# SPATIAL PREPOSITIONS

MARCUS KRACHT

## 1. Basic Concepts

Spatial prepositions are prepositions that talk about the location or change of location of some object. For example, the following sentence is telling us something about the place where we can find John.

(1) John is at the station

The next sentence tells us by contrast something about John's change of location.

(2) John went to the station.

How the spatial prepositions end up doing what they do is the topic of this essay. Before we can begin, though, we need to agree on some terminology. The expression "at the station" talks about the location of an object (or a person in this case). This object is called the *figure* or *trajector*. A PP names the location of the figure in terms of another object, called *ground* or *landmark*. The landmark or ground appears as the complement of the preposition while the figure or trajector typically is outside of the PP. So, in the examples (1) and (2), John is the figure, and the station is the ground. Though it is customary to use as pairs exclusively figure versus ground or trajector versus landmark, respectively, I use the terms figure and trajector interchangeably, and likewise ground and landmark.

Comparing (1) and (2) we find that there are two kinds of prepositions. Those that simply tell us where the trajector can be found in relation to the landmark; and the others that tell us how the trajector moves with respect to the landmark. However, on closer inspection we see that there is a hierarchical structure at play. Compare the following sentence.

(3) A mouse emerged from under the table.

The propositions "from" and "under" can appear both by themselves. In this example however "from" takes the PP "under the table" as its complement. In this connection we cannot fail to notice that "under" appears in its nondirectional use and serves to identify a location, which then serves as a reference point for identifying the motion of the trajector, viz. the mouse.

The example (3) is actually quite complex. We shall look at it in detail. Many questions arise in connection with it. One point to note is that the landmark may

I wish to thank Johanna Domokos, Henk van Riemsdijk and Arhonto Terzi for their help and useful discussions.

itself be in motion. This may be more obvious in

(4) A mouse emerged from under the car.

What counts in this respect is the relative motion of the trajector with respect to the landmark. It is similar to the word "overtake". It requires that both subject and object are in motion, and that they also change their relative positions.

Another factor which we shall look at is the interaction between selection and meaning. Many verbs select particular PPs. This has consequences for the semantic import of the prepositions. In the following example the word "over" is basically meaningless.

(5) The experts were divided over the proposal.

Selection as it were nullifies the meaning. How this interacts with the hierarchical structure of (3) is an interesting question that we shall pick up below.

## 2. Overview

Before I delve into formal exploration of the formal semntics of space it is worthwhile to contextualise the topic in the linguistic research.

From the point of view of a semanticist, space and time belong to the fundamental categories of human experience. No wonder that cognitive science teems with research into the nature of spatial cognition. Representative of this endeavour are (Bloom et al., 1996), (van der Zee and Slack, 2003) and (Jackendoff and Landau, 1992). Also, when we look at cognitive grammar (Langacker, 1987) we find that reasoning is often done with the help of spatial diagrams. Space and spatial cognition seem to be pretty fundamental. (Howard, 2004) provides an answer to this: the visual cortex has so much computation power that it can be recruited to do quite complex computations, which need however not be visual in themselves. (Computer are nowadays doing something similar: they are borrowing computational capacity from their graphic chips.) This leads to a ubiquity of spatial talk in language. Historical linguistics has demonstrated over and over again that spatial meanings are the source of almost every other abstract meaning: they radiate into the temporal domain (Haspelmath, 1997), the logical domain (Merin, 1996), and many others (Heine and Kuteva, 2002). A fine example of this development is presented by Merin (1996). The English particle "but" is historically related to the Dutch word "buiten" *outside* (compare the word "besides").

However, as much as that explains the importance of space as a category, linguists still had to become convinced that there is something intrinsically different to the notion of space. It is clear, of course, that there is such a thing as spatial language. And in the three domains, syntax, morphology and semantics, the development has been quite different. From a morphological viewpoint, the idea that spatial notions are important in understanding case systems has been promoted among others by Hjelmslev (1935, 1937). Crucial in this connection was the discovery of case systems with rich sets of local cases in diverse languages (primarily Eskimo-Aleut, Fenno-Ugric, and Caucasian languages). Basically, the richer the case system the more spatial cases we are likely to find, as the non-spatial cases rarely count more than a dozen, while the record in number goes to the language Tsez (Comrie and Polinsky, 1998). A good overview over the morphology of spatial cases can be found in Mel'čuk (1994).

The advent of generative grammar has changed the picture somewhat. Initially, morphology was treated in a rather ad hoc fashion. The so-called case theory of Government and Binding Theory had very little to offer in terms of theory of cases, as it treated only the nominative and the accusative. Everything else was labelled *inherent* Moreover, the distinction between cases and prepositions seemed to create more problems than it actually solved. Syntactic theory seemed to be obsessed with morphological detail. What is more, it took a long time until the realisation sunk in that spatial prepositions where a pretty complex affair. They typically show a layered structure, with two or even three heads stacked inside each other. Pioneering work has been done in van Riemsdijk's dissertation (van Riemsdijk, 1978) and in Koopman (1997). It has been picked up later by den Dikken (2010) and Svenonius (2008). For details I refer to the historical overview (Terzi, 2014).

Semantics, or better said formal semantics, also has only recently discovered space. Compared with the literature on events or aspect the literature on the semantics of spatial expressions has been rather small, although that is now changing quickly. In principle, it would have been possible to benefit from a long history of research in geometry and topology, but the needs of the formal semanticists are often quite different, as we shall see below. The first to propose a formal approach to spatial locations, apart from the abovementioned Merin (1996) were (Zwarts and Winter, 2000) and (Zwarts, 2003). They proposed to use vectors as primitives. The use of shapes as primitives is promoted in Gambarotto and Muller (2003). For the semantics of paths, (Nam, 1995), Piñon (1993) and (Zwarts, 2005a,b). For an integrated approach see Kracht (2008).

The present article does not intend to look into the cognitive aspects. It tries to show rather that the linguistic structure of spatial prepositions can not only be motivated from its semantics but also that the interaction of morphology and syntax on the one hand and semantics on the other offers unique insights into the basic mechanisms of language itself.

