Aspects of a Typology of Direction

Joost Zwarts

Radboud University Nijmegen

P.O. Box 9103

6500 HD Nijmegen

The Netherlands

Joost.Zwarts@let.ru.nl

Abstract[*]

Although direction plays an important role in the semantics of prepositions and verbs, there are not many precise and systematic treatments of this notion. This article offers a characterization and typology of directionality, based on two algebraic properties of spatial paths: cumulativity and reversability. This typology makes clear how directionality relates to the aspectual property of telicity, it generates implicational predictions about directional marking in systems of cases and adpositions around the world, and it suggests broad parallels between the realizations of directionality in prepositions and verbs.

Like all parts of speech, prepositions can be classified in different ways. When we focus on the semantic side of spatial prepositions, we find a major division between locative prepositions (like *in* and *under*) and directional prepositions (like *into* and *through*):

(1) a. Alex is in/under the car.   (locative)

     b. Alex went into/through the forest.   (directional)

Locative prepositions correspond to places (where something is), directional prepositions to paths (where something is going) (see Jackendoff 1983 and many others). Further classifications can be made within both locative and directional expressions, like the distinction of goal ('to'), source ('from') and route ('via') prepositions, for example. Such semantic categories are of central importance for the grammar of adpositions in languages across the world, as well as for case systems (Van Riemsdijk and Huijbregts 2001, Kracht 2002).

We can also classify prepositions as telic or atelic, according to the contribution that they make to the aspectual structure of a sentence:

(2)   Alex walked …

    a.   … in the forest/towards the station/along the beach.   (atelic)

    b.   … into the forest/to the station/around the barrier.   (telic)

According to the usual aspectual tests (Dowty 1979), prepositions like *in*, *towards* and *along* lead to atelic, unbounded aspect, while *into*, *to* and *around* make the sentence they modify telic, bounded in aspect. All locative prepositions are atelic, but directional prepositions can be telic or atelic, depending on their particular lexical definition.

The purpose of this paper is to take a closer look at classes of prepositions (section 1), building on the algebra of paths in Piñon (1993), Nam (2000), and Zwarts (2005), and to show that this algebra allows a richer typology of direction than the one that has emerged in the linguistic literature (section 2). This typology does not only show us more clearly how the system of prepositions hangs together semantically and how the spatial and aspectual dimension relate (section 3 and section 4), but it also provides a basis for markedness patterns in the morphosyntax of directionality, whether expressed by adpositions or case markers (section 5). The directional typology that we find for prepositions can be extended to verb meanings, giving a partial typology of 'event shapes', similar to the more informal verb contours of Talmy (1978) and others (section 6).

1   Paths and prepositions

Building on much earlier work on prepositions, I assume that the interpretation of directional prepositions is based on paths, more specifically, that a directional PP denotes a set of paths.[1] A path can be taken as a directed curve, corresponding to a sequence of positions in space. I will assume here that a path is formally defined as a continuous function $\mathbf{p}$ from the real interval $[0,1]$ to some domain S of places, which is a common mathematical way to define a path. Such a mathematical definition has its limitations, of course, when it is applied to linguistic phenomena, and alternatives are easily conceivable. However, this formalization is convenient and it does serve our purposes well here. For some further discussion, see Zwarts (2005). A path has a starting point, that we indicate with $\mathbf{p}(0)$, an endpoint $\mathbf{p}(1)$, the two extremes of the path, and for every i between 0 and 1, $\mathbf{p}(i)$ is an intermediary point of the path, between the extremes. Paths have to be integrated in the interpretations of the sentence in one way or another. I will not go into that here, but assume that there is a thematic relation TRACE between a (motion) event e and the path $\mathbf{p} = \text{TRACE}(e)$ that represents the spatial trace of that event, an common enough assumption in work on aspect and prepositions (e.g. Krifka 1998).

With this in place we can give definitions of directional prepositions (or rather, the PPs they project) and a rough first classification, based on the way the prepositions are defined. Most of the prepositions can be defined in terms of locative conditions they impose on particular parts of the path. There is a class of *source* prepositions, for instance, that impose a locative condition on the initial part of the path. Examples are *from*, *out of*, *off*, *from under*, and *away from*.[2] The definition of *from under the bridge* is as follows:

(3) ⟦ from under the bridge ⟧ = { **p**: there is a proper subinterval *I* of [0,1] that includes 0 and that consists of all the *i* ∈ [0,1] for which **p**(*i*) is under the bridge }

Interval *I* corresponds to the portion of the path that is under the bridge. This portion includes the starting point 0, but it excludes the endpoint 1, because it picks out a proper part of the path. As a result, the definition divides the domain [0,1] of the path in two parts (*phases* in the terminology of Löbner 1987 and Fong 1997), a 'positive' part that is mapped to positions under the bridge and a 'negative' part mapped to positions that are not under the bridge. Schematically, with *I* corresponding to the + part:

(4) `++++++------`
     `0          1`

The source prepositions differ from each other in their spatial conditions on the positive part. For *off* it is 'on', for example, and for *away from* it is 'near'. Such conditions can receive precise definitions in a formal model of locations (see for example Nam 1995, Zwarts and Winter 2000, Kracht 2002).

With goal prepositions like *to*, *into*, *onto*, and *up* and *down* we get the opposite pattern, with a positive phase following a negative phase:

(5) `------++++++`
     `0          1`

Into the house, for instance, denotes the following set of paths:

(6)   ⟦ into the house ⟧ = { **p**: there is a proper subinterval *I* of [0,1] that includes 1 and

that consists of all the indices *i* ∈ [0,1] for which **p**(*i*) is inside the house }

I assume, following Jackendoff (1983), that a PP like *under the bridge* can also have such a goal meaning, denoting the set of paths that have their second phase under the bridge, derived through an invisible operator from the locative denotation of that PP. For *up the hill* and *down the hill* we can take the goal of the path to be the top and the bottom of the hill, respectively.

The third class of prepositions involves a condition on a middle part:

(7)   ```
      ----++++----
      0   1
      ```

Examples are *via*, *past*, *through*, *across*, and *over*. To illustrate how such route prepositions are defined I give the definition of *over the fence* here:

(8)   ⟦ over the fence ⟧ = { **p**: there is an interval *I* ⊂ [0,1] that does neither include 0

nor 1 and that consists of all the *i* ∈ [0,1] for which **p**(*i*) is on/above the fence }

The PP *under the bridge* can also have a route interpretation, as Jackendoff (1983) showed, derived through an invisible 'via'.

