On the Distributed Morphology of Spatial Prepositions and Anaphors

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Abstract

This paper presents a Distributed Morphology approach to the morphology and semantics of spatial prepositions (in front of) and anaphors (here), complete with a situation semantics interpretation. The proposal is shown to account both known and recalcitrant data, such as anaphoric relations between elements of the two categories.

1. Introduction: why a Distributed Morphology of Spatial Ps and As

Within Minimalism, Distributed Morphology (henceforth: DM) is perhaps the proposal that offers the most thorough analysis of the morphology-semantics mapping. This fact can be seen as stemming from two kernel assumptions that underpin DM. First, the operation merge recursively combines sets of bundled features (traditional “morphemes”) into larger units such as words, phrases and sentences (Halle and Marantz 1993; Embick and Noyer 2006; among others). Second, this morphological output is mapped onto the semantic component, and operations such as function application determine the interpretation of morphemes, in a compositional way (Harley 2010, 2012). Hence, DM offers a simple theory of the morphology-semantics interface.

However, current analyses mostly focus on the nominal and verbal domains (Harbour 2007; Harley 2010). Other categories, such as prepositions and adjectives, are seldom discussed in thorough detail. Furthermore, DM proposals usually rely on pre-minimalist semantic analyses, which may not be directly suited for a compositional treatment in a DM framework.

The main goal of this paper is to fill part of this empirical void. We offer a DM fragment complete with a specifically tailored situation semantics, and test it on the macro-class spatial P (Svenonius 2010). We concentrate on English Spatial Prepositions (SPs) and Spatial Anaphors (SAs), on which few DM proposals exist (cf. Thomas 2004). Consider examples (1)-(3):

(1) Mario is in front of the hill
(2) Mario is here
(3) *Mario is here (here=in front of the hill)

* The first author would like to thank Captain Harlock for the inspiration, and his princess for her support. The usual disclaimers apply.

1 For the sake of simplicity, we use the label “morpheme” both for abstract nodes and vocabulary items, here and in the remainder of the paper.
Mario is here inside the car

At first glance, SPs and SAs appear to share a similar interpretation, although they seem to have a different morphological structure. While in front of seems to consist of three distinct morphemes (in, front and of, Asbury 2008), here seems decomposable into at least two morphemes, h- and -ere (Kayne 2007). However, both categories can act as complement phrases of the copula is. Also, both can denote the same position that Mario occupies, provided that here finds its interpretation against an external context (von Fintel 1994: ch.2), as the identity in (2) indirectly suggests. SPs and SAs can also co-occur in a sentence, denoting the same location or position, via an anaphoric relation. In (3), here and inside the car denote the position that Mario occupies, also defined as proximal to the speaker.

Examples (1)-(3) also allow us to outline a brief but concise picture of the multi-faceted problem we must solve, to offer a unified DM analysis of SPs and SAs. At least three facets can be identified. First, current non-DM analyses do not offer a unified analysis of these categories. A sub-set of SPs lacks an analysis of their morphological structure (e.g. inside in (3)), unlike other SPs and SAs. Second, analyses of SAs. Third, semantic analyses of SAs tend to be non-compositional, assuming that elements such as here denote single spatial elements (Creary, Gawron and Nerbonne 1989; Zeevat 1999). Analyses of SPs, instead, are overall compositional, and assume that SPs such as inside the car denote sets of spatial elements (Svenonius 2008). Hence, these analyses do not allow to account the anaphoric relation in (3), as inside the car and here denote non-matching types of model-theoretical objects. Furthermore, SAs are still in need of a compositional analysis that would also be compatible with a compositional analysis for SPs.

Given this multi-faceted problem, our goal is to show that our DM proposal can solve each face of the problem. We show that we can derive the structure and interpretation of SPs and SAs, as well as addressing how their anaphoric relations can emerge in context. We offer this solution by following these steps. In section 2, we introduce some basic notions and data. In section 3, we offer our type-logical variant of DM, paired with a situation semantics interpretation. We offer our analysis in section 4, and conclude in section 5.

2. Basic Notions and Previous Accounts of SPs and SAs

Our goal in this section is to concisely review previous proposals on SPs and SAs, morphological (sections 2.1, 2.2), and semantic alike (section 2.3).

2.1. Basic Notions and Previous Accounts: SPs

Most analyses of SPs tend to share certain morpho-syntactic and semantic assumptions about this category, which can be briefly defined as follows.
Sentences including SPs are usually assumed to denote a relation between a located entity, or figure, and a landmark object or ground (Talmy 2000). DPs are the key elements that introduce these two discourse referents, a notion we import from Discourse Representation Theory (DRT: Kamp, van Genabith and Reyle 2011). SPs are taken to form a phrase with a ground DP, the resulting SP phrase being the complement of a verb (Jackendoff 1983, 1990; van Riemsdijk 1990; a.o.). Some examples are in (4)-(9):

(4) The boy is sitting in the park
(5) The boy is sitting outside the room
(6) The boy is ahead of the car
(7) The boy has gone to the park
(8) The boy has gone towards the car
(9) The boy has gone into the room

SPs are usually distinguished between locative and directional classes. Examples are respectively in, outside, ahead of and in front of, in (1), (4)-(6) and to, towards and into, in (7)-(9) (Cresswell 1978; Jackendoff 1983, 1990). While locative SPs denote a “static”, unchanging position of the figure with respect to the ground over time, directional SPs denote include a dimension of “change”. Classical approaches propose a decomposition of SPs into two syntactic objects, the heads known as Path and Place. This decomposition is based on the existence of SPs explicitly realizing Path and Place heads, such as into, from under, with Path governing Place (Jackendoff 1983, 1990). Other proposals offer a “mirrored” linear order for Path and Place, although the hierarchical order remains unaltered (van Riemsdijk 1990; van Riemsdijk and Huybregts 2007; a.o.). The “lexical Syntax” approach also offers an account of SPs (Hale and Keyser 2002: ch.4; Mateu 2008: ch.1). This proposal does not employ specific labels, but suggests that a relational P takes a DP and a second SP as its complement and specifier, respectively. Hence, it also proposes a “two-headed” analysis of SPs, like other classical approaches.