## 3. Semantic Primitives

Before we can analyse the relationship between expressions and their meaning we need to discuss the reality that is denoted by spatial expressions. In what is to follow we shall try to outline a description of the real (physical) denotations, and do not work out a mental or cognitive semantics. This will result in some differences, which are mostly rather inessential. But focussing on real space eases the exposition somewhat.

At first we need to agree on some semantic primitives, or *types* we shall work with. We shall assume that there are *things*, the type of which is denoted by e. Things include also animals and humans. And then there are places, the type of which is denoted by p. It is sufficient to think of places as points in a space, say the Euclidean space of our daily experience. If you are more comfortable thinking of spatial points as triples of coordinates (also known as vectors (Zwarts and Winter, 2000)), this is fine but not necessary. Each object occupies a set of points, known as the *location* or *eigenspace* of that object. The notion of an object is deeply connected with the location that it occupies. It is clear, for example, that an object must enjoy a spatial connectedness. A set of points is called *connected* if for any pair of points within it you can walk from one to the other remaining within that set at all times. Two spherical balls placed at some distance to each other will therefore not be counted as a single object for the reason that the space the two are occupying is not connected. We shall be a little stricter than that. Even if the two balls touch they would not be counted one object since they share a single point in space (in the case of ideal spheres, of course). For to be the set of points occupied by a single object must be what I call a *region*. To be a region, a set must be a regular closed set whose interior is path connected. The type of regions is denoted by r, and it is a subtype of the type of sets of points. There is a primitive function loc, which for each object $o$ and each time point $t$, returns a region $\mathrm{loc}(o)(t)$, the eigenspace of $o$ at $t$, or the region occupied by $o$ at $t$. This region identifies the distribution of mass of that object. For example, when $o$ is a box, $\mathrm{loc}(o)(t)$ denotes the region of the solid of the box, not its interior.

The function loc has as its arguments both an object and a time point. This is needed because the region that an object occupies may change over time. Thus we add the type of *time points*, denoted by $\tau$. The members are from the set of reals, $\mathbb{R}$. These are however just the time points. As with objects, it is far more widespread to talk about regions of time points, also known as *intervals*. Intervals are sets of the form $[t', t''] = \{t : t' \leq t \leq t''\}$ such that $t' < t''$. Notice that $t' = t''$ would mean that $I = \{t'\}$, a single time point. This is excluded. The intervals always include their boundaries and are proper stretches of time. Intervals are to time points what regions are to spatial points. The type of intervals is denoted by $\delta$.

The function loc has the type $e \to \tau \to r$. It assigns to an object $o$ the function $\mathrm{loc}(o)$ of type $\tau \to r$. The function $\mathrm{loc}(o)$ is required to be continuous in $t$ (this is the principle "natura non facit saltus" in English: nature does not make jumps). Many authors assume that paths are discrete (Nam, 1995), others remain agnostic (Piñon, 1993). Physical space seems to be best modelled by the real line. Even though there are things where the idea of a location-at-a-time does not seem to make much sense as they seem to be fixed in space (mountains, continents etc.), it does not hurt to consider an additional time parameter. On the other hand, there also exist things that do not have a location, but these will be excluded from consideration.

The function $\mathrm{loc}(o)$ is of type $\tau \to r$. We call continuous functions of that type a *path*. Normally, paths are understood to be of type $\tau \to p$ (so they assign points rather than regions to time points), but there will be no confusion in calling both of them paths. Letters $\pi, \pi'$ will stand for paths.

Let's quickly see how the above examples can be rendered formally. We start with (1). Let $j$ denote John, and let $s$ denote the station. The location of John at any given time point $t$ is $\mathrm{loc}(j)(t)$. Let $t_u$ be the utterance time of (1). Then the sentence says that $\mathrm{loc}(j)(t_u)$ is near or close to $\mathrm{loc}(s)(t_u)$. We can formalise this by assuming a relation AT between regions and then render (1) as

(6) $\mathrm{AT}(\mathrm{loc}(j)(t_u), \mathrm{loc}(s)(t_u))$

The exact details of AT do not matter at this point. We may say, for example, that $\mathrm{AT}(r, r')$ is true if (and only if) $r$ and $r'$ are close. We shall return to the difficulties of pinning down meanings of spatial relations. What is important at this point is that the relation is a relation between regions, not objects. And that for any such relation $G$, the first argument shall be the region of the trajector and the second that of the landmark.

Assuming that the event time of (2) is the closed interval $[t_0, t_1]$, the meaning of (2) is as given in (7).

(7) $(\exists t_0)(\exists t_1)(t_0 < t_1 < t_u \wedge \neg\, \mathrm{AT}(\mathrm{loc}(j)(t_0), \mathrm{loc}(s)(t_0)) \wedge \mathrm{AT}(\mathrm{loc}(j)(t_1), \mathrm{loc}(s)(t_1)))$

Roughly, it asserts the existence of a "temporal region" in the past during which the proposition "John is at the station" changed into being true. We see that the meaning of (2) is built on top of that of (1). So we shall focus on the latter first and then move on to (2).

## 4. The Basic Case

The simplest case is the static one. A spatial expression is called *static* if it does not express change. Cases in point are "at" or "in" or "in front of". We consider their basic meaning to be a relation between regions. So, $r$ is "at" $r'$ iff $r$ and $r'$ are disjoint and $r$ is close to $r'$ in the sense that the minimum distance between the points of $r$ and the points of $r'$ is small in comparison to the size of $r$ and/or $r'$. $r$ is "on top of" $r'$, if $r$ and $r'$ touch and some points of $r$ are vertically above some points of $r'$. And so on. So, spatial Ps denote (in first approximation) relations between regions. However, syntactically the spatial Ps take only one argument. Thus we need to adapt the meaning of the Ps somewhat. To this end we shall use some $\lambda$-calculus. When we have a relation $G$ between regions we wish to define a function $G^\spadesuit$ that takes a single region $r'$ as its input and returns a property of regions $G^\spadesuit(r')$ such that $G^\spadesuit(r')$ is true of $r$ if and only if $G(r, r')$.

To this effect, if $G$ is such a relation, we can form the function

(8) $G^\spadesuit := \lambda r'.\lambda r.G(r, r')$

This is a function from regions to functions from regions to truth values. To turn that into a denotation for a spatial P, we need to take into account two more things. One is the time dependency and the other is the fact that the Ps do not take region denoting elements but rather object denoting elements. (In fact, this is not quite true. We can say "from the station" just as we can say "from here". There is, as always, a lot of type fiddling involved.)