Another class of prepositions involves a spatial ordering of the extremes of the path. I represent this schematically as follows, with a sequence of plusses ranging from white to black:

(9)   ```
      ++++++++++++
      0           1
      ```

The core example here is *towards*, that I interpret as referring to paths that have their endpoint closer to the reference object than their starting point:

(10) ⟦ towards the gate ⟧ = { $\mathbf{p}$: $\mathbf{p}(1)$ is nearer$_F$ to the gate than $\mathbf{p}(0)$ }

It is necessary to relativize the proximity and distance notions assumed here to a particular physical 'frame' F. In many situations where *towards* is used, the distance will be measured in a straight line, but there are situations in which the distance is measured along a curved track. If the road to the gate makes a wide curve to avoid an obstacle, then it is possible to say that we walked towards the gate, even if, measured in a straight line, our distance to it increased. This is one of the many ways in which a geometric notion gets a special contextual implementation in the semantics of prepositions. But in spite of this complication, *towards* has a clear *comparative* structure that it shares with prepositions like *up* and *down*: *up the hill* can mean 'higher and higher on the hill', for instance. Another example might be *away from* if used with the meaning 'further and further away from'.

   Constant prepositions impose one and the same locative condition on all the points of the path:

(11) ++++++++++++
      0   1

The simplest example is probably *through* in its atelic meaning, defined in (12a) below, where the whole path is in the interior of the reference object, as opposed to the telic meaning that has the structure in (7). *Over* is ambiguous in a similar way.

(12) a. ⟦ through the park ⟧ = { **p**: for all $i \in$ [0,1] **p**(i) is in the park }

  b. ⟦ along the river ⟧ = { **p**: **p** is parallel to the major axis of the river }

Along is a more complex preposition in this class, involving reference to a more global geometric relation between path and object (Talmy 1983). The definition in (12b) implies that all the points of the path are at roughly the same distance from the reference object.

The preposition *around* is somewhat of a special case. In order to see this, let us focus on its most prominent meaning, involving a circular path enclosing an object on all sides (see Zwarts 2004 for more discussion about the polysemy of *around*). It is fairly easy to see that this configuration cannot be characterized in terms of a straightforward locative condition on some or all of the points of the path. *Around* is a constant preposition in the sense that all the points of the path are roughly at the same distance to the object (the constant radius of the circle), but this is not enough. The path is also like a goal preposition: its endpoint is identified as its starting point. Furthermore, we need to make sure that there is a point of the path at every side of the object in the horizontal plane, which is what complete enclosure requires. A proper definition of *around* requires the use of *vectors*, with the path mapping the interval [0,1] to vectors emanating from the house (Zwarts and Winter 2000, Zwarts 2004), as illustrated in Figure 1.

*** FIGURE 1 ABOUT HERE***

This allows us to define the core meaning of *around* in the following way:

(13) ⟦ around the house ⟧ = { **p**:

  (i) for every $i, j \in$ [0,1] **p**(i) and **p**(j) have the same length

(ii) only $\mathbf{p}(1) = \mathbf{p}(0)$ and

(iii) for every direction there is an i such that $\mathbf{p}(i)$ is pointing in that direction }

This definition is of course too strict and there are several ways to weaken it to allow for more vagueness and polysemy. The important point here is to show that at least one preposition requires in its definition reference to various parts and properties of the path, making it - in this respect - different from the other prepositions that we already discussed. As a result, we can give no simple 'phase' diagram for *around*. But notice that *around the house* is still of the same general semantic type as the other directional prepositions: it denotes a set of paths, each of which is a mapping from indices to positions or vectors. What differs is *how* this mapping is defined. I will use the term *geometric* preposition for this class, just to be able to refer to it. Certain route and constant prepositions, especially *along* and *across*, might also be candidates for this class, because they refer to geometric configurations of parallelism or orthogonality (Talmy 1983).

Finally, we have a class of preposition that show a repeating pattern: *periodic* prepositions. Here we find examples like *around and around*, *up and down*, but also iterative uses of *through*, *across* and *over*. What happens is that a pattern X is repeated:

(14) XXXXXXXXXXXX
      0   1

That pattern might be a sequence of an up and a down path, for example, or a single circular enclosure of an object. Here is a very rough definition of the periodic PP *around and around the house*:

(15) ⟦ around and around the house ⟧ = { **p**: **p** is a sequence of paths that each go around the house once }

Summarizing this section, we have see seven classes of directional prepositions, illustrated here with the schematic diagram and one typical example for each:

(16) Source prepositions   +++++−−−−−   from

       Goal prepositions   −−−−−−+++++   into

       Route prepositions   −−−−+++++−−−   over

       Comparative prepositions   +++++++++++   towards

       Constant prepositions   +++++++++++   through

       Geometric prepositions   (no diagram)   around

       Periodic prepositions   XXXXXXXXXXXX   around and around

Some of the classes correspond to *path functions* proposed in Jackendoff (1983) or *modes* in Kracht (2002), that map places to paths:

(17)

	Jackendoff (1983)	*Kracht (2002)*
Source	FROM	coinitial
Goal	TO	cofinal
Route	VIA	transitory
Comparative	TOWARDS	approximative
Constant	-	-
Geometric	-	-
Periodic	-	-

Such functions take a particular place L and map it to the set of paths that take L as their starting point, endpoint, route, or point of approximation. It is not difficult to derive constant prepositions through a function that maps L to paths that are entirely located in L. However, as we saw above, geometric prepositions work in a different way. Periodic prepositions are also special, because they are defined as the repetition of a pattern.

What we have in (16) and (17) is just an enumeration of classes of directional prepositions. We will now turn to an exploration of the system behind these seven classes, based on the algebra of paths of Zwarts (2005).

2   Towards a typology of directional prepositions

There are different ways to set up a typology of directional prepositions. One way would be to look at the way that prepositions are defined, by conditions on the location of certain parts of the path. This is a valuable approach, which has often been followed (and it was implicitly used in the previous section), but it is not the one that I will follow in this section. Instead I will look at certain structural (algebraic) properties of the set of paths denoted by the PP that is projected by a particular preposition, following Piñon (1993). This has a number of advantages. The first advantage is that we can study the properties of a preposition without knowing exactly how to give the definition of that preposition. For example, *around* is a difficult preposition to define, but given a rough idea of the kind of paths that correspond to it, there is not much difficulty in determining certain properties of the corresponding set. The second advantage of this structural approach is that we can study how this typology of prepositions relates to the aspectual and quantificational distinctions that are common in the

formal, algebraic semantics of nouns, verbs and determiners,. In this paper, it is the connection with the aspectual property of cumulativity that is especially important (e.g. Krifka 1998, Rothstein 2004a).

The typology that we are going to present is based on three properties: connectivity, cumulativity and reversability.

2.1 The role of connections

Suppose that we have two paths **p** and **q** such that **p**(1) = **q**(0), i.e. **q** starts where **p** ends. We say that **p** and **q** *connect*. Based on this notion on connection we can distinguish two properties for sets of paths:

(18) A non-empty set of paths **X** is

     a.   non-connected iff   there are no **p** ∈ **X** with a connecting **q** ∈ **X**.

     b.   connected iff   there are **p** ∈ **X** with a connecting **q** ∈ **X**.

The prepositions divide as follows over the two types:

(19)   a.   Non-connected: source, goal prepositions

       b.   Connected: comparative, route, constant, geometric, periodic

                                       prepositions

The source and goal prepositions are non-connected because the extremes of their paths are always in different spatial regions. Take the denotation of *into the house*. The starting points are always outside the house, while the endpoints are all inside the house. This means that we

cannot find any $\mathbf{p}$ and $\mathbf{q}$ in the denotation such that $\mathbf{p}(1) = \mathbf{q}(0)$. The set is non-connected. This can easily be seen in the diagrams of the previous section: the extremes of the path have opposite 'polarity'.