Recent cartographic approaches have suggested a more fine-grained analysis, based on cross-linguistic findings. They suggest that SPs have a rich internal structure, which involves more than just two distinct morphemes (Asbury 2008; Bortwinik-Rotem 2008; Pantcheva 2008; den Dikken 2010; Svenonius 2010; Terzi 2010; a.o.). We do not discuss all the distinct cartographic approaches at our disposal. We choose the more “conservative” Asbury (2008), to show the various structures:

(10) \[PathP (P) \[PlaceP \[in \[front of \[DP \[the hill \]]]\]\]]\]
(11) \[PathP \[PlaceP \[in \[inside \[of \[DP \[the car \]]]\]\]\]\]\]
(12) \[PathP \[in \[front \[of \[DP \[the car \]]]\]\]\]\]
(13) \[PathP (P) \[in \[front \[of \[DP \[the hill \]]]\]\]\]\]\]

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The structure in (10) shows the structure assigned to the locative SP *in front of* in the classical approach. A phonologically null Path head, represented as “(P)” is merged with the Place head *in front of*. The structure in (11), instead, shows “mirror” approaches such as van Riemsdijk (1990), which also involve the movement of the ground DP *the car* in the complement position of the Path head. The “lexical Syntax” analysis in (12) differs in forsaking labels, and offers a similar structure to (11), minus DP movement. The structures in (13)-(14), based on the cartographic Asbury (2008: ch.1), show that each SP morpheme projects a distinct head. Hence, *in, front and of* project each a head: Place, the novel Axpart and Kase heads, respectively. As in classic approaches, directional SPs such as *into* are derived via head movement of Place *in*, adjoined to the Path head *to*. Hence, it can be said that cartographic approaches refine classical ones, via a more fine-grained analysis of SPs.

Example (15) plays an important role in our discussion. It shows that cartographic approaches treat SPs such as *inside* as single morphemes projecting an Axpart head, not unlike previous approaches (cf. (10)-(12)). However, a known fact is that *inside* and other “axial” SPs such as *behind, around, below, under* and several others seem to involve two distinct, although conflated morphemes (Huddleston and Pullum 2002: 608-610). Some cartographic works make similar remarks, but leave aside a possible analysis (Svenonius 2006: 79-84, 2010: fn.5; Pantcheva 2008: 310-314 on Persian; den Dikken 2010: 80-82 on Dutch). We call these understudied elements “Complex SPs”, a theory-neutral label. A partial list is in (16):

\[
\text{(16) Complex SPs: } \{\text{in-side, out-side, be-side, be-hind, be-between, be-tween, un-der, in-to, to-wards, out-wards, a-round, a-top, a-cross,} \ldots\}\]

This last set of data opens an interesting problem. While cartographic approaches seem to offer the most accurate analysis of SPs in the literature, they nevertheless fall silent on this sub-set of SPs. So, an approach that exhaustively covers all the morphological data about this category must still be proposed. Overall, these facts suggest that we have two goals at stake, in offering our DM analysis. A first goal is that of offering an account of the understudied complex SPs. A second goal is to also test this account on other SPs, to verify its soundness. In other words, our DM proposal can (and must) offer a more precise and thorough account of SPs, than the current accounts.

2.2. Basic Notions and Previous Accounts: SAs

SAs include distinct parts of speech that can have two closely related functions. A first is that of referring to the external context, and express
implicit spatial information (cf. (3)). A second function, on which we mostly focus our discussion, is that of establishing anaphoric relations with SPs, directional and locative alike (Jackendoff 1983: ch.3; Diessel 1999, 2012). Examples include spatial indexicals here and there (Creary et al. 1989; Kayne 2004, 2007; Diessel 2012), and pro-forms where, somewhere, anywhere (“r-pronouns”: van Riemsdijk 1990; den Dikken 2010). Anaphoric readings are particularly evident when an internal context is defined (von Fintel 1994: ch.2), such as a sentence containing and SA and an explicit SP antecedent (cf. (3)). SAs can co-occur with SPs and apparently form a Phrase, possibly involving a distinct prosodic contour, orthographically marked with a comma. Furthermore, SAs share with SPs the property of occurring in subject position, a phenomenon often known as locative inversion (den Dikken 2006: ch.3).

Examples that illustrate these properties are (17)-(24):

(17) Mario lives in Stockholm, and Luigi lives there, too (there= in Stock.)
(18) Mario lives in Stockholm. Luigi lives there, too (there= in Stock.)
(19) Luigi is sleeping here, inside the tent
(20) Here it is warm but not hot, in summer (here= in Stockholm)
(21) Here under the bridge lie the old boats
(22) In Stockholm is warm but not hot, in summer
(23) Mario is sitting somewhere (somewhere= in an indefinite place)
(24) Somewhere in Stockholm, Mario is enjoying fika

Examples (17)-(18) show that there can have an intra- or inter-sentential antecedent (in Stockholm), which determines its interpretation, via an anaphoric relation. Again, this relation is represented as the identity within brackets. Example (19) shows that SPs and SAs can co-occur in a sentence, possibly with a certain prosodic contour to mark this structure. Furthermore, examples (20)-(22) respectively show how SAs, combinations of SAs and SPs, SPs can occur in inverted position. The distribution and semantics of an r-pronoun such as somewhere, as (23)-(24) show, follows that of indexicals here and there, hence justifying the unification of these elements under the SA rubric. The gloss we propose in the brackets, in (23), also suggests that r-pronouns seem to involve the presence of a silent “place” noun-like element (Kayne 2004; Pantcheva 2008). As these data show, SAs seem to share key properties with SP phrases. They can occur in both argument positions of verbs, and denote spatial content. Also, SAs can, and perhaps must, enter in anaphoric relations with SPs, in the opportune licensing contexts.