Given a time point $t$, we get from an object $o$ the region $\mathrm{loc}(o)(t)$, which we can feed to $G^\spadesuit$. Abstracting that time point and the object we get

(9) $G^\circ = \lambda o'.\lambda o.\lambda t.G(\mathrm{loc}(o)(t), \mathrm{loc}(o')(t))$

This is of type $e \to (e \to (\tau \to t))$. Given $o'$ and $o$, $G^\circ(o')(o)$ denotes a time dependent truth value.

Next we shall build the dynamics on top of that. To do that, we shall use the notion of a phase quantifier. Given a proposition $p$ and an interval $I = [t_0, t_1]$, there are two possibilities: either the truth value of $p$ remains constant (static case) or it changes (dynamic case). When it changes, we consider only two scenarios: $p$ becomes true or $p$ becomes false during $I$.

(10)

| $p(t_0)$ | $p(t_1)$ | |
|---|---|---|
| true | true | static |
| false | true | dynamic |
| true | false | dynamic |
| false | false | static |

Considering the change of location, we only have a three-way system: the last option is virtually nonattested (though there are languages with a so-called abessive, like Finnish, but the abessive is rather expressing nonpossession).

This results in a threefold classification (Fong, 1997). Consider the proposition "John is at the station." Suppose that throughout event time it remains true. This exemplifies the first option and is expressed by (1). Now consider the second option, that it is first false and then true. This expressed as

(11) John went to the station.

Two changes occur: the verb can no longer be "is", because we need to express change also in the verb. Second, the preposition is now "to" rather than "at". The third option is when the proposition is first true and later false. This is expressed in (12).

(12) John went away from the station.

The P has changed to "(away) from". So, from one spatial relation we get three complex expressions call them a *triad*; another triad is "in", "into" and "out of" and "under", "(to) under" and "from under". (The last of the three is not lexicalised).

To get the triads we introduce the following three phase quantifiers $Q_{++}$, $Q_{-+}$ and $Q_{+-}$. Given an interval $I$, beg($I$) denotes the begin point of $I$ and end($I$) the end point. In other words, if $I = [t', t'']$ then $\text{beg}(I) := t'$ and $\text{end}(I) := t''$.

(13)
$$\begin{aligned} Q_{++} &:= \lambda P.\lambda I.P(\text{beg}(I)) \wedge P(\text{end}(I)) \\ Q_{-+} &:= \lambda P.\lambda I.\neg P(\text{beg}(I)) \wedge P(\text{end}(I)) \\ Q_{+-} &:= \lambda P.\lambda I.P(\text{beg}(I)) \wedge \neg P(\text{end}(I)) \end{aligned}$$

The phase quantifiers have the type $(\tau \to t) \to (\delta \to t)$. They lift a time dependent proposition into an expression that yields a truth value for an interval. The time dependent proposition that needs to be supplied is "the region of the trajector is contained in the parameterized neighbourhood of the landmark". Since the trajector is not yet given nor the region of the figure, we need to massage the meanings as follows.

The property to be used is "$o$ is in relation $G$ to $o'$", where $o$, $G$ and $o'$ are given. Only the time parameter is missing.

(14)
$$P := \lambda t.G(\text{loc}(o)(t), \text{loc}(o')(t)) = G^\circ(o')(o)$$

Using $\gamma$ of type $e \to (e \to (\tau \to t)))$ as a variable we get

(15)
$$
\begin{aligned}
Q'_{++} &:= \lambda\gamma.\lambda o'.\lambda I.\lambda o.\gamma(o')(o)(\mathrm{beg}(I)) \wedge \gamma(o')(o)(\mathrm{end}(I))\\
Q'_{-+} &:= \lambda\gamma.\lambda o'.\lambda I.\lambda o.\neg\gamma(o')(o)(\mathrm{beg}(I)) \wedge \gamma(o')(o)(\mathrm{end}(I))\\
Q'_{+-} &:= \lambda\gamma.\lambda o'.\lambda I.\lambda o.\gamma(o')(o)(\mathrm{beg}(I)) \wedge \neg\gamma(o')(o)(\mathrm{end}(I))
\end{aligned}
$$

Here is now the full meaning of the prepositions of the "AT" triad.

(16)
$$
\begin{aligned}
\mathsf{at}' &= Q'_{++}(\mathrm{AT}^\circ)\\
\mathsf{to}' &= Q'_{-+}(\mathrm{AT}^\circ)\\
\mathsf{from}' &= Q'_{+-}(\mathrm{AT}^\circ)
\end{aligned}
$$

Each of them needs an object (the landmark) and then provides a change of truth for a proposition.

## 5. Layers of P

So far we have assumed that the prepositions are a unit. However, for many reasons the underlying structure assumed for spatial Ps is somewhat different.

(17) [from [under [the bed]]]

The DP, "the bed" is the complement of a head, "under", which describes for a given time point the spatial whereabouts of the figure. This head is called a *locator*, or L. The phrase "under the bed" is therefore an LP. The type of that expression is $e \to (\tau \to t)$. This LP is the complement of another head, "from", that describes the dynamics of the figure with respect to the landmark. This head is called a *mode*, or M. The entire phrase is thus an MP. Its type is $\delta \to (e \to t)$.

(18) $[\text{from}_{\mathrm{M}}\ [\text{under}_{\mathrm{L}}\ [\text{the bed}]_{\mathrm{DP}}]_{\mathrm{LP}}]_{\mathrm{MP}}$

The locators and modes are written in upper case letters. We have as locators eg AT, IN and ON. As modes we have STAT ("static"), to express no change; COF ("cofinal") to express change from falsity to truth, and COI ("coinitial") to express change from truth to falsity.

We have seen that the Ps "at", "to" and "from" are actually a combination of two heads, so in deep morphology they are STAT+AT, COF+AT and COI+AT. Notice that "into" actually spells out the locator *before* the mode. Many prepositions in English are ambiguous between static and cofinal mode, eg "under" and "near".