Other prepositions build sets of paths that are connected. For example, if we take a path $\mathbf{p}$ from the denotation of *over the fence*, then it is easy to find a path $\mathbf{q}$ such that $\mathbf{p}(1) = \mathbf{q}(0)$, namely a path $\mathbf{q}$ that goes back over the fence in the opposite direction. The same connectivity property holds not only for route prepositions like *over*, but also for comparative prepositions (*towards*), constant prepositions (*along*), geometric prepositions (*around*), and periodic prepositions (*around and around*). The reason is that the extremes of the relevant paths are in the same spatial domain. For example, a path in the denotation of *towards the gate* brings us to a point closer to the gate, but from that point we can still get closer to the gate.

2.2   The role of reversals

A natural operation on paths is *reversal*: ~$\mathbf{p}$, the reversal of $\mathbf{p}$, is the path which assigns to every $i \in [0,1]$ the position that $\mathbf{p}$ assigns to $1-i$.

(20)   A set of paths $\mathbf{X}$ is reversible if and only if for every $\mathbf{p}$,

if $\mathbf{p} \in \mathbf{X}$ then ~$\mathbf{p} \in \mathbf{X}$.

If we take a path $\mathbf{p}$ in the denotation of the route PP *over the fence*, then the reversal ~$\mathbf{p}$ is also in that denotation. The same is true for constant, geometric and periodic prepositions. They are all reversible, which means that these prepositions are directional without being 'polarized'.

On the other hand, source and goal prepositions are not reversible. If **p** is a path *into* the house, then ~**p** is a path *out of* the house. *Into* and *out of* are each other's reverses. The comparatives also lack the property of reversibility. If we reverse the paths of *towards the gate*, we do not get the same set, but a set that corresponds to *away from the gate*. This is because the ordering in the definitions of comparatives gives them a 'polarity'. The comparatives come in pairs (*towards - away from*, *up - down*), just like the source and goal prepositions (*to - from*, *into - out of*, *onto - off*). Notice that we do not find reversible prepositions that are non-connected: if a set of paths is reversible, then every path **p** is inevitably connected to another path, namely its reversal ~**p**.

Individual path reversal is not the only way to define a directional opposition in the set of paths. Here is one alternative, suggested to me by an anonymous reviewer. *Asymmetric* sets have the following property: if a path from point A to B is in the set **X**, then *any* path from B to A is *not* in the set **X**. For *symmetric* sets the following holds: if a path from A to B with spatial property P is in the set **X**, then any path from B to A with this property P is also in the set **X**. This might lead to a tighter and more natural typology (because the notion of path opposition that it uses is more general), although it is not immediately obvious how to extract the spatial property P from a set of paths that is needed to define symmetry. A set of paths does not come with the spatial criterion that was used to define it. In contrast, (non-)reversability is a general algebraic property that we can apply to sets of paths without having to know how the individual paths relate spatially to the reference object.

2.3 The role of cumulativity

When **p** and **q** connect, we can form a new path **p+q** that is the *concatenation* of **p** and **q** (Habel 1989, Nam 1995, Zwarts 2005). Concatenation allows us to define a set of paths as being *cumulative*, i.e. closed under concatenation:

(21)   A connected set of paths **X** is cumulative iff for all **p**, **q** ∈ **X**, if **p+q** exists, then

   p+q ∈ **X**.

According to this definition the prepositions that lead to cumulative denotations are the comparative, constant and periodic prepositions. The spatial property that characterizes the individual paths **p** and **q** also characterizes their concatenation **p+q**. For example, if **p** brings you closer to the gate and it connects to a path **q** that brings you closer to the gate, then, inevitably, **p+q** brings you closer to the gate.

   The source and goal prepositions are non-cumulative, because they don't even have the connection property that forms the basis for non-trivial cumulativity.[3] The route prepositions allow concatenation, but this concatenation does not preserve the spatial properties of the concatenants. For instance, if we concatenate two paths **p** and **q** that are in the denotation of *over the fence*, as defined in (8), then the result is a path that is not in this denotation, because it goes over the fence twice, i.e. it has the following schematic structure:

(22)   ````----++++----++++----````
           0   1

So, assuming that the basic meaning of *over the fence* is 'singular', it follows that it is therefore non-cumulative.

The notion of cumulativity and 'number' that I focus on here strictly concerns the spatial, path-based meaning of prepositions and PPs only. I am not concerned in this paper with the semantic effects of a bare plural noun phrase in a PP, as in *over fences*. Like in the verbal domain, such a bare plural can lead to atelic aspect (*jump over fences for hours*), but this atelicity does not involve the kind of cumulativity that I explained in this section. The notion of cumulativity that I use here is very similar to that of S(ingular)-cumulativity in Rothstein (2004a, 2004b, this volume). It is an algebraic property of a set of *singular* entities. In Rothstein's proposal (about activity verbs like *run*) these are singular events that can be joined together in a cumulative fashion when they are temporally adjacent, in my proposal the singular entities are paths that are concatenated under spatial adjacency. The cumulativity that we see in *over fences* is of a higher level, involving not concatenation of paths, but aggregation of paths in plural sums.

2.4   Types of simple directional prepositions

With these formal properties in place we can give a typology of simple prepositions now, along the lines indicated in Table 1.

TABLE 1 ABOUT HERE

I would like to suggest that these are fundamental types, not only for the semantics of directional prepositions, but also for the semantics of dynamic verbs, as I will show in section 6. With an eye on that wider application, I will introduce four general terms here: *transitions*, *cycles*, *progressions*, and *continuations*, given at the bottom of the columns.

• *Transitions* This type involves paths that go from one spatial domain to a different, complementary spatial domain, which makes them non-connected and therefore also non-cumulative and non-reversible. There are two sub-types of the transitions, that differ in the direction of the transition.

• *Cycles* The route prepositions, refer to paths that enter a particular spatial domain and leave it again, ending up in the same spatial conditions that they started with, which is why I call them cycles. This makes them connected and reversible, but they are non-cumulative because the concatentation of two cycles does not yield a cycle, but two cycles in sequence. The same is true for geometric prepositions, like *around*.

• *Progressions* When we define an ordering on the points of the path, we get a progression, a type that is not reversible, because it has a direction. But, in contrast to the other directional type, the transitions, the paths of a progression are connected and they add up in a cumulative way.

• *Continuations* have connectivity as well as cumulativity, but they are also reversible. This is because there is a constant property that holds over the entire path.

The typology is similar to the one given in Piñon (1993), who, building on the path concepts of Jackendoff (1983,1991), distinguishes bounded paths, bounded routes, directions and unbounded routes.

