] and generate explanations about its own reasoning when prompted [67]. Such a framework, based on Abstract Meaning Representation [3], has recently been proposed by Bonial et al. [6].

As we have shown in § 3 and § 4, circumstantial, configurational, and participant relations are frequently expressed with adpositions and case in German. Here we look at a few examples where understanding this kind of language is crucial for successful task execution.

In this first exchange, the user requests a spatial transfer action from a mobile robot. She chooses to designate the RECIPIENT with a dative pronoun.

- U: Fido, bring **mir:RECIPIENT** ein Glas Wasser!
Fido, bring me a glass of water!
- R: (Zu) wem:**RECIPIENT** soll ich das Wasser bringen?
Wohin:**GOAL**
To whom/where should I take the water?

It is reasonable for the robot to ask a grounding question about the RECIPIENT or GOAL of the transfer, provided it correctly identifies the scene-specific roles of the entities involved.

Consider now an alternative scenario with a stationary robot capable of producing artwork:

⁶ These thought experiments are in their style and purpose inspired by Trott et al. [70].

Table 5 : Examples of adpositional expressions translated by an automatic system, along with the scene roles of plausible, intended (asterisks), and chosen semantic readings

User input	System output	Plausible Scene Role(s)	Chosen	Function
1. <u>Unter</u> den Brettern war ein Schatz.	There was a treasure <u>under</u> the boards.	LOCUS*	LOCUS	LOCUS
2. <u>Unter</u> ihnen war mein Schatz.	My darling was <u>among</u> them.	WHOLE*, LOCUS	WHOLE	LOCUS
3. <u>Unter</u> den Rosen war ein Schatz. Target: <u>Under</u>	<u>Among</u> the roses was a treasure.	WHOLE, LOCUS* (buried beneath the roses)	WHOLE	LOCUS
4. <u>Unter</u> den Rosen war mein Schatz. Target: <u>Among</u>	<u>Under</u> the roses was my sweetheart.	WHOLE*, LOCUS (the Little Prince is in love with a personified rose)	LOCUS	LOCUS
5. Hier ist das Bild mal <u>nachgezeichnet</u> .	Here the picture is drawn.	TOPIC*, PATH, FREQUENCY	N/A	DIRECTION
6. Hier ist das Bild <u>nachgezeichnet</u> .	Here the picture is drawn.	TOPIC*, PATH, FREQUENCY	N/A	DIRECTION
7. Hier habe ich das Bild mal <u>nachgezeichnet</u> .	Here I have drawn the picture <u>again</u> .	TOPIC*, PATH, FREQUENCY	FREQUENCY	DIRECTION
8. Hier habe ich das Bild <u>nachgezeichnet</u> . Target: Here is a <u>copy</u> of the drawing.	Here I have <u>traced</u> the picture.	TOPIC*, PATH, FREQUENCY (a new drawing modeled after the original)	PATH	DIRECTION

U: Dali, zeichne **mir**:BENEFICIARY ein Schaf!
Dali, draw me a sheep!

*R: (Zu) wem:RECIPIENT soll ich ein Schaf zeichnen?
Wohin:GOAL
To whom/where am I supposed to draw a sheep?

R: Gerne zeichne ich ein Schaf für:BENEFICIARY dich!
I'm happy to draw a sheep for you!

Here the same dative construction marks the BENEFICIARY: the product will benefit or be dedicated to the user. Given the user's communicative intent, selective preferences of the verb *zeichnen* 'to draw' corresponding to expectations about the evoked action of drawing, and of course the robot's physical abilities, a grounding question involving the RECIPIENT or GOAL of a transfer would be inappropriate. If, instead, the robot indicated that it successfully disambiguated the user's contextual role, the immersive experience would be greatly enhanced. However, this would constitute an extra requirement on the language interface design that goes beyond mere practical functionality since, in contrast to the previous example, the user is not part of this robot's actionable environment.

In order to avoid such misinterpretations, we recommend integrating supersense information into robots' language understanding (and generation) modules. There are many methodological options for doing this. E.g., one could train and run an explicit supersense tagger in conjunction with a semantic parser [55], or directly optimize an end-to-end language model with respect to the latent posterior distribution of supersenses [42]. At least a subset of supersenses (e.g., LOCUS, GOAL, RECIPIENT) could also be explicitly mapped to a robot's extra-linguistic, i.e., visual and navigational representations.

5.2 Machine Translation

Adpositions are hard to translate! Hashemi and Hwa [23] found that prepositions were consistently among the largest sources of errors in texts automatically translated into English from German, Czech, Spanish, and French in the WMT 2012 shared task [9]. At the time, this problem was addressed, e.g., by Weller et al. [74,75], who explicitly modeled semantic properties of prepositions and case in English-German translation. With the transition from statistical to neural MT (NMT), large pretrained transformer models have had great success in both quality and accessibility of fast automatic translation, though this by no means solves the problem entirely [54].