Whether or not L and M are expressed separately depends on many factors and is not uniform even in a single language. To be sure, languages do contain expressions that are LPs, for example "here", "there", and there are question words such as "where", to ask for places. We can use these words as diagnostics, as it turns out that some verbs do select for LPs, for example "work" or "live". Being LPs, they can be selected by an M. Thus we have expressions "to here", "from here", "wherefrom" and "whereto". Furthermore, we also have verbs selecting MPs, such as "change", which requires a complement "into"+DP. Hungarian and German have many verbs that select spatial PPs.

A note on types is in order. The types of LPs and MPs are subject to considerable variation. First, while ordinary LPs such as "behind the bus" do not denote locations (since they require as input parameter a time point), deictics do ("here" is a location). Furthermore, the types do not necessarily correspond to the types needed in constructing an entire sentence. For example, if an MP is used as a modifier of VP, its type should be $(\varepsilon \to t) \to (\varepsilon \to t)$, $\varepsilon$ being the type of events. For notice that verbs denote properties of events and so are of type $\varepsilon \to t$. It is easy to adapt the type of MP by means of a function. All we need to assume is a function $z$ that yields the temporal trace of an event, and a function $\mu$ that yields the mover of an event (more on that later). The function that turns an MP into an event modifier is

(19) $f := \lambda\xi.\lambda\mathcal{P}.\lambda e.\mathcal{P}(e) \wedge \xi(z(e))(\mu(e))$

Namely, given an MP $\xi$ and an event property $\mathcal{P}$, $f(\xi)(\mathcal{P})$ returns true on an event $e$ where $\mathcal{P}(e)$ holds, and where $\xi(z(e))(\mu(e))$, that is, the entity of $e$ that moves $(\mu(e))$ moves during the event time $z(e)$ in the manner described by $\xi$.

## 6. Morphological Expression

It is necessary to briefly discuss morphological issues. Although the title is “Spatial Prepositions”, there is arguably no semantic or syntactic difference between a (spatial) PP and a DP in (locative) case. The only difference there is is of purely morphological nature. The claim therefore is, that we cannot establish a difference between these morphological forms of expression either in semantics nor in syntax. This removes any considerations whether there is a structural difference between these different kinds of expressions. And it justifies mixing local PPs and DPs in local case except when discussing morphology.

Let us see some arguments. Consider in Hungarian the expression “a fa alá ” (lit. the tree under-to). It is a PP, constructed from a DP “a fa” and the postposition “alá” (to under). Hungarian also has three triads of local cases, for example the illative case for COF+IN. The illative of “a ház” (the house) is “a házba” (into the house). Semantically, the two expressions have the same type. In fact, they can be coordinated.

(20) a fa alá és a házba

This suggests that the two are not only of same type but also of same syntactic category. Consider by way of example the verb “bújni” *to hide*. With this verb you can use cofinal mode in the meaning of motion to hide. Hence we have

(21) A gyerekek elbújtak a fa alá és a házba.

It does not matter whether you put a locative DP or a spatial PP as long as they are in cofinal mode. This can be explained only if we assume that syntax can see the decomposition of the postposition as a combination of IN and COF; but the same must be true of the locative case as well.

In some languages the case endings are still transparently showing a combination of locator and mode. One of the richest case systems is found in the language Tsez (Northeastern Caucasus, data is from Comrie et al. (1999)). The local cases come in two kinds; the non-distal cases, shown in Table 1, and the distal cases shown in Table 2. A distal case specifies that the location that is invisible. Notice

TABLE 1. The Locatives of Tsez (Non-Distal)

| | Mode → | | | |
|---|---|---|---|---|
| Configuration ↓ | Stative | Coinitial | Cofinal | Approximative |
| IN | -ā | -āy | -ā-r | -āɣor |
| AMONG | -ɬ | -ɬ-āy | -ɬ-er | -ɬ-xor |
| AT | -x(o) | -x-āy | -xo-r | -x-āɣor, -x-ār |
| UNDER | -ƛ | -ƛ-āy | -ƛ-er | -ƛ-ɣor |
| ON (horizontal) | -ƛ'(o) | -ƛ'-āy | -ƛ'o-r | -ƛ-āɣor, -ƛār |
| ON (vertical) | -q(o) | -q-āy | -qo-r | -q-āɣor, -q-ār |
| NEAR | -de | -d-āy | -de-r | -d-āɣor, -d-ār |

TABLE 2. The Locatives of Tsez (Distal)

| | Mode → | | | |
|---|---|---|---|---|
| Configuration ↓ | Stative | Coinitial | Cofinal | Approximative |
| IN | -āz | -āz-ay | -āz-a-r | -āz-a |
| AMONG | -ɬ-āz | -ɬ-āz-ay | -ɬ-āz-a-r | -ɬ-āz-a |
| AT | -x-āz | -x-āz-ay | -x-āz-a-r | -x-āz-a |
| UNDER | -ƛ-āz | -ƛ-āz-ay | -ƛ-āz-a-r | -ƛ-āz-a |
| ON (horizontal) | -ƛ'-āz | -ƛ'-āz-ay | -ƛ'-āz-a-r | -ƛ-āz-a |
| ON (vertical) | -q-āz | -q-āz-ay | -q-āz-a-r | -q-āz-a |
| NEAR | -d-āz | -d-āz-ay | -d-āz-a-r | -d-āz-a |

the placement of the suffix -āz right after the locator.

The language Archi, a Dagestanian language from the Caucasus, exemplifies a rather rich set of modes. While we have spoken above about just three, already Tsez has presented fourth one the *approximative*. It is used for a motion that gets closer without necessarily reaching the location. Archi adds a *terminative* for a motion that exactly ends at the location and goes no further, and a *translative* (sometimes called *prolative*) for a motion that goes beyond the location. Mel'čuk (1994) lists also a *recessive* for motion away but gives no examples.

On the other side of the morphological spectrum we find languages that have rather complex Ps. One such example is French. The English P "above" is rendered in French as "au dessus de", lit. *at the above of*. Generally, the structure is

(22) à + Definite Article + Noun + de

Despite their complexity they are units. So they may be considered prepositions of French.