Given the three parameters, these are all the types that are possible and relevant for the classification of basic prepositions. We might have expected 8 types, given that there are three parameters with each two values. Notice however that we can never find a reversible type that is also non-connected: if a set of paths is reversible, then every path **p** is inevitably connected to another path, namely its reverse ~**p**. Also, there is no set of paths which is not connected but still cumulative: the connections are lacking that allow concatenation to apply in a non-

vacuous way. This means that there necessarily is only one non-connected type: the transitions.

There is a type, though, that is not ruled out for principled reasons: the type that is connected, but that lacks cumulativity and reversibility. There is no *simple* preposition with these properties, but as we will see in the next section, there are *complex* prepositions that express this type in English, like *one hundred feet up (the hill)* or *clockwise around the room*. With this in mind, we can leave the property of connectivity in the background and represent the four types of simple prepositions in a two-dimensional way, as in Table 2.

TABLE 2 ABOUT HERE

Horizontally we find the primary directional distinction and vertically the aspectual distinction. Further dimensions might be possible, but I believe that the ones defined are the major ones.

2.5   Types of complex directional prepositions

The type of a simple directional PP can change when it is modified by a measure phrase or directional adverb. Continuations and progressions can become *bounded* when they are modified by a measure phrase, for instance. While *up the hill* is a progression, the modified PP *one hundred feet up the hill* has lost the property of cumulativity. A path that leads 100 feet up the hill can have a connection to another path going 100 feet up the hill. The sum of these two paths, however, is obviously not a path that can be described as *one hundred feet up the hill*. I will call this type of PP a *bounded progression*, because of this non-cumulativity.

As we already noticed, there is no simple PP in English (and maybe not in any other language) that expresses bounded progressions.

We also find *bounded continuations*, like the complex PP *ten miles through the woods*. If this PP refers to paths that go through the woods and that have a length of ten miles, then we get a PP denotation that is connected and reversible, but not cumulative. This is the same algebraic type as the cycles, but derived in a rather different way. We can see this by contrasting the cycle *through the woods* with the bounded continuation *ten miles through the woods*:

(23)   a.   Alex walked through the woods in half a day.

      b.   Alex walked ten miles through the woods in half a day.

(23a) is intended to express that Alex entered the woods and left them half a day later, (23b) describes a situation in which Alex is walking in the woods all the time and it took him half a day to walk ten miles there. In both sentences the PPs are 'bounded', but for different reasons. (23a) is bounded by the woods, while (23b) is bounded by the measure phrase.

We can also change the type of a simple PP through a directional modifier, like *north*, *up*, or *clockwise*. If we take the continuation *along the river*, then by adding up, we get a *directed continuation*: *up along the river*, which is still connected and cumulative, but no longer reversible, hence ending up in the same class as the progressions. Notice that we can then add a measure phrase to make the PP a *bounded directed continuation*: a complex PP like *two miles up along the river* refers to a set of paths that is only connected, but not cumulative, nor reversible.

With cyclic PPs there can be two effects when we add direction. If we take *around the room* to refer to a single tour of the room, then *clockwise around the room* denotes a set of

paths that is connected, but neither cumulative nor reversible. It has the same properties as a bounded progression, but through a different structure. We get a different result when we add *north* to *across the river*, for instance. The directional element *north* makes the PP *north across the river* not only non-reversible, but also non-connected, resulting in a type with the same algebraic properties as a transition. I will call both of these types *directed cycles*, without further going into the differences among them, that depend both on the preposition involved and the modifier.

So, we have seen the following examples of complex PPs:

(24) Bounded continuation: *ten miles* through the woods

Bounded progression: *ten feet* up the hill

Directed continuation: *up* along the ladder

Directed cycle: *north* across the river, *clockwise* around the room

Bounded directed continuation: *two miles up* along the river

which fit into the two-dimensional Table 3 as indicated.

TABLE 3 ABOUT HERE

Measure phrases map cumulative into non-cumulative denotations and directional modifiers map reversible into non-reversible denotations. This gives a rough idea of the effect of modification on the denotation of directional expressions of different types. In the remainder of this paper, we will focus on simple (non-modified) prepositions, considering the implications of this typology, first for the more semantic domain of aspect, then for the

morphosyntactic expression of direction. After that we will turn our attention to a different syntactic category, that of verbs.

3   The aspect of directions and paths

In Zwarts (2005) I argued that cumulativity (closure under concatenation) is the crucial property for the aspect of directional prepositional phrases. All other things being equal, non-cumulative PPs (transitions and cycles) make a sentence telic, while cumulative PPs (progressions and continuations) make it atelic, as shown by the kind of durative modifiers that are allowed in each case:

(25)   Alex walked …

    a.   to the house/out of the forest *in an hour.*   (telic)

    b.   over the hill/around the village *in an hour.*   (telic)

    c.   towards the coast/up the hill *for hours.*   (atelic)

    d.   along the river, around and around the house *for hours.*   (atelic)

It would go to far here to discuss here how the algebraic structure of PPs determines the aspect of a sentence in a compositional fashion. In Zwarts (2005) I followed Krifka (1998) in assuming that the thematic TRACE function, relating paths to events, is responsible for this, while at the same time assuming, in the spirit of Rothstein (2004a), that the relevant event algebra consists of *singular* events only, together with a concatenation operation. I will assume that here too.

The first important thing to note now is that this primary aspectual distinction cuts right across the distinction of directedness, that we characterized as reversible versus non-reversible in the previous section. This means that we have non-directed telicity (25b), as well as directed atelicity (25c).

However, the directedness is not independent of aspect, but it plays an important role in determining certain aspectual patterns. Even though transitions and cycles are both non-cumulative and lead to telic aspect, their aspectual behaviour is not completely identical. With the atelic *for* adverbial, cycles can be coerced into an atelic reading much easier than transitions:

(26) a. ?Alex walked to the house/out of the forest for hours.

b. Alex walked over the hill/around the city for hours.

Although not entirely impossible, an iterative reading sounds strange for the transitions in (26a). In the cyclic examples in (26b), on the other hand, we can much more easily get an iterative reading, with Alex walking back and forth over the hill or around and around the city. This difference in iterativity between transitions and cycles follows directly from their path structures: the cycles are connected, but the transitions are not. We can easily iterate the paths of a cycle PP like *over the hill*, because every path $\mathbf{p}$ is connected to a path $\mathbf{q}$. It is possible to define an operation PLURAL for a set of paths that creates this iteration by putting paths together head to tail (Zwarts 2005):

(27) PLURAL([[over the hill]]) = the closure under concatenation of [[over the hill]]

This yields a cumulative set of paths. But with a transition like *out of the forest* this operation would not yield any concatenations of paths, because there are no two paths in its denotation that connect.

Cycles and transitions also behave differently with respect to the imperfective paradox (Dowty 1979):

(28) a.   Alex was walking out of the house. $\nrightarrow$ Alex walked out of the house.

b.   Alex was walking over the hill. $\rightarrow$ Alex walked over the hill.