It is not hard to come up with examples of simple sentences whose adpositions confuse even industry-leading machine translation systems. A well-known freely available transla-

tion system⁷ has no trouble disambiguating the different senses of *unter* (‘under’/‘among’) in sentences 1 and 2 shown in Table 5, but struggles with producing the intended interpretations of sentences 3 and 4.⁸

Which interpretations of *unter*—and thereby of the described scene—are available depends on the entity types of the subject (or conceptual trajector) *Schatz*, and the respective prepositional objects (or landmarks) *Brettern*, *ihnen*, *Rosen*. If trajector and landmark are of matching types (in terms of animacy, likelihood to be perceived as valuable, ...), the metrological sense (**WHOLE**) is more likely; and conversely, if certain expectations about size, shape, position etc. are (plausible to be) met given the description of the scene, the spatial sense (**LOCUS**) might be preferable. In our case, *Bretter* ‘boards’ are—rather unambiguously—inanimate objects with a certain prototypical size, shape, and purpose; *Rosen* ‘roses’ are plants to which culturally a high level of beauty or pleasantness is ascribed; *Schatz* can either be ‘treasure’, an inanimate but valuable object, or ‘sweetheart’, a highly-valued animate sentient entity; and *ihnen* ‘them’ is a pronoun that may assume the type of whatever entities it refers to.

An automatic system with access to massive amounts of raw text may well be able to pick up on such patterns purely based on having observed millions of similarly structured examples involving similarly distributed vocabulary, and so on. Yet, such a system clearly lacks any conceptual representation of the relations that hold between boards, treasures, roses, and sweethearts, neither in the real nor the metaphorical world—it chooses a statistically likely translation for the string *unter* given the other word strings and its model of word strings, without ever understanding what the strings mean.

This shortcoming becomes even more apparent in sentences 5–8. Sentence 5 is taken from the first chapter of our annotated Little Prince corpus, and slightly manipulated without dramatic changes to its meaning in sentences 6–8.⁹ The system outputs vary wildly in how the verb particle *nach* is expressed (sentences 7 and 8), if at all (no part of the generated translations of sentences 5 and 6 corresponds to *nach*), even though we would expect near-identical translations for all four versions. The adposition *nach* itself is highly ambiguous, allowing both spatial **DIRECTION** and temporal **INTERVAL** function readings, each with multiple associated

scene roles. As a verb particle in *nachzeichnen* (lit. ‘draw after’) it can be translated as ‘to trace’ (emphasizing the **PATH** of the drawing motion), ‘to draw again’ (emphasizing the **FREQUENCY** of repeated drawing events), or ‘to make a copy’ (emphasizing that the content or **TOPIC** of a newly produced artwork resembles the existing one). These interpretations are all fairly similar, but their fine profiling distinctions are obvious to human readers.

Adding information about adposition supersenses to an automatic translation system, either as additional training data, or as an ontological resource at prediction time, could thus improve its adequacy, consistency, and fluency. As with the human-robot interaction scenario, the idea is to encourage the model to account for the adposition and its meaning in relation to the rest of the utterance, commit to an overall consistent and likely analysis, or at the very least recognize the potential for ambiguity and in turn suggest plausible alternative outputs.

5.3 Language Teaching and E-learning

Adpositions are hard to learn and teach! Adpositions and case are seldom the focus of automated or computer-assisted language teaching (or language instruction at all), and when they are, the learner is often just referred to lists or rules(-of-thumb), making it difficult to truly internalize their meaning [37,49,50,69,78]. This difficulty and, therefore, the need for high-quality pedagogy are highlighted in the academic literature, e.g., in DeHaven’s dissertation on German two-way prepositions [15], Vyatkina [73] on German verb-preposition collocations, and Gradel [21] on the German case system.

To improve instructional methods, many researchers argue for cognitive and conceptual approaches where learners are encouraged to engage directly with the meaning of grammar rather than just the form [14,21,78].

We thus suggest equipping learning software with knowledge about the role/function distinction and conceptual semantic representations of adpositional expressions such as ours, in order to provide much more direct feedback to learners, for instance by retrieving concrete exemplars from a corpus or database.

6 Conclusion

We adapted the SNACS semantic annotation scheme to the analysis of German adposition and case semantics and piloted it in a novel corpus that will be released to the research community. Our framework is more comprehensive than previous approaches: alongside “classic” prepositions it includes several of their morphological variants as well as possessive and dative pronouns. By discussing examples and their SNACS analyses in the context of concrete NLP applications, we

⁷ Google Translate

⁸ The examples here are cherry-picked, and especially sentence 4 requires specific background knowledge, without which no automatic or human translator is expected to generate the intended output. However, by demonstrating that subtle differences in lexical meaning—even and especially that of adpositions—can have a dramatic impact on sentence meaning, we argue that translation systems that lack semantic awareness and nuance are inherently unreliable and prone to inconsistencies.

⁹ *mal* is a modal particle establishing that the scene ‘just happens to unfold this way’.

hope to have convinced the reader of the importance of treating these phenomena with proper care for the future of AI.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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