Aside these key properties, classic and recent analyses of SAs have also investigated their morphological structure in some detail. The classic Katz and Postal (1966: 128-137) suggests that here and there, among others, are “lexical” adverbial phrases, equivalent in structure and meaning to at this/that...
place (here, there, respectively). A null P head combines with a noun phrase, itself a combination of a determiner and a null “Place” pro-nominal form, to form an adverbial phrase. This analysis does not assign specific morphemes to each position, as it assumes that this structure exists at a deep structure level. Modern cartographic analyses, instead, propose an explicit morphological, hierarchical structure for SAs (Kayne 2004, 2007; Pantcheva 2008). For instance, Kayne (2007) observes that there shares the morpheme th- with other demonstratives and determiners (e.g. th-ose, th-is, th-at, th-e). Similarly, he suggests that g-ere also occurs in other r-pronouns such as h-ere, wh-ere, every-wh-ere, and can be further decomposed in the morphemes -e- and -re. The structures that Katz and Postal (1966), and Kayne (2007) propose are in (25)-(28). The symbol “→” reads “it is decomposed as”:

(25) here/there → [AdvP (at) [NP[DetP the+PROX/DIST] [Npro (Place)]]]
(26) here/there → [Place[Loc[Deix h-th- ] -e- ] -re ] (Place) ]
(28) [DeixP[ here ] (P) [PathP inside [or the tent ]]]

The structure in (25) illustrates Katz and Postal (1966)'s treatment of here/there, while the structures in (26)-(27) illustrate Kayne (2007)'s cartographic analysis. Each morpheme, including the nominal-like wh- and some-, projects a head (e.g. Det, Deix for “Determiner”, “Deixis”). In each analysis, a null “(Place)” head acts as the topmost head, and labels an SA as an inherently spatial element. So, SAs seem to have complex structures, as also suggested for categories such as quantifiers (Szabolczi 2010: ch.10). While these proposals do not directly analyse phrases involving SAs and SPs, some cartographic approaches can offer an elegant analysis of these structures, as shown in (28) (cf. Svenonius 2010: 130-134). An SA is merged in the specifier position of a null Deix head governing a Path head. The result is a Deix phrase such as here inside the tent, as (28) shows, in which a syntactic and semantic relation between here and inside the tent is established.

Overall, these analyses seem to offer quite accurate accounts of the fine-grained structure and distribution of SAs. In doing so, though, they indirectly raise two problems. First, if SAs can merge in argument position, then they should analysed as phrases, rather than heads (cf. (26)-(27)). Second, if SAs contain a Deix head, then an apparent linearization problem between this and the “main” Deix head emerges, as (28) indirectly suggests. Hence, or DM proposal must improve upon previous proposals that attempt to analyse the structure of SAs, as well as that of SPs.

2.3. Basic Notions and Previous Accounts: Semantics and Desiderata

Our discussion so far suggests that SPs and SAs are inherently phrasal units,
which can act as arguments of verbs. The simplest assumption about their semantics, then, is that both categories would denote single, specific referents of some sort. Works on indexicals indeed suggest that here and there can denote specific regions of space, “places” where the figure is located (Creary et al. 1989; Caponigro and Pearl 2008). Furthermore, DRT accounts suggest that indexicals can also establish anaphoric relations, identity relations between spatial referents (Zeevat 1999; Maillat 2001; Kamp et al. 2011). However, works that investigate the semantics of SPs take a different tack, and propose that SPs denote spatial relations. Given this basic assumption, SPs denote a relation between figure, ground and a set of spatial referents (Nam 1995; Zwarts and Winter 2000; Svenonius 2008; Kracht 2008). We sketch the interpretations for in front of the hill and here in (29)-(30):

(29) [[ in front of the hill ]]:=λv.(ext'(h,v)∧front'(h,v))
(30) [[ here ]]:=p:place'(p)?=?
(31) here=in front of the hill:= p:place'(p)=λv.(ext'(h,v)∧front'(h,v))=#

Example (29) is a simplified denotation based on the “vector space semantics” approach (Zwarts and Winter 2000; Svenonius 2008). It says that in front of the hill denotes a set of vectors v that is oriented outwards, with respect to the frontal axis of the hill h, and ends at the figure (cf. Svenonius 2008: 66-68). The simplified denotation in (30) is adapted from DRT approaches (Zeevat 1999: 72-75; Maillat 2001). It says that here denotes an anaphoric (identity) relation between a “place” referent, and a relevant, but unspecified antecedent in context (i.e. the place-holder “?”). Example (31) illustrates that, if we combine the analysis in (29) and (30) via standard (DRT) assumptions about anaphora resolution, then the result will be uninterpretable (represented as “#”). Leaving aside ontological and lexical matters, we observe that if SPs denote sets of spatial referents and SAs specific, singleton referents, then no anaphoric relation can be established between ill-matched referent types. Hence, data such as (3), (17)-(24) become unaccounted for.