Transitions used in the progressive form never entail the simple past form. Alex could have been stopped in the door on his way out in example (28a). With cycles the pattern is different. There is a sense in which the progressive form in (28b) does not entail the simple form, when Alex started at one side of the hill with the intention to go to the other side, but was interrupted somewhere at the top. Then he did not walk all the way over the hill and with this sense we get an instance of the imperfective paradox, like in (28a). However, in contrast with the transitions, the cycles can easily be coerced into a reading where the entailment does go through, by interpreting *over the hill* in an atelic way (as a constant preposition), referring to paths that are on the hill, without necessarily leading from one side to the other side. This coercion can be defined in terms of a kind of 'grinder' operation on paths that extracts parts (Zwarts 2005):

(29)   GRIND([[over the hill]]) = { $\mathbf{p}$: there is a minimal $\mathbf{q} \in \mathbf{X}$ such that $\mathbf{p} < \mathbf{q}$ }

This operation corresponds to the verbal progressive and the nominal partitive. If $\mathbf{X}$ is a set of paths that go all the way *over the hill*, then GRIND selects from $\mathbf{X}$ the minimal paths (of which

only the extremes $\mathbf{p}(0)$ and $\mathbf{p}(1)$ are not on the hill) and it then takes the subpaths ($<$) of these paths. Zwarts (2005) shows that transitions have no minimal paths and therefore cannot be grinded.

The cycle prepositions also allow for a *stative* use, based on an operation sometimes called endpoint focus (Cresswell 1978, Jackendoff 1983, Lakoff 1987), but this is not possible with transitions:

(30) a.   *Alex lives out of the forest.

b.   Alex lives over the hill.

We find this use not only with *over*, but also with other route prepositions:

(31) a.   Alex lives around the corner.

b.   Alex lives across the road.

c.   Alex lives past the railroad station.

We can define the relevant operation as a mapping from paths to their endpoints:

(32) ENDPOINT($[\![$ over the hill $]\!]$) = { $\mathbf{p}(1)$: $\mathbf{p} \in \mathbf{X}$ }

With transitions, this operation always gives us a region of space that we could also have described in simpler terms, through a locative PP, for example:

(33) a.   *Alex lives out of the forest. = Alex lives outside the forest.

b.   *Alex lives to the castle. = Alex lives at the castle.

With cycles however, there is no locative preposition that could block the endpoint use.

So, we see that it makes much sense for the study of aspect to have a richer typology of prepositions, based not only on the distinction between cumulativity and non-cumulativity, but also on a distinction between reversible (non-directed) and non-reversible (directed), and, at the background, the distinction between connected and non-connected. Only the reversible prepositions show a tendency for atelic uses through iteration, grinding and stative endpoint shift. We can add to this one final observations to illustrate the aspectual relevance of directedness. Only reversible prepositions can be used statively in simple configurational extension uses with plural or elongated themes:

(34) a. *The cable is lying into the house.

b. *The trees are standing towards the city.

c. The cable is lying across the street.

d. The trees are standing along the river.

Directed PPs are not possible with simple locative predicates like *stand* and *lie*, as (34a) and (34b) show, but with non-directed prepositions this is possible, as in (34c) or (34d). Notice also that many of the non-directed prepositions can be accompanied by the quantifier *all* in their stative, locative use (Jackendoff 1990):

(35) a. I have searched for them *all along* the road.

b. There was a wall *all around* the garden.

c. The famine has spread *all over* the country.

Describing the workings of this quantifier goes beyond the scope of this paper, but it illustrates the importance of adding directionality to a broader aspectual typology.

4   The relation between path types and path operations

In the previous section we encountered two important operations mapping from the two non-cumulative types of path meanings (transitions and cycles) to the two cumulative types (progressions and continuations). As I pointed out in Zwarts (2005), non-cumulative prepositions like *into* or *across* correspond to singular count nouns (referring to one single bounded spatial object), while cumulative prepositions like *towards*, *along* or *around and around* correspond to mass and plural nouns. The GRIND operation makes 'mass prepositions' and the PLURAL operation makes 'plural prepositions', very much in the same way as we get mass and plural versions of the noun *apple*.

An interesting option present itself now.[4] Suppose that there are basically only singular count prepositions. All the other prepositions are derived from these basic prepositions through the two operations GRIND and PLURAL. Grinding a transitional preposition gives us a progression (maybe this is how *towards* is derived from *to*) and grinding a cycle gives us a continuation (as *over* in (29) above). Pluralizing a transitional preposition is not possible (because of the lack of connection), but pluralizing a cycle gives us a periodic continuation (*around and around*). This would give us a very tight typology of directional prepositions, in which complex (mass and plural) meanings are generated in a small number of ways from a restricted set of basic (count) meanings.

Now, the question is whether it is possible to derive all possible prepositional meanings from more basic meanings in this way, and, if it is possible, whether it is natural to do so. In

Zwarts (2005), I have tried to argue that *towards* should not be treated as the progressive or partitive of *to*, but as a preposition defined in its own right (as in (10) above). It is also very hard to see what basic count meaning we would have to GRIND in order to get the meaning of *along*, while we can define its mass meaning in a very natural way, as in (12b). For some ambiguous cases, like *down the hill* it is not obvious that the telic use is basic and the atelic use derived. The adverbial origin of this preposition suggests that the atelic use might actually be more basic here.

We have to conclude then that not all mass prepositions can be derived from more basic count prepositions. There are basic mass prepositions, just like there are basic mass nouns (like *water*) that we would not want to derive from a more basic count meaning. However, the count prepositions are still basic in another important sense to which we will turn in the following section.

5 The expression of directions and paths

We started this paper with a general distinction between directional (path) prepositions and locative (place) preposition. The term 'directional' turns out to be a bit of a misnomer, because we find prepositions in this class that actually lack directionality, being reversible. In that sense, these path prepositions are a bit like place prepositions, and we also saw in this section that they can behave statively, much like locatives. This suggests that there is a hierarchy of decreasing directionality in the set of prepositions, with the reversible path prepositions between the non-reversible path prepositions and the place prepositions:

(36) > > > > > > > > > > > > > > Decreasing directionality > > > > > > > > > > > > > > > >

Non-reversible path prepositions > Reversible path prepositions > Place prepositions

to, towards   across, along   in, under

This hierarchy is closely related to an aspectual hierarchy of prepositions, based on cumulativity:

(37) > > > > > > > > > > > > > > Decreasing directionality > > > > > > > > > > > > > > > >

Non-cumulative path prepositions > Cumulative path prepositions > Place prepositions

to, across   towards, along   in, under

The cumulative prepositions are closer to the locative prepositions than the non-cumulative prepositions. In both hierarchies we can find a transitional preposition like *to* as the most typical of the directional prepositions. Prepositions like *towards* or *across* are less typical for a directional preposition, because they are sometimes closer to the place prepositions in one of the two relevant dimensions.

In this section I am going to use this idea in exploring the morphosyntax of directionality. The hypothesis is that the expression of a transition in a system of directional case markers or adpositions will be less marked than the expression of the other types. We can break this hypothesis down into the two more basic markedness orderings that we saw above:

(38) *More directional > Less directional*

a.   Non-cumulative > Cumulative

b.   Non-reversible > Reversible

If a language chooses to use a preposition or case form to mark directionality, then it gives precedence to the expression of non-cumulative and non-reversible paths over cumulative and reversible paths. In other words, if it has a form for a cumulative or reversible path meaning, then it will also have a form for a non-cumulative or non-reversible path meaning. Furthermore, we expect the expression of a less directional meaning to be more marked than the expression of a more directional meaning.