## 7. SELECTION

MPs may be adverbials. However, they can also be arguments of some higher heads, notably verbs. In this situation the verbs select for the MP. In syntax, this is seen as a head-to-head relation, also known as *selection*. Selection here means that the form of the selected head is determined by the selecting head. Since the MP is complex, there is a genuine question as to which head it is that the verb enters a relationship with. Here is a simplified representation of the constituent structure.

(23) [V [M [Loc DP]]]

We shall show that the following two possibilities arise.

① V selects only M.
② V selects both M and Loc.

It is not common in the literature to acknowledge selection of several heads in a row. Nevertheless, the case ② is the more common one. In German we find combinations such as "warten", which selects the PP with preposition "auf" and a DP in accusative case. In Hungarian, the (semantic) analogue is the sublative case; Hungarian has similar verbs "számolni" *to count* likewise selects sublative. Also, Corbette (2012), in a discussion of languages with rich sets of local cses, discusses the question whether the case morphemes should rather be counted as derivational. His argument against that consists in the fact that these cases are subject to selection. Here is the example given there, from the language Archi.

| | | | |
|---|---|---|---|
| (24) | zari | to-w | ow-t:u-t |
| | 1.SG.ERG | that.one-I.SG.ABS | do.PFV.I.SG-ATR-IV.SG |
| | hekł'əm-mi-t:i-š | ił:uk | aw |
| | thing(IV)-OBL.SG-SUPER-EL | regret | do.PFV.IV.SG |
| | *I made him regret the thing he had done.* | | |

The verb "ił:uk" governs the case called superelative, which is a combination of SUPER ("above") and ELATIVE ("away from"), here called coinitial.

The option ① was called *directionality selection* in Kracht (2006). This is exemplified by Finnish "jäädä" *to remain* or "unohta" *to forget*. Evidence that this is not the same as ② is the fact that these verbs can cooccur with any Loc in contrast to such verbs that select both M and Loc.

(25) Janne unohti rahansa autoon/pöydälle/kirjan alle.
*Janne forgot his money in the car/on the table/under the book.*

There are also semantic consequences to this. The basic mechanism is the so-called *Emptiness Principle* of Kracht (2002b).

**Emptiness Principle.**
A head that is selected for is semantically void.

Semantically void here means: *void in the particular context that selects it*. So, if a verb selects a DP in sublative case, then that case makes no contribution to the meaning. In the construction "számoltam a tanárra" *I counted on the teacher*, semantically the verb takes the meaning of the DP as its argument. In cases of directionality selection, however, the Loc head contributes its full meaning. This is explained as follows (see Kracht (2002a)). There are two ways can combine a head H and a constituent C. In the first mode, the head is added as a syntactic property of C, with no change in the semantics. In the second mode, the head applies semantically to C, but no change is made in the syntax.

This means that the Finnish expression “laivalle” can be composed in three different ways from the primitives LAIVA, AT and COF.

(1) Both heads are added in the syntax only. The this expression is a DP in allative case with meaning “the ship”.
(2) Only the COF head is added syntactically. Then this expression is a LocP in cofinal case with meaning “on the ship”.
(3) Both heads are added semantically. Then this expression is an MP with meaning “onto the ship”.

The proposal of Kracht (2002a) is somewhat different, however. It first generates the DP in in allative case and then optionally exchanges the cases for their meanings. This is a refinement of an idea found in Niikanne (1993) that Finnish locative DPs bear structural case assigned by an empty preposition.

Let us remark that this presents a rather novel approach to the notion of interpretability in the Minimalist Program. While the mainstream view is that in a given language features are intrinsically either interpretable or not, here interpretability is relative to a context. More exactly, features are seen primarily as morphological affixes. Syntax and semantics are in competition as to whether they get to see the feature. If syntax wins, the feature remains uninterpreted in semantics. If semantics wins, it is interpreted but invisible to syntax.

This removes a defect of a proposal in (Fong, 1997). Basically, Fong assumes what I call the “additive theory” of meaning composition. It interprets each and every morpheme in a compositional way and thus allows it to add its meaning into every context it appears in. This runs into difficult problems when trying to understand what the contribution of a directional is in connection with the verb “jäädä” *to remain*. Basically, the additive meaning theory can only be maintained by sufficiently weakening the meaning of the directional. But it must be weakened to a point where its contribution in other contexts is not strong enough. If we claim that “jäain bussiin” *I remained in the bus* is just a diphasic event where there is no physical change, where does the meaning of cofinality come from in “menin bussiin” *I went into the bus*?

## 8. Orientation

The problem of orientation has been identified first in (Nam, 1995). It is a pervasive phenomenon of modification. Whenever we are dealing with modification there are numerous parameters that need to be handed over to the modified element. The meaning of “previous” for example modifies “bicycle” in a manner that involves change over time. We say that the time point (of possession in this case) is a parameter, as it is not necessarily present in adjectives. Similar for “alleged”, which involves the world parameter. There does not seem to be a general rule as to how this negotiation of parameter values is performed. In the context of locatives, we can note a few trends.

A locative PP specifies the location or path of the trajector with respect to the landmark. While the landmark is expressed in the PP, the trajector is not. Thus arises the question which constituent of the sentence is the trajector. As a matter of terminology, we say that the PP has a certain orientation (Nam (1995)), which is computed from the constituents of the sentence. Mostly, the orientation is towards the location of a single constituent, such as the subject in "walk" or the object in "throw". For if we say "John walked into the forest" we understand that it is John who is moving into the forest, but if we say "John threw the banana out of the window", it is the banana and not John that is moving out of the window. However, in "John accompanied Mary to the doctor" it is the location of both John and Mary that is being qualified. Sometimes there are also implicit constituents whose location gets talked about. This is the case in "drive", "fly", "shoot", where the motion involves a car, an airplane and a bullet, respectively.

(Nam, 1995) contains a list of verbs together with their orientation. Some of the patterns are rather involved ("reach across the table"), but there is one overall rule (Kracht, 2002b). If the verb denotes motion, then movement is predicated of the trajector, which is the one constituent whose motion is necessary for the event to be what it is. For example, a throwing event needs an object to be tossed into the air to be a throwing. Hence "John threw the banana out of the window." can never be true if only John jumped out of the window. It must be the banana that goes through the window. Similarly,

(26) The police followed the gangsters to the entrance of the house.