A non-trivial problem that complicates matters further is the lack of a compositional analysis for SAs. Recent works on SPs show that an interpretation such as (29) can be obtained compositionally, by combining the interpretation of in, front and of (Svenonius 2008; Kracht 2002, 2008). Analyses of SAs simply lack this level of fine-grainedness, in part because they are couched in DRT. So, if we rely on current semantic analyses of both categories for our DM analysis, then we cannot offer a compositional, coherent approach to their semantics, including their anaphoric potential. As matters stand, our multi-faceted problem takes shape as a problem of offering a correct, compositional and unified account of SPs and SAs, stemming from their morphological analysis. The next two sections offer our solution.
3. The Proposal: Morphological and Semantic Assumptions

The goal of this section is to present the apparatus that we employ in our analysis of the data (Ursini 2011, 2013a, b). We first offer our variant of DM, which we label “type-logical DM” (section 3.1). We then offer an interpretation couched into a situation semantics approach (section 3.2).

3.1. The Proposal: morphological assumptions, and type-logical DM

Our discussion in section 2 has highlighted three crucial desiderata that we must pursue, for a unified analysis of SPs and SAs. First, our derivational focus must be on the “types” of morphological units that make up these categories, rather than their precise linear order. Second, our analysis must also capture the fact that both SAs and SP phrases can act as arguments. Third, our analysis must account the structure of the still unaccounted complex SPs, and that of SAs as well. For this purpose, we adopt some core assumptions of type-logical grammar types of calculi (Jäger 2005; Moortgat 2011; Morrill 2011; Steedman 2012; a.o.). We defined the key notions that we employ.

In type-logical calculi, morpho-syntactic categories are mapped onto types, which are represented as being either “complete” or “incomplete” information units. Complete types represent derivational elements that can stand as distinct, independent elements (e.g. np for noun phrases as the girl). Incomplete types are elements that must combine with other elements, to form a complete type. For instance, an intransitive verb such as runs can be assigned type s/np, since it can combine with an np item, the girl. The result is the sentence the girl runs, which is assigned the type s of “sentences”.

We use the connective “/” to represent both the merge operation and “type formation”, in a manner we define below (Moortgat 2011: § 2; Morrill 2011: ch. 1; cf. also Chomsky 1999: 2-4). We define merge as a binary, associative operation. We only implement the right-associative version of merge, which we label merge right, and assume that derivations compute information about types in a top-down manner. Hence, we assume that figure DPs are merged with verbs “before” ground DPs are merged, or that here is merged before inside the tent, in (19). This assumption will allow us to easily capture the morphological properties of SPs and SAs, and is consistent with psychological models of word-production (Levelt 1989; Phillips 2006; Jarema and Libben 2007; a.o.). We leave aside the possibility that other connectives and “directions” of merge can be implemented (e.g. merge left “\”, Jäger 2005’s connective “|” for anaphors).

We then make a novel assumption on the basic set of atomic types in our lexicon. Standard definitions of atomic types in type-logical calculi take a perhaps naïve view of parts of speech, representing them via types such as np and s (cf. Jäger 2005, Morrill 2011: ch.1). This view is hardly compatible with
current findings and analyses of lexical categories in DM. These analyses suggest that traditional categories emerge as the result of merging category-less roots with category-assigning elements such as little v, p, n (Harbour 2007; Harley 2010, 2012). To represent this key assumption in type-logical format, we choose to employ only one atomic type, from which other types are derived as incomplete types, via type formation. We call this atomic type \( p \), mnemonic for “phrase”. We can now define our closure type, in (32):

(32) 1. \( p \) is a syntactic type (Lexical type)
2. If \( x \) is a type and \( y \) is a type, then \( x/y \) is a type (Type formation)
3. If \( x/y \) is a type and \( y \) is a type, then \( (x/y)/x = y, y/(x/y) = x \) (Type red.)
4. Nothing else is a type (Closure property)

The rules read as follows. From the basic type of arguments/phrases \( p \) (rule 1), more complex types can be defined recursively, via formation/merge (rule 2). Conversely, if one merges a complex type with a simple type, the result will be a “lower” type (rule 3). No other combinatorial options are available (rule 4). Via this set of assumptions, we can generate the minimal set type \( \text{TYPE} = \{p, p/p, p/p/p\} \), with \( p/p/p \) being short for \( (p/(p/p)) \). While \( p \) is the type of phrases/arguments (e.g. the car), \( p/p/p \) is the type of heads qua relational elements (e.g. of). The type \( p/p \) is that of “incomplete” morphemes, a category we will identify in section 4, in more detail.

Via this set of assumptions, we can define the types we assign to our constituents, and also derive SP and SA phrases. We can also abstract away from problems of linearization, as we represent the contribution that morphemes offer in a derivation, rather than their “position”. This will become clear once we define one last aspect. To capture the cyclical nature of our derivations, we define a simple pre-order as the pair of an interval set \( I \), and an addition operation “\( + \)”, i.e. \( <I, +> \). This pre-order represents an index set, which in turn allows to represents the steps in a derivation as ordered elements. We implement two operations, lexical selection and merge introduction, to explicitly note the introduction of a new element in a derivation, and the merge of two elements. A sample derivation is in (33):

(33) a. The girl runs
   b. t. \[ \text{the girl}_p \] (Lexical selection)
      \[ +1. \text{[run}_p \]  \] (Lexical selection)
      \[ +2. \text{[the girl}_p ]/[\text{run}_p ] = [a[ \text{the girl}_p ] \text{run}_p ] \] (Merge introduction)

This simplified derivation reads as follows. A phrasal element, the DP the girl, is merged with a unary operator, the intransitive verb runs. Since the first element is assigned type \( p \) and the second type \( p/p \), the merge of these elements is assigned type \( p \), as a result of this derivational process. Leaving
functional projections aside, this can be seen as the type of the VP that the two constituents form, via merge. Given these assumptions about morphological structures and derivations, we can now turn to the semantics.