As a first illustration of this idea, we can take the contrast between *to* and *towards* in English, exemplifying the first part of the hierarchy in (42). The cumulative directional *towards* is more marked than the non-cumulative directional *to*, because it is less typical as a directional preposition. The general prediction is that in prepositional systems in the world, a form for 'towards' will either be missing, or, if it exists, be more complex than the 'to' form in one way or another. The same is true for *from* and *away from*: only the second, more complex form can be used cumulatively.

On the basis of the formal relation between *to* and *towards* in English, and given the suggestion in section 4, one might also tentatively maintain an alternative hypothesis: 'towards' implies the presence of 'to' because it is actually morphosyntactically *derived* from it. Adding the suffix *-wards* corresponds to a kind of progressive operation and so, *towards* presupposes the existence of *to* in the same way in which a progressive form presupposes the existence of the non-progressive form on which it is based. There are several problems with this derivational view, as I already pointed out in section 4. But even if this type of analysis might work for English, it cannot work for many other languages that do not have a formal similarity between the two prepositions. We can see this clearly in Dutch: the unmarked goal directional is *naar* 'to', which is non-cumulative, but for expressing the cumulative progression 'towards', Dutch uses the preposition *richting* (which is actually the noun for 'direction':

(39) richting het vliegveld

direction the airport

'towards the airport'

French *à* and *vers* divide their meanings in roughly the same way. This means that the

markedness implication corresponding to (38a) does not reduce to a derivational dependency.

However, the hierarchy might be taken to predict that languages tend to derive their word for

'towards' from their word for 'to', rather than the other way around.

In rich local case systems we see the same pattern. As is clear from Blake (1994),

Comrie and Polinsky (1998), Van Riemsdijk and Huybregts (2001), and Kracht (2002), the

rich case systems that we find in Uralic and Caucasian can be decomposed into two

dimensions. One dimension is concerned with distinctions of place (like interior or exterior),

the other dimension is concerned with the fundamental distinction between locative and

directional and finer distinctions within the directional category. The local cases of Finnish,

for example, can be analyzed two-dimensionally, as in Table 4, with horizontally the locative

dimension, with a contrast between 'in' and 'on', and vertically the directionality dimension,

with a three-fold contrast between location, source, and goal (Blake 1994:155):

TABLE 4 ABOUT HERE

The vertical dimension is what Kracht (2002) calls the *mode* and Comrie and Polinsky (1998)

the *type of motion* or *direction*. This is the claim that we can make about these rich case

systems: they do not have a case corresponding to 'towards' unless they also encode the more

basic directional distinction between source and goal. There are in fact case systems, richer

than Finnish, that have a case for progression, like the Caucasian language Tsez (as reported in Comrie and Polinsky 1998). The case is called *versative* and is glossed as 'towards'. See Table 5.

TABLE 5 ABOUT HERE

The suffixes in the third column are added after a series of special locative case forms for 'spatial orientation'. The important point for this paper is we claim that such a versative case can only be part of a case system if there are also more basic transitional case markers in the system.

Let us now turn to the second part of the directionality hierarchy in (38) that says that non-reversible markers are less marked than reversible markers. There are languages with a case for 'through' or 'via', which is called *perlative*, like the Caucasian language Avar (Blake 1994:154). It has an essive (location), allative (goal) and ablative (source), but it also has a suffix *-n* that it adds to the ablative *-a* to form perlative cases. This satisfies the implicational universal that we proposed: the presence of the perlative implies the presence of markers of non-reversible directionality: the allative and ablative case. Notice that the perlative is also morphophonologically more complex than the other cases.

We expect to find the same pattern in adpositional systems: if there are adpositions for notions like 'through', 'over', 'along' or 'around', then there must also be more basic adpositions for transitions. At this point I have not made a survey of adpositional systems to see whether that is actually true, so exploring this hypothesis has to wait for another occasion.

6   Event shape

The main focus of this paper is on directional prepositions, for which we proposed the two-dimensional typology of Table 2. In this final section, I will briefly sketch the relevance of this typology for aspectual verb classes. Of course, an in-depth treatment of such an extensive topic as verbal aspect is impossible here. My purpose is to suggest how we can view the semantics of verbs in *spatial* terms, as places and paths in conceptual spaces. This helps us to bring out analogies, but also differences, between the two domains. For a more extensive discussion of some features of this approach, and its relation to Davidsonian event semantics, I have to refer the reader to Zwarts (2006).

The basic idea is that the events that verbs refer to have a particular 'shape', a trajectory or contour in a conceptual space, that can be modeled as a path. Just like directional prepositions impose certain conditions on paths, verbs specify conditions on the conceptual shape of events. In cognitive semantics, this way of looking at verbs was first suggested by Talmy (1978) and one recent elaboration can be found in Croft (to appear). We also find it, at a more general level, in the theory of conceptual spaces of Gärdenfors (2000). It can also be seen as a generalization of the interval semantic approaches of the seventies (Dowty 1979) and the phase quantification of Löbner (1987) and Fong (1997). It is a somewhat different way of carving up the class of verbs than the well-known Vendler classes, but one that is compatible with this classification and quite close to the analysis of Rothstein (2004b), which works with concatenation and cumulativity defined over singular events.

Table 6 shows how the major aspectual verb classes fit into the two-dimensional typology given earlier (except for the states, to which I will come back later).

TABLE 6 ABOUT HERE

Transitions are verbs that express a change from one state to a complementary state. This is where we find the accomplishments and achievements, which express a (one-way) change of state, like *die*, *open*, *break*, *arrive*. To use an intuitive representation inspired by Talmy (1978), we can represent the shape of such events as in Figure 2, with a path leading from one conceptual domain to its complement.

FIGURE 2 ABOUT HERE

In such a diagram, time is represented horizontally, and the conceptual dimension represented vertically. In this conceptual dimension we find the opposition between two opposite states or qualities, like 'life' - 'death' or 'open' - 'closed'. A transition (like *to open*) corresponds to a set of paths that have their starting point in one particular state ('closed') and end point in the opposite state ('open'), as illustrated in Figure 2a. We can revert these paths, but then we get the opposite transition (*to close* in Figure 2b), so a transition is non-reversible in this sense.[5] Many transitions come in pairs that are each other's reversals and this opposition often has its morphological expression, as shown in such pairs as *lock - unlock*, *embark - disembark*. As we saw already with prepositions, a transition is non-cumulative, because it has no connecting paths.