At the closing of the event of following the police is at the entrance of the house. Where the gangsters are we are not told. And this is because even though there is no event of following someone if that someone has not moved, this is merely the presupposition; the event itself is the motion of the one retracing the steps of that someone.

## 9. Body Parts and Axes

When we look at expressions of spatial relation there is a large contingent of what is known as "body part nouns" (Svorou, 1993). They derive their meaning mainly from nouns such as "foot", "head", "back", "belly" and so on. English has a few of those: "in front of" (from Latin "frons" *forehead*), "in the back of", "at the foot of" (in connection with mountains).

(27) A cat is in front of the car.

Characteristic is that the body part nouns select a direction on the basis of some part of the body. For that to work, the object must be likened to the human body (or the body of an animal). Or better still, we consider a human observer in the place of the object in question (here the car). The question is now how that human is to be positioned. In the case of the car, the reasoning is simply, and roughly as follows. The eyes look in the direction in which the car is going. And this determines where "in front of" points to. A location is "in front of" the car, if it found at a distance in that direction, with a certain deviation in direction. (There is a correlation between the acceptable distance and the angular deviation from the ideal direction (O'Keefe, 2003).)

The body part nouns are actually even lower than the locators, as claims (Svenonius, 2008). The semantics is as follows. From a human perspective, six directions are notable: “front”, “back”, “up”, “down”, “left” and “right”. These six cardinal directions form a system of half-axes. These are instrumental in setting up a coordinate frame. For at the start we only have a landmark $o$. Its location at $t$ has a center, call it $\gamma_o(t)$. This point $\gamma_o(t)$ is time dependent. It forms the center of a coordinate frame that the landmark takes with it. So the landmark will always be at the point (0,0,0). Now, orient the human observer in $\gamma(t)$ according to a set of rules (that depend on the object in question and a host of other factors). This will establish three directions, and ultimately result in three vectors $e_1$ (front), $e_2$ (right) and $e_3$ (down) that allow to issue coordinates. At this point we can actually proceed with the story told above and even use vectors.

The semantics of “left” and “right” has been much studied. Their origin as body part nouns is not transparent any more. However, there is cross-linguistic as well as developmental evidence that points to this direction. The way children learn the use of “left” and “right” is by first learning to distinguish between the left part of their body and the right part (e. g. “left hand” versus “right hand”), and then extending that in the manner of body parts. Its use is further extended to objects for which an axis system can be established. The determinants for establishing an axis system are quite involved, more so with “left” and “right” than with “front” and “back”. First, after establishing a center of the axis system we need to see whether we project it taking only the landmark into account or whether we project it with the help of the observer. If, for example, A is standing in front of the chair and sees a ball to his right side, he can either say “The ball is to the right of the chair.” or “The ball is to the left of the chair.” The latter use follows the intrinsic axis system of the chair, the former the axis established between A and the chair, positioning the observer facing the opposite way. To see the difference, imagine a doctor examining you asking which of your knees is giving you trouble and you answer “The left knee.” Or, when exiting a train the announcement tells you that the exit is on the right hand side. In the case of the doctor, it is understood that no matter what is normally the case, only the patient’s intrinsic left is to be taken (thus it is a true body part expression), while in the case of the train the announcement is more nuanced (effectively, they say “The exit is to the left in direction of the train.”). Often, however, this additional qualification is unnecessary. For when the landmark is in motion the motion vector may as well be used to establish a “front” axis. Sometimes that is even obligatory. Niikanne (2003) categorises the Finnish adpositions into three classes: those that require motion of the landmark, those that implicate a static landmark, and those that are neutral. Here is some data.

(28a) Maija istuu Ville-n takana/*perässä/jäljessä
Maija sits Ville-GEN behind

(28b) Maija istuu Ville-n *edellä/edessä.
Maija sits Ville-GEN in-front-of

Compare this with

(29) Buick on Volvo-n edellä.
The Buick is driving in front of the Volvo.

The verb "on" in (29) is the copula, so it just means "is". That we need to translate this as "is driving" is part of the meaning of "edellä", which requires that the landmark be in motion.

Niikanne also notes that the construction of the coordinate frame is governed by subtle rules. When we have two rockets which are shooting vertically into the air, and A is behind B, it is pretty odd to say that A is "below" B, both in Finnish and in English — and, I add, in German.

## 10. Historical Development

When we talk about historical development, we must distinguish two different questions. The first is: where spatial expressions come from? And the second is: where do they end up? What is their trajectory in language?

Of course, we can only indicate large trends. Each word presents its own microcosm. Neverthrless, the sources and trends of local expressions are quite clear. The biggest source of local expressions is body parts. For other spatial expressions we also find heavenly bodies and maybe also stable features of the surrounding. However, when we look at PPs, the body parts are almost unique Svorou (1993). To give just one example, the grammatical concept IN derives according to Heine and Kuteva (2002) from the following: belly, bowels, center, heart, interior. For example, the Hungarian inessive marker "bel" derives from "bél" *intestines*. In Oceanic languages the word "heart" generally has developed into the meaning "in".

In the other direction, spatial expressions are very frequently at the origin of the chain of diachronic development. They constitute the source of many expressions denoting concepts from a vast variety of domains, ranging from tense to complementizers. It has also been argued that spatial concepts underly case systems (this is a central claim of case grammar). To give an example, consider the locative. According to Heine and Kuteva (2002) it can develop into the meanings agent, cause, comparative, concern, continuous, personal pronoun, possessive, subordinator and temporal location (cf. English "in one week").

Also, there are common ways to perceive certain situations that give rise to spatial expressions. For example, in many Eurasian languages, good emotions are said to flow from experiencer to target, while bad emotions flow the opposite way. Hence, one says in Hungarian "félek tőled" lit. "I fear from you." (German by contrast uses a static PP "Ich fürchte mich vor Dir." lit. "I fear in front of you.") These are cases of virtual motion.

## 11. Refinements

In this section I shall touch on some refinements. First, as has often been observed, spatial PPs are correlated with aspect. For example, contrast (2), repeated below as (30a) with (30b).

(30a) John went to the station.

(30b) John went towards the station.