3.2. The Formal Apparatus: Semantics

In section 2.3 we observed that semantic approaches to SPs and SAs tend to differ with respect to ontological assumptions, since they assume vectors or regions as possible referents. To side-step a long discussion on ontological matters, we take a more coarse-grained approach. We assume that all of our morphemes denote situations, whether these situations correspond to implicit or explicit referents, and which all belong to a universal set of situations. We then assume that the set of situations is a Boolean algebra, a partially ordered set that also includes an empty situation (Landman 1991, Szabolcsi 1997). We assume that the set of situations can include various sub-types of referents, such as individuals or spatial entities (von Fintel 1994: ch.2; Kratzer 2007; cf. also Kamp et al. 2011: ch. 4). Hence, we assume that SPs and SAs denote “spatial” situations, and remain agnostic on their exact “geometrical” status: whether these situations are vectors, regions or other spatial entities.

We turn to formal definitions. We represent this domain as the set \( S \), of which we study the sub-type \( S' \) of spatial situations. The set \( S' \) includes a denumerably infinite set of elements (i.e. we have \( S' = \{s, r, t, v, \ldots, z\} \)). We use “Quine’s innovation”, and assume that singleton sets represent atomic situations (i.e. \( s \) stands for \( \{s\} \); Schwarzschild 1996: ch.1), while complex sets represent sum situations (e.g. \( \{s, g\} \)). So, all referents are represented as sets, which may or may not be made of distinct parts/sets. The empty situation is thus represented via the empty set \( \emptyset \).

These definitions allow us to define both the possible semantic type set for our structure, and the types of semantic relations defined over this structure, as shown in (34):

\[
(34) \quad \begin{align*}
1. & \text{a is a semantic type} & \text{(Lexical type)} \\
2. & \text{If a is a type and b is a type, then } \langle a, b \rangle \text{ is a type} & \text{(Functional type)} \\
3. & \text{If } \langle a, b \rangle \text{ is a type and } \langle b \rangle \text{ is a type, then } \langle a, b \rangle / \langle a \rangle = \langle b \rangle & \text{(F. a.)} \\
4. & \text{Nothing else is a type} & \text{(Closure property)}
\end{align*}
\]

A minimal set of types generated by this definition is the set \( TYPE = \{\langle s \rangle, \langle s, s \rangle, \langle s, <s,s> \} \). Since we have one basic lexical type and one rule to build up complex types, no (semantic) objects more complex than relations can exist (of type \( \langle s, <s,s> \rangle \): Landman 1991: ch. 2-3). The other two types are those of referents (type \( <s> \)), and functions/one-place predicates (type \( <s, s> \)). Our third definition gives us function application as a rule that allows to “reduce” types. It says what is the type of the constituent that corresponds to the merge of two constituents (e.g. \( <s> \) from \( <s,s> \) and \( <s> \)).
We now turn to interpretive matters. We implement a simple form of $\lambda$-calculus to represent our functions and relations (e.g. Gamut, 1991). Since we are working with Boolean Algebras as our structures of choice, we can define one basic relation over the elements of the domain: the part-of relation. This relation is usually represented as “$a \leq b$”, which reads: “$a$ is part of $b$”. The following properties hold: if $a$ is part of $b$, then $a \cup b = a$ and $a \cap b = b$. In words, if a situation is part of another situation, then their union will be the “bigger” situation, and their intersection the “smaller” situation. As we implement Quine’s innovation for our situations, mereological sum (product) and set union (intersection) become equivalent operations.

For practical reasons, we will use a prefixed notation for this relation, i.e. $P(a,b)$. This basic assumption allows us to represent complex or structured situations simply as: “$\lambda x.\lambda y.s:P(x,y)$”. This reads: a structured situation is defined as a part-of relation $P$ between two basic relations, e.g. a situation representing a ground, and one representing a distance. This relation also shows that structured situations are situations with proper parts, and situations that include relations between these parts (Barwise and Etchemendy 1990; Kratzer 2007; a.o.). The type $<s,<s,s>\Rightarrow$ captures the fact that the result of saturating the two argument slots is that of forming a structured situation, rather than a truth value. We also assume that (1-place) functions can be defined as either characteristic functions for situations (e.g. $\lambda x.s:f(x)$), or as partially saturated relations (Landman 1991: ch.2, Szabolczi 2010: ch.2).

We now define the relation between our syntactic and semantic types. We assume that the following isomorphism is defined, as a general instance of the interpretation function. When two units are merged, function application and $\lambda$-conversion applies; the result is a unit of “lower” type. So, the result of merging a unit with two $p$ units is a Phrase of a “recursive” $p$ type that denotes a structured situation $<s>$. We show the mapping in (35):

$$
\begin{align*}
\text{MORPHOLOGY} & \Rightarrow \text{SEMANTICS} \Rightarrow \text{INTERPRETATION} \\
\text{p/p/p} & \Rightarrow <s<s,s> \Rightarrow \lambda x.\lambda y.s:P(x,y) \\
\text{p/p} & \Rightarrow <s,s> \Rightarrow \lambda x.s:f(x), \lambda y.s:P(x,y) \\
p & \Rightarrow <s> \Rightarrow s, s:P(a,b), s:f(c)
\end{align*}
$$