Cycles cover semelfactive verbs like *flash*, *knock* or *cough* that correspond to a trajectory that starts and stops in the same domain (e.g. 'dark' for *flash*), but has a middle portion in the complementary domain ('light'), as illustrated in Figure 3a. In contrast to transitions, cyclic verbs are reversible and therefore they don't come in pairs of opposites and don't allow reversive prefixes like *un-* or *dis-*. Like transitions, cycles are non-cumulative. Because of their trajectories, both transitions and cycles have clearly identifiable beginning and end points, which makes them non-cumulative and hence telic. They form what Rothstein

(2004a) would call *naturally atomic events*. However, there is an important difference between transitions and cycles. Because the trajectory of a cyclic verb starts in the same state where it stops, as Rothstein argues, cycles can connect, concatenate and form iterations. These iterations however are in a different class, that of continuations. .

FIGURE 3 ABOUT HERE

There are also verbs that refer to paths in a 'gradient' domain, from 'less' to 'more' of something, or the other way round, a type that we have called progressions. The core examples here are degree achievements like *brighten*, *widen*, *rise*, or *cool*. Like *flash*, the verb *brighten* refers to a trajectory in the domain of light, but the condition (and maybe the structure of the underlying space) is different: the endpoint of the path is in a conceptual region of 'more light' than the starting point, as shown in Figure 3b. Nevertheless, every *brighten* path (from A to B on the brightness scale) connects with another *brighten* path (from B to C) and the concatenation (going from A to C) is an instance of *brighten* again, making this type of verb cumulative, and hence atelic, unless there are contextual clues that suggest a transition (Hay, Kennedy, and Levin 1999, Rothstein 2004b). In other words, progressions normally don't describe naturally atomic events and they cannot be iterated like the cyclic semelfactives, because, in a sense, they are already iterated. Note furthermore that a progression is non-reversible: reversing the paths gives us the opposite verb, e.g. *to widen - to narrow*.

In the fourth class of verbs in Table 6 we find the activities. As Rothstein (2004a) and others showed, there are two subtypes here. We already mentioned iterated semelfactive verbs like *flash* and *cough* that oscillate between two opposite domains in a regular periodic fashion, as illustrated in Figure 4a.

FIGURE 4 ABOUT HERE

They are the verbal counterparts of plural prepositions like *around and around*, in the sense that we can distinguish a clear period in their trajectory. Typical activity verbs like *glitter*, *murmur*, and *walk* are different in this respect. The structure of the path is much less periodic, and if it is periodic, there are no clear points on the vertical qualitative dimension that we can use to identify such a period (Figure 4b). What, for example, is the cycle in walking? Is it one step, or is it two steps? As Rothstein (2004a:186) shows, with iterated semelfactives, numerals can be used to count the cycles (the 'minimal events'), but not with ordinary activities:

(40) a.   Dafna jumped twice.

      b.   Dafna ran twice.

While (40a) could mean that Dafna made a jump twice, (40b) cannot mean that Dafna made two running steps, but only that there were two times when she ran. There are many other differences between these two types of verbs across languages. We can understand the semantic source of this difference, and bridge the gap between lexical semantics and aspectual semantics, by studying more closely the fine-structure of the conceptual trajectories underlying this difference.

Seen from this general perspective directional prepositions and dynamic verbs share an important semantic typology. In both domains there are transitions and cycles (both telic) and progressions and continuations (both atelic), based on the same general algebraic structure of paths, with concatenation and reversal. This also allows us to connect the two important

notions of *direction* and *change*, an old theme in localist semantics (Gruber 1976). In the broadest sense all the prepositions that we discussed here (i.e. the non-locative ones) are directional and all the verb classes that we mentioned (i.e. the non-stative ones) are verbs of change, dynamic verbs. However, as we saw, within these broad classes there are degrees of directionality and dynamicity. Among the verbs, the transitions (achievements and accomplishments) are most clearly the verbs of change, as opposed to the continuations (activities), while the progressions (degree achievements) and cycles (semelfactives) take a middle position:

(41) > > > > > > > > > > > > > Decreasing dynamicity > > > > > > > > > > > > > > > > > >

      Achievements   >   Degree achievements   >   Activities

      Accomplishments   Semelfactives

We saw in section 5 that a similar hierarchy for spatial directionality has important grammatical effects cross-linguistically. It would be interesting to see what grammatical role this verbal hierarchy might play, for instance in the distribution of markers of grammatical aspect over verb classes.

     A remark is in order about the role of *time* in the two domains. It would be wrong to characterize the distinction between prepositions and verbs as a distinction of space and time, as if, roughly speaking, (directional) prepositions describe movements in space, while (dynamic) verbs describe 'movements' in time. The verbal parallel to prepositional space is not time, but *conceptual space*. Verbs generally don't describe movements in time, but in various qualitative or scalar spaces. There are, however, a couple of verbs for which this conceptual space happens to be time, such as *postpone* or *antedate*. For these very special cases, we could say that there is some sort of movement in time. Also, when we apply the

operation of reversal to verbal meanings we don't need to go backwards in time; what reversal does is map one particular ordering of states to another ordering, both of which are mapped to the normal temporal order of precedence.

If we want to look for differences between prepositions and verbs, within the general typology proposed, we should not focus on the structure of time, which is the same for both parts of speech, but to the structure of the different conceptual spaces involved, the paths defined over these, and the factors that shape the paths. This will also help us to understand the points of difference between verbs and prepositions. Let me mention one example of this.

Even though cycles in the verbal and prepositional domain have the same general algebraic properties (reversibility and non-cumulativity), we count verbal and prepositional cycles in different ways. As we saw in (40a), the adverb *twice* can count two atomic jumping events, but it can also count two separated turns of repeated jumpings. This is related to the observation that all by themselves semelfactives like *knock*, *flap*, and *wink* can quite easily refer to iterations of the individual cycle, without any adverbial forcing this iteration. For the cyclic prepositions, however, iteration is much more marked. Furthermore, cardinal adverbs behave differently with prepositions, as shown in the following examples:

(42) a. Alex walked across the street twice.

      b. ?Alex walked around and around the house once.

The adverb *twice* in (42a) can only count individual crossings of the street, but it cannot mean that there were two times when Alex walked across the street back and forth repeatedly. The infelicity of (42b) suggests that *once* cannot refer to a single sequence of circular movements around the house.[6] The following examples show that this is not a property of prepositions *per se*, but of spatial cycles more generally:

(43) a.   Alex crossed the street twice.

       b.   ?Alex circled and circled the house once.

The verbs *to cross* and *to circle* are clearly cyclic, because they have the same basic meaning as *go across* and *go around* (although there might be differences in *closure*, as argued in Winter 2006). Nevertheless, they behave differently from many of the typical semelfactive verbs.