In (30a) we have perfective aspect, while in (30b) it is imperfective (Piñon, 1993). To model this, it has been proposed to use a path algebra. This is a structure $\langle P, \circ\rangle$, where $P$ is the set of paths (say, maps from the intervals of time points to the space $\mathbb{R}^3$) and $\circ$ is the following operation. (Evidently, it should be done with regions in place of points, but I ignore that complication.) Assume that $\pi : [t, t'] \to \mathbb{R}^3$ and $\pi' : [t'', t'''] \to \mathbb{R}^3$, then $\pi \circ \pi'$ is defined if an only if $t'' = t'$ and $\pi(t') = \pi'(t'')$. And in this case,

(31) $$(\pi \circ \pi')(\hat{t}) := \begin{cases} \pi(\hat{t}) & \text{if } t \leq \hat{t} \leq t' \\ \pi'(\hat{t}) & \text{if } t'' \leq \hat{t} \leq t''' \\ \text{undefined} & \text{otherwise} \end{cases}$$

Then $\pi \circ \pi' : [t, t'''] \to \mathbb{R}^3$. Evidently, this defines a path that consists in following through with $\pi'$ right after $\pi$. The concatenation of paths is associative, that is to say, for all paths $(\pi \circ \pi') \circ \pi'' = \pi \circ (\pi' \circ \pi'')$, where the left hand side is defined if and only if the right hand is defined, and if defined, both are equal.

Now, say that $\pi$ is a *part* of $\pi'$, in symbols $\pi \leq \pi'$, if there are paths $\rho$ and $\rho'$ such that $\pi' = \rho \circ \pi \circ \rho'$. Finally, a directional expression such as “towards the station” is a property of paths. We can thus say that a property $P$ is *downward entailing*, if from $P(\pi)$ and $\pi' \leq \pi$ we may infer that $P(\pi')$. And we may say that it is *cumulative* if from $P(\pi)$ and $P(\pi')$ we may infer $P(\pi \circ \pi')$, provided $\pi \circ \pi'$ exists. Now, “towards the station” is both downward entailing and cumulative, while “to the station” is neither. This is standard evidence that (30a) is perfective, while (30b) is not.

For the semantics presented above the example (30b) presents a problem. There is no way to render the meaning by using a distinction between simply being and not being at a location. The use of paths presents one way around this difficulty. Another is the use of truth degrees, as proposed in Kracht (2008). Basically, we assign a proposition instead of just the values 0 and 1 a real number between 0 and 1, called a “truth degree”. The higher the number, the better the fit with reality. Given this, the sentence (30b) expresses that John’s motion is such that during event time the truth degree of “John is at the station.” is increasing, that is, that it fits the reality better and better.

Also, the complexity of spatial representations is given a particular angle in Kracht (2008). Consider the expression “in front of”. If it is a relation between points in space, its denotation is a set of pairs of points in the space. This is of course not the way in which it can be stored in the brain. However, the ascent from DP to PP is accompanied by a recoding of the space (called “aspect”, though that is different from the verbal aspect). This recoding will eventually reduce the complexity to subsets of $\mathbb{R}^3$. Using the vector model of O’Keefe (2003), this can be drastically reduced. Essentially, we can compress the meaning into a function that computes goodness of fit from two numbers: (1) the deviation from the axis denoted by “front”, and (2) the distance from the landmark. There is only one such function, additional parameters (like size of the object) are needed only in the process of constructing the coordinate frame. As a consequence, they are needed only to compute the spatial aspect and can henceforth be ignored.

Another issue, raised in Levinson (2003) is whether language structure influences the cognitive categorisation. Particularly, he observes that certain languages lack any kind of intrinsic or observer relative axis systems. All they use is absolute systems (“north”, “west”, and so on). One such language is Guugu-Yimithirr. In this language, two situations differing only in the orientation of the observer are considered identical, while situations are different if they are rotational variants of each other. For example, if you are sitting in front of your plate, the fork to the left of the plate, and opposite you someone, say John, is sitting likewise in front of his plate, facing you, then for him the fork is to the left of his plate. But Guugu-Yimithitt lacks the means to express the uniformity. If for example my fork is to the south of my plate, then John’s fork is actually to the north of his plate.

While we can mirror the effect of Guugu-Yimithirr spatial talk by using expressions with similar mechanics, the difference is that we ordinarily to not talk like that. And that, Levinson claims, influences our categorisation of what situations count as the same. Speakers of Guugu-Yimithirr are likely to say that the layout of fork and plate is different for John and me, while we would see that differently. For a somewhat more nuanced view see Bowerman and Choi (2001).

## 12. Conclusion

We have seen that local PPs are not only syntactically very complex, more complex than “ordinary” PPs. We have also seen that out of this structural complexity arise many questions of detail that have relevance to the way in which we interpret these expressions. For example, the question of syntax and semantics competition coupled with the theory of selection opens a theory of systematic meaning differences, triggered mainly by the context.

Thus, the arising questions are far from trivial. Given the importance of space in everyday life, understanding spatial PPs it actually a topic worthy of study in linguistics. Above all, it is a very interesting and beautiful topic.

## References

Paul Bloom, Mary A. Peterson, Lynn Nadel, and Merrill F. Garrett, editors. *Language and Space*. MIT Press, Cambridge, Mass., 1996.

Melissa Bowerman and Soonja Choi. Shaping meanings for language: Universal and language-specific in the acquisition of semantic categories. In Melissa Bowerman and Levinson Stephen C., editors, *Language acquisition and conceptual development*, pages 475–511. Cambridge University Press, 2001.

Bernard Comrie and Maria Polinsky. The great Daghestanian case hoax. In Anna Siewierska and Jae Jun Song, editors, *Case, typology and grammar. In honour of Barry J. Blake*, pages 95–114. John Benjamin’s, Amsterdam, 1998.

Bernhard Comrie, Maria Polinsky, and Ramazan Rajabov. Tsezian languages. In Alice Harris and Rieks Smeets, editors, *The languages of the Caucasus*. Curzon, London, 1999.

Greville Corbette. *Features*. Cambridge Textbooks in Linguistics. Cambridge University Press, 2012.

Marcel den Dikken. On the Functional Structure of Locative and Directional PPs. In Guglielmo Cinque and Luigi Rizzi, editors, *Mapping Spatial PPs: The Cartography of Syntactic Structures*, volume 6, pages 74–126. Oxford University Press, 2010.