Since we define all our morphological types as built out of one basic type (i.e. $p$) recursively, the semantic types follow this principle, too, as they are built on the basic type $<s>$. In other words, phrases are mapped onto structured situations, heads onto relations, and morphological segments onto functions. This principled mapping between morphology and semantics is a natural and appealing property of our type-logical approach. The types of interpretations assigned to each unit, instead, bear a resemblance to classic situation semantics approaches (Barwise and Etchemendy 1990; Kratzer 2007, a.o.), or structured
meanings ones (Cresswell 1985). Setting intricate formal details aside, this mapping has one specific virtue: it defines a tight, systematic relation between the “morpho-logical” type of a constituent, and its intended interpretation, as per standard DM assumptions. If this assumption is correct, then we would expect that the data we discussed in section 2 can be accounted for, via the assumptions we highlighted in this section. Section 4 shows if this is the case.

4. The Analysis
The goal of this section is to show how our approach can offer a unified account of SPs and SAs. We do so by first offering a morphological analysis of our data (section 4.1), then a semantic analysis (section 4.2).

4.1. The Analysis: Type-Logical DM and Morphology
We tackle our morphological data by first proposing a type assignment for SPs, then SAs, and then their combination thereof. We first assign the type p of phrases to DPs such as the hill, or the car, as we are not concerned with their internal structure. We then move to SPs, and make three preliminary observations. For silent heads “(P)” and the overt of and to, we can assign them the type p/p/p of heads, a cross-categorial motivated choice (cf. Hale and Keyser 2002; den Dikken 2006: ch.5). For other SP morphemes, we must however assign different types. Our reason is as follows. If we take each morpheme to be a head, of type p/p/p, then a type mismatch would arise at every derivational step involving two such morphemes. That is, the merge of on and top, on top, would be ungrammatical (i.e. \( (p/p)/(p/(p/p)) = * \)), contrary to facts. Hence, we must implement a different approach than the cartographic one, regarding the status of each SP morpheme. Third, SP phrases and SAs can also be “subjects” of a verb, via locative inversion (cf. (21)-(22)). Both must be of type p, given their distribution at a sentential level.

We propose the following analysis, to solve this conundrum. We start from complex SPs (cf. (16)), “axial” terms such as behind, atop, that present a challenge for current analyses of SPs. We have two possible analyses for this category at our disposal. First, we can treat these as heads of type p/p/p, to highlight their apparent status as relational terms. We must immediately exclude this option: the merge of front and of would be ungrammatical. Second, we can assign these terms type p, a choice that seems appropriate. Take ahead of the car from (6), which we assign type p. If the car is of type p and of is of type p/p/p, then ahead must clearly be of type p. We then look at their internal structure, and the types to be assigned to a- and -head. For the nominal elements that form complex SPs (head, hind, side, cross, etc.), type p seems the best choice: we treat them as elements akin to bare NPs (cf. Pantcheva 2008: 322-323; Terzi 2010: 196-201). For the prefix-like segments
such as _a_, _be_, _in_ and similar others, we note the following. If _head_ and _ahead_ are of type _p_, then _a_- must be of type _pp_. Intuitively, we treat these prefix-like elements as “markers” that turn nominal elements into spatial ones (cf. Pantcheva 2008; Terzi 2010; a.o.), the resulting phrasal-like element being one “argument” of, in this case, _of_.

We turn our analysis to SAs. We observe that both _here_ and _somewhere_ (cf. (20), (23)-(24)) must be assigned type _p_, given their phrasal nature. We follow our previous assumption about prefix-like elements (e.g. _some_-, _wh_-,...) and assign them type _pp_. The merge of these morphemes into _here_, _somewhere_ is also assigned type _pp_, via “transitivity” (Moortgat 2011: §2.1; Morrill 2011 ch.1; cf. (38) below). Our problem is how these units turn into phrases, of type _p_. We solve this problem by assuming that the silent (bare) noun _Place_ is assigned type _p_, hence that it acts as the argument of the stacked morphemes of an SA. With these assumptions on the types and structures of SPs and SAs, we can also account the interplay of SPs and SAs. We assume that a silent head “(_P_)” takes elements of these categories as elements, and forms a complex phrase such as _here in the garden_. The resulting, non-exhaustive type assignment stemming from this discussion is defined in (36), whereas three sample derivations are offered in (37)-(39):

(36) a. _p/p/p_ = _{of, to, (P); (P)’,...}_
b. _p_ = _{the car, in front, ahead, head, front, PLACE, here, there...}_
c. _p/p_ = _{in-, a-, be-, on-, h-, th-, wh-, any-, -ere, where, anywhere,...}_

(37) t.

| _t+1._ [ -headp ] | (Lexical selection) |
| _t+2._ [ a/ -headp ] := [p a/ -head p ] | (Lexical selection) |
| _t+3._ [ ofpp ] | (Lexical selection) |
| _t+4._ [ _p a/ -headp ] [ ofpp ] := [ _p _p a/ -head p ] ofpp | (Lexical selection) |
| _t+5._ [ the carp ] | (Lexical selection) |
| _t+6._ [ _p a/ -headp ] ofpp ] [ the carp ] := [ _p _p a/ -headp ] ofpp [ the carp ] | (Lexical selection) |

(38) t.

| _t+1._ [ h/ -erep ] | (Lexical selection) |
| _t+2._ [ h/ -erep ] := [ _p _p h/ -ere p ] | (merge intr.; transitivity) |
| _t+3._ [ (Place)p ] | (Lexical selection) |
| _t+4._ [ _p h/ -erep ] [ (Place)p ] := [ _p h/ -erep ] [ (Place)p ] | (Merge introduction) |