Iteration then, seems to come much more easily with non-spatial cycles than with spatial cycles. One possibility, still very vague at this moment, is that these two cycles work at different levels of *granularity*. At the spatial level we typically have bigger objects (usually human beings) moving with respect to objects that often have at least the same size (streets, houses). The objects involved in semelfactive verbs are often smaller, typically body parts, like hands (*knock*), eyelids (*wink*), wings (*flap*) moving over smaller distances and taking only a second or so, while the spatial cycles have a duration of at least several seconds, but they can also take minutes, hours, or weeks, depending on the size of the reference object (e.g. when crossing the ocean or going around Cape Horn). This means that, when we take short 'samples' of time, we might expect to find iterations of knockings, winkings and flappings in a single sample, but no iterations of crossings or circlings. It is therefore more natural and economical for speakers to be able to refer to the non-spatial iterations at an unmarked, lexical level, as one turn of activity, but not to the spatial iterations. This is all still quite vague and tentative, and based on a few empirical observations, but it illustrates the fruitfulness of what we did in this paper: try to fit the semantics of verbs and prepositions in one general framework, to bring out similarities, but also differences, arising from the different ontologies that underlie the different conceptual spaces.

We have seen now that three of the four Vendler classes find a place in this bigger system: accomplishment, achievements, and activities, as well as two classes that were always hard to classify: semelfactives and degree achievements. What about *states*? We can view stative verbs as the counterparts of *locative* prepositions. Stative verbs like *sleep* or *shine* and adjectives like *red*, *wide* and *dark* do not refer to trajectories in conceptual space, but to single *points* or *positions*. This makes much sense when we want to relate stative predicates to dynamic predicates. The transition denoted by *die*, for instance, always leads to an end point that we can refer to by the adjective *dead*, in the same way in which the directional PP *into the house* refers to paths that end in a location that can be described as *in the house*. This is of course an old idea, that has been worked out in different ways in the localist tradition, for example with the BE and GO functions of Jackendoff (1983), or in a more model-theoretic context with the BECOME operator, following Dowty (1979). I mention it here to give a more complete picture of the typology of prepositions and verbs.

This is just the rough and overly simplified outline of a general approach to verb meanings and, as always with verb classes and aspect, this approach raises numerous difficult questions. I have ignored the argument structure dimension by giving only intransitive examples, thereby also avoiding the compositional nature of verbal aspect (Verkuyl 1993). The demarcation between certain classes is not always obvious. Is *sleep* a continuation (activity) or a position (state), for example, a question that involves the fine-structure and dynamics of this verb. There is also more structure within the classes, having to do with punctuality (achievements) and duration (accomplishments). Obviously, the typology of verbs also needs more flexibility, in view of the many contextual coercions and construals that have been found. Nevertheless, this seems like a promising way to look at verb meanings, that allows us to exploit a well-defined model of spatial meanings for the analysis of the much richer domain of situations.

Conclusion

This paper has shown the importance of bringing the dimensions of boundedness and direction together in one prepositional typology, building on earlier typologies of directional prepositions in Jackendoff (1983,1991) and Piñon (1993). We have distinguished four types of prepositions (transitions, cycles, progressions and continuations), in addition to the type of locations. The relevance of this typology has been demonstrated for semantic phenomena of aspect and for morphosyntactic patterns of directionality marking, as well as for the study of verb meaning.

Notes

[1] For example, Jackendoff (1983), Habel (1989), Piñon (1993), Nam (1995), Krifka (1998), Kracht (2002).

[2] I am treating cases like *out of* and *from under* both as complex prepositions, without meaning to imply that they are both idiomatic or non-transparent. *From under* is clearly transparent and productive, *out of* is not.

[3] Cumulativity is only defined for sets of paths that are connected, because for non-connected sets, the conditional would be trivially true.

[4] As suggested to me by an anonymous reviewer.

[5] Croft (to appear) uses the term irreversible in a much more specific way, for those transitional verbs, like *shatter* or *die*, that are not 'resettable', as Talmy (1978) calls it. My algebraic notion of non-reversibility is more general, characterizing all transitions, but it makes sense to distinguish within this general class between resettable and non-resettable verbs.

[6] I am grateful to an anonymous reviewer for pointing out to me this contrast between verbs and prepositions.

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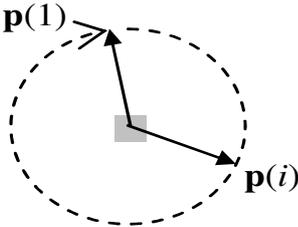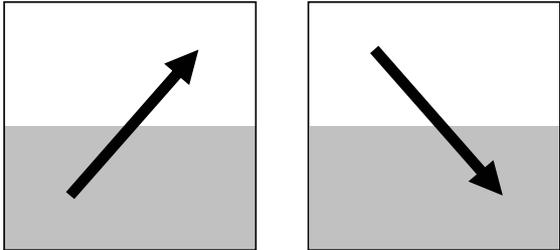
Figure 1: Around the house
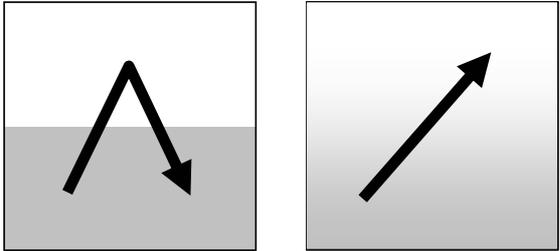
Figure 2: Transition and reverse transition

Figure 3: Cycle and progression
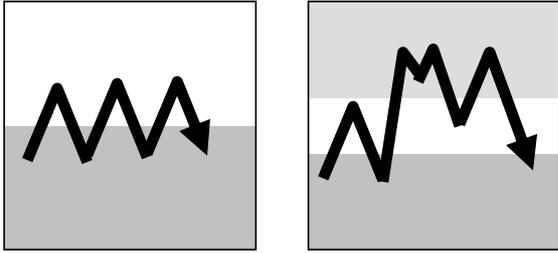
Figure 4: Two types of continuations

	Source, goal	*Route, geometric*	*Comparative*	*Constant, periodic*
Connected	no	yes	yes	yes
Cumulative	no	no	yes	yes
Reversible	no	yes	no	yes
	Transitions	*Cycles*	*Progressions*	*Continuations*

Table 1: Four types of directional prepositions

	Non-reversible	*Reversible*
Non-cumulative	Transitions (source, goal)	Cycles (route)
Cumulative	Progressions (comparative)	Continuations (constant, geometric, periodic)

Table 2: Two dimensions of directionality

	Non-reversible	Reversible
Non-cumulative	Directed cycles	Cycles
	Bounded progressions	
	Bounded directed continuations	Bounded continuations
Cumulative	Progressions	
	Directed continuations	Continuations

Table 3: Shifts in directionality type

	'in'	'on'
Location	INESSIVE 'inside'	ADESSIVE 'on'
Source	ELATIVE 'out of'	ABLATIVE 'off'
Goal	ILLATIVE 'into'	ALLATIVE 'onto'

Table 4: Two-dimensional decomposition of local cases

Category	Case	Form	Gloss
Location	ESSIVE	-∅	'at'
Source	ALLATIVE	-r	'from'
Goal	ABLATIVE	-āy	'to'
Progression	VERSATIVE	-γor/-a	'towards'

Table 5: Basic cases of direction in Tsez

	Non-reversible	*Reversible*
Non-cumulative	Transitions: achievements, accomplishments	Cycles: semelfactives
Cumulative	Progressions: degree achievements	Continuations: activities

Table 6: A typology of dynamic verbal classes