Vivienne Fong. *The Order of Things: What Directional Locatives Denote*. PhD thesis, Stanford University, 1997.

Pierre Gambarotto and Philippe Muller. Ontological Problems for the Semantics of Spatial Expressions in Natural Language. In Emile van der Zee and John Slack, editors, *Representing Direction in Language and Space*, number 1 in Explorations in Language and Space, pages 144–165. Oxford University Press, Oxford, 2003.

Martin Haspelmath. *From Space to Time: Temporal Adverbials in the World's Languages*. Number 03 in Studies in Theoretical Linguistics. Lincom, München, 1997.

Bernd Heine and Tania Kuteva. *World Lexicon of Grammaticalization*. Cambridge University Press, Cambridge, 2002.

L. Hjelmslev. *La catégorie des cas: Étude de grammaire générale I.* Munksgaard, Kopenhagen, 1935. Acta Jutlandica: Aarsskrift for Aarhus Universitet 7.1.

L. Hjelmslev. *La catégorie des cas: Étude de grammaire générale II.* Munksgaard, Kopenhagen, 1937. Acta Jutlandica: Aarsskrift for Aarhus Universitet 9.3.

Harry Howard. *Neuromimetic Semantics*. Elsevier, Amsterdam, 2004.

Ray Jackendoff and Barbara Landau. Spatial language and spatial cognition. In Ray Jackendoff, editor, *The Languages of the Mind*, pages 99–124. MIT Press, Cambridge (Mass.), 1992.

Hilda Koopman. Prepositions, Postpositions, Circumpositions and Particles: The Structure of Dutch PPs. unpublished, 1997.

Marcus Kracht. Against the Feature Bundle Theory of Case. In Eleonore Brandner and Heike Zinsmeister, editors, *New Perspectives on Case and Case Theory*. CSLI, Stanford, 2002a.

Marcus Kracht. Directionality selection. In Patrick Saint-Dizier, editor, *Linguistic Dimensions of Prepositions*, pages 101–114. Springer, 2006.

Marcus Kracht. The Fine Structure of Local Expressions. In Anna Asbury, Jakub Dotlacil, Berit Gehrke, and Rick Nouwen, editors, *The Structure of Local P*, pages 35–62. John Benjamin's, Amsterdam, 2008.

Marcus Kracht. On the Semantics of Locatives. *Linguistics and Philosophy*, 25: 157–232, 2002b.

Ronald W. Langacker. *Foundations of Cognitive Grammar*, volume 1. Stanford University Press, Stanford, 1987.

Stephen C. Levinson. *Space in Language and Cognition. Explorations in Cognitive Diversity*. Number 5 in Language, Culture and Cognition. Cambridge University

Press, Cambridge, 2003.

Igor Mel'čuk. *Cours de Morphologie Générale, 2ème Partie: Significations Morphologiques*. Les Presses Universitaires de Montréal, Montréal, 1994.

Arthur Merin. Formal semantic theory and diachronic data: A case study in grammaticalization. Technical Report 75, SFB 340, University of Stuttgart, 1996.

Seungho Nam. *The Semantics of Locative Prepositional Phrases in English*. PhD thesis, UCLA, 1995.

Urpo Niikanne. How Finnish Postpositions See the Axis System. In Emile van der Zee and John Slack, editors, *Representing Direction in Language and Space*, number 1 in Explorations in Language and Space, pages 191–208. Oxford University Press, Oxford, 2003.

Urpo Niikanne. On Assigning Semantic Cases in Finnish. In B. Holmberg and U. Niikanne, editors, *Case and Other Semantic Categories in Finnish Syntax*. Mouton de Gruyter, Berlin, 1993.

John O'Keefe. Vector Grammar, Places, and the Functional Role of the Spatial Prepositions in English. In Emile van der Zee and John Slack, editors, *Representing Direction in Language and Space*, number 1 in Explorations in Language and Space, pages 69–85. Oxford University Press, Oxford, 2003.

Chris Piñon. Paths and their names. In Katharine Beals, Gina Cooke, David Kathman, Sotaro Kita, Karl-Erik McCullough, and David Tesen, editors, *Papers from the 29th Regional Meeting of the Chicago Linguistic Society, Volume 2: Papers from the parasession on the correspondence of conceptual, semantic and grammatical representations*, page 287–303. Chicago Linguistic Society, 1993.

Peter Svenonius. Projections of P. In Anna Asbury, Jakub Dotlacil, Berit Gehrke, and Rick Nouwen, editors, *The Structure of Local P*, pages 63–84. John Benjamin's, Amsterdam, 2008.

Soteria Svorou. *The Grammar of Space*. John Benjamins, Amsterdam, 1993.

Leonard Talmy. *Toward a Cognitive Semantics*, volume 1 & 2. MIT Press, Cambridge (Massachussetts), 2000.

Arhonto Terzi. Complex spatial expressions. In Martin Everaert and Henk van Riemsdijk, editors, *The Blackwell Companion to Syntax*. 2014.

Emile van der Zee and John Slack. *Representing Direction in Language and Space*. Number 1 in Explorations in Language and Space. Oxford University Press, Oxford, 2003.

Henk van Riemsdijk. *A Case Study in Syntactic Markedness: The Binding Nature of Prepositional Phrases*. Foris, Dordrecht, 1978.

Joost Zwarts. Prepositional Aspect and the Algebra of Paths. *Linguistics and Philosophy*, 28:739–779, 2005a.

Joost Zwarts. Paths Around a Prototype. In Patrick Saint-Dizier, editor, *Semantics of Prepositions*. Springer, 2005b.

Joost Zwarts. Vectors across Spatial Domains: From Place to Size, Orientation, Shape and Parts. In Emile van der Zee and John Slack, editors, *Representing Direction in Language and Space*, number 1 in Explorations in Language and Space, pages 39–68. Oxford University Press, Oxford, 2003.

Joost Zwarts and Yoad Winter. Vector Space Semantics: A Model–Theoretic Analysis of Locative Prepositions. *Journal of Logic, Language and Information*, 9: 169–211, 2000.

Fakultät Linguistik und Literaturwissenschaften, Universität Bielefeld, Postfach 100131, D-33501 Bielefeld, Germany, marcus.kracht@uni-bielefeld.de