(39) t.

| _t+1._ [ _p/here ] | (Lexical selection) |
| _t+2._ [ _p/here ] := [ _p [ herep ] (P)p/ ] | (Merge introduction) |
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The type assignment in (36) partially shows that specific type assignments can include “basic” and derived items. For instance, both head and ahead are assigned type $p$, as they can both occur as phrases. The same reasoning holds for here, -ere and here and other SAs as elements of type $p/p$, prior to their merging with a null Place element. The derivation in (37) shows that the merge of a- and head results in ahead, which in turn acts an argument of the relational morpheme of. Once the DP the car is merged, as the second argument for of, the full SP phrase ahead of the car is formed (cf. (6)). We take that SPs that lack an overt head, such as behind, follow the same derivational steps, as we assign type $p/p/p$ to “(P)”. We assume that, in general, any SP phrase can be derived via the same type of derivation.

The derivation in (38) shows instead how the structure for here is derived a transitive instance of merge, h- and –ere are merged, forming the type $p/p$ morpheme here, then merged with Place, of type $p$. Both (37) and (38) show that here and ahead of the car are derived as items of type $p$. This allows us to offer a reduced derivation in (39) for here, inside the tent (cf. (19)), in which both are merged as arguments of a silent head “(P)”. As we assume that this head plays a key role in the derivation of the anaphoric relation between these two phrases, we use the prime as a mnemonic device to track its different interpretation from “(P)”. Before we move to the semantic side, three considerations are worth mentioning, briefly.

First, we take an approach to SPs that resembles the P-within-P hypothesis (Hale and Keyser 2002), as one SP is merged as a phrase, in the “specifier” position of the head SP. As in cartographic approaches, we assume that each distinct morpheme can be assigned a distinct position. However, we take a quite more flexible approach to their status, thanks to our type-logical system, and as in works on languages other than English (Greek: Terzi 2010; Hebrew: Bortwinik-Rotem 2008; a.o.). We also think that our analysis of complex SPs is in line with treatments of “small” categories (e.g. v, Harley 2010), with type $p/p$ prefixes acting as category- assigning elements. Furthermore, since we remain agnostic on the specific labels or positions that each morpheme would project, we can leave aside eventual problems of linearization, e.g. the ordering of the Deix heads.

Second, our approach to SAs is more closely related to the previous cartographic accounts, as we explicitly derive their morphological structure (Kayne 2007; Pantcheva 2008). However, we do not assume that -e- is a distinct morpheme, as (38) shows, since assigning a precise semantic interpretation to this morpheme strikes us as a complex task. Nevertheless, in
using our specific type assignment, we capture the status of SAs as phrases in a simple way, a feature that is missing in these approaches. Phrases involving SAs and SPs are trivially accounted for, as (39) shows.

Third, our top-down approach seems empirically adequate, as it indirectly rules out the existence of morphemes such as -ere (Place), which would not be ruled out in bottom-up approaches. With these morphological results in hand, we turn to semantic matters.

4.2. The Analysis: Type-Logical DM and Morphology

We now turn to our semantic analysis. Our crucial concern, on the semantic side, is to show that both SPs and SAs receive an argument-like interpretation, from which anaphoric relations can be established. However, we must first make some technical observations. The operations interpretation and function application, function composition are the semantic counterparts of lexical selection and merge introduction. Function composition is an iterated version of function application, as it combines functions that are applied onto a given argument (Landman 1991: ch.2; Morzycki 2005: ch.1). Hence, function composition corresponds to the merge of same-type units via transitivity. The semantic type assignment is offered in (40), the derivations in (41)-(43):

(40) a. \(<s, <s, s>> = \{\text{of, to, (P); (P)', Id...}\}

b. \(<s> = \{\text{the car, in front, ahead, head, front, PLACE, here, there...}\}

c. \(<s, s> = \{\text{in-, a-, be-, on-, h-, th-, wh-, any-, -ere, where, anywhere, ...}\}

(41) t. [ [ a- ] ] := \lambda x. s :: ext'(x), s, s (Interpretation)

 t+1. [ [ -head ] ] := h, s, s (Interpretation)

 t+2. [ [ a- ][ [ -head ] ] ] := \lambda x. s :: ext'(x), s, s, (h, s, s) (Function a.)

 t+3. [ [ of ] ] := \lambda x. \lambda y. s : P(x, y), h, s, s (Interpretation)

 t+4. [ [ ahead ][ of ] ] := (s :: ext'(h), s, s, \lambda x. \lambda y. s : P(x, y) :=

 \lambda y. s : P(s :: ext'(h), y), s, s (Function a.)

 t+5. [ [ the car, ] ] := c, s, s (Interpretation)

 t+6. [ [ ahead of ][ [ the car, s, s ] ] ] := \lambda y. s : P(s :: ext'(h), y), c, s, s :=

 s : P(s :: ext'(h), c), s, s (Function a.)

(42) t. [ [ h- ] ] := \lambda x. l : prox'(x), s, s (Interpretation)

 t+1. [ [ -ere ] ] := l : spec'(x), s, s (Interpretation)

 t+2. [ [ h-ere ][ [ -ere ] ] ] := \lambda x. l : prox'(spec'(x)), s, s (F. composition)

 t+3. [ [ (Place) ] ] := p, s, s (Interpretation)

 t+4. [ [ here, ][ [ (Place) ] ] ] := \lambda x. l : prox'(spec'(x)), s, s, (p, s, s) :=

 l : prox'(spec'(p)), s, s (Function application)

(43) t. [ [ h-ere ] ] := l : prox'(spec'(p)), s, s (Interpretation)

 t+1. [ [ (P') ] ] := \lambda x. \lambda y. s : Id(x, y), s, s, s (Interpretation)
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\[ t+2. \text{[[ here ]]](\text{(P')}) = \lambda x.\lambda y.\text{s:Id}(x,y)_{x,y}, s, (F. a.) \]

\[ t+3. \text{[[ inside the tent ]]} = i: \text{P}((s':\text{int}'(h),t)_{s,s}, (\text{Interpretation}) \]

\[ t+4. \text{[[ here (P')]][[[ inside the tent ]]]} = \text{s:Id}(l:\text{prox}'(\text{spec}'(p)),y)_{x,y}, s, t (\text{Function application}) \]

The derivations in (41)-(43) offer the interpretations of those in (37)-(39).

For lexical matters, we roughly follow the vector space semantics approach (Zwarts and Winter 2000; Maillat 2001; Svenonius 2008). So, we assume that the lexical content of SPs can be represented via functions such as \text{ext}', which identify the spatial, geometrical properties of a situation. In this case, \text{ext}' identifies a situation \( h \) as being external to the ground, which is then identified with the situation \( s' \). Hence, the interpretation of \text{ahead of the car} corresponds to a “larger” situation \( s \). In this situation, a “smaller” external frontal situation \( s' \) is defined as part of the space defined with respect to a given car.

The interpretation of \text{here}, as shown in (42), corresponds to a specific, proximal region or “place”. The two characteristic functions \text{spec}' and \text{prox}' roughly capture the two aspects of the lexical meaning of \text{here} that are taken as uncontroversial (Caponigro and Pearl 2008; Diessel 2012). That is, \text{here} denotes a specific (spatial) situation that is also defined as proximal to the speaker. Since we employ full Boolean Algebras as our model, this composition of these functions commutes, and could be also represented as the intersection (meet) of the two functions. In other words, \text{l:prox}'(\text{spec}'(p)) is equivalent to \text{l:prox}'(\text{spec}'(p)) \cap \text{spec}'(p) \) (cf. Morzycki 2005: ch.1). We adopt the more “compressed” notation for simple space reasons.

The derivation in (43) presents our key result on the anaphoric properties of SAs. It says that the silent head “(P’)” denotes a situation in which an \text{identity} relation \( \text{s:Id}(x,y) \) holds between the situations that \text{here} and \text{inside the tent} denote. The intuition behind this analysis is that anaphoric relations act as identity statements between referents, as assumed in DRT (Kamp et al. 2011: ch.0). The relation \text{Id}(x,y) simply is a prefixed counterpart of the infix notation \( x=y \), while the functions that identify our structured situations may be seen as equivalent to DRT conditions, to an extent (cf. also Maillat 2001). Here we choose a DRT-style approach, over situation semantics-based treatments of anaphora (e.g. Elbourne 2005), as we think that DRT offers more intuitive tools to represent this type of relations. Nothing crucial hinges on this fact. Before we conclude, we make three observations on our analysis.

First, we diverge from vector space semantics approaches by treating axial elements, such as \text{side}, as denoting single spatial situations, rather than relations over vectors. However, in our analysis root-like elements, of type \text{p}, can be interpreted as structured situations, it would be ideally possible to
identify this structure with their encyclopaedic content. In other words, we may capture the lexical content of *side* via a structured situation $s:P(a,b)$, which could represent that e.g. a side is a part of a larger object.

Second, although we have left aside the locative/directional distinction, our proposal implicitly reduces this distinction to the semantics of the "main" head (cf. Kracht 2002, 2008). However, several works observe that most SPs can either receive a locative or directional interpretation in context (Cresswell 1978; Gerhke 2008; Svenonius 2010; a.o.). So, we believe that this choice could be appropriate, to capture the relevant data in an elegant manner.

Third, for cases of referential *here*, such as our initial example (2), we assume that standard mechanisms of presupposition resolution can establish the relevant anaphoric relation. When *here* is interpreted against the external context $C$, presupposition resolution will retrieve the implicit situation that is identified with *here* (Zeevat 1999; Maillat 2001; Elbourne: ch.4). Aside these three observations, we can now conclude that we have an explicit, unified and compositional DM treatment of SPs and SAs, which can also account their anaphoric relations. In other words, we have offered a solution to our outstanding problem, which is a welcome result.

5. Conclusions

In this paper we have offered a unified analysis of SPs and SAs, such as *in front of the hill* and *here*. Our analysis is a type-logical variant of DM, coupled with a situation semantics interpretation, which is furthermore fully compositional. We have shown that this novel approach can account three types of recalcitrant data. First, it can account the structure of complex SPs (e.g. *in-side*). Second, it can account the phrasal nature of SAs. Third, it can account how anaphoric relations between SP phrases and SAs emerge (*here in front of the hill*). Therefore, we have solved all the facets of our problem, via a unified type-logical DM approach of SPs and SAs. Nevertheless, we think that several other problems could be ideally tackled within this proposal. For instance, we think that a more accurate analysis of the lexical semantics of SPs could reconstruct current “spatial” treatments as part of our situation semantics approach (e.g. Zwarts & Winter 2000). A similar consideration holds for a more thorough analysis of the locative/directional distinction, and its relevance for aspectual matters (e.g. Gerhke 2008). Cross-linguistic extensions could also be assumed, since our proposal is consistent with works focused on other languages (Persian: Pantcheva 2008; Spanish: Ursini 2013b). However, we leave all these intriguing problems for future research.

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