On the Semantics of Locatives

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Abstract

The present paper deals with the semantics of locative expressions. Our approach is essentially model–theoretic, using basic geometrical properties of the space–time continuum. We shall demonstrate that locatives consist of two layers: the first layer defines a location and the second a type of movement with respect to that location. The elements defining these layers, called *localisers* and *modalisers*, tend to form a unit, which is typically either an adposition or a case marker. It will be seen that this layering is not only semantically but in many languages also morphologically manifest. There are numerous languages in which the morphology is sufficiently transparent with respect to the layering. The consequences of this theory are manifold. For example, we shall show that it explains the contrast between English and Finnish concerning directionals, which is discussed in Fong [16]. In addition, we shall be concerned with the question of orientation

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of locatives, as discussed in Nam [42]. We propose that nondirectional locatives are oriented to the event, while directional locatives are oriented to certain arguments, called *movers*.

1 Introduction

Space is a very tangible notion. Almost any animal — although unable to speak — can reason spatially, and very skillfully so. We humans are also much better in doing spatial reasoning than in doing logic, for example. Even when we deal with abstract notions, we prefer to reason using spatial concepts, because this is what we understand best. This is the reason why language is so deeply entrenched with spatial metaphors, and we use spatial concepts unknowingly all the time. [1] Yet, the notion of space has not stirred the intellect of linguists and logicians to any degree comparable to time, aspect, plurality or presupposition. And this is not because spatial notions are used metaphorically more than truly spatially. Also the genuine use of spatial expressions to refer to concrete locations has been treated with considerable neglect. Although there is already a sizeable literature on this subject (for example Bierwisch [4], Creary et al. [11] and [12], Herskovits [20], Jackendoff [23] and [24], Wunderlich and Herweg [52] and references therein, Nam [42] and Fong [16], as well as for the recent Bloom et al. [7] for the more cognitively oriented research to name a few) our knowledge of the use of space in language seems quite limited. However, there are clear semantic and syntactic questions relating to locative expressions. For example, there is a solid intuition that in sentence (1.1) it is the box and not John that ends up outside of the car. This has little to do with the fact that the box is a transitive object. For example, (1.2) is simply ungrammatical.

(1.1) John threw the box out of the car.
(1.2) *John watched his neighbour into the shop.

These facts are not so easily explained [2] and they require deep analysis. Moreover, it needs to be seen exactly what is required for (1.1) to be true. Does the box have to have been fully inside the car before? And in what ways does it have to be moved by John? And so on. Further questions

[1] See Jackendoff [25] and references therein for a defense of this claim.

[2] In fact, this question is hardly adressed in the literature. A notable exception is Nam [42], who builds on Keenan and Faltz [27].

concern the status of locatives: are they adjuncts or arguments, and where can they appear in the syntax? We shall try to shed light on all of these questions. We shall argue in particular, that the difference between the sentences (1.1) and (1.2) is the fact that a directional locative needs a moving entity, which is something which is by necessity moving in the specified event. As neither argument of watch or the subject of throw is necessarily in motion it is therefore incompatible with the directional locative, in contrast to the object of throw. Further, we will show that locatives sometimes are adjuncts and sometimes arguments, and that depending on this their semantics is different as well. If used as arguments, they can for example be void of any spatial meaning, namely if the locative phrase is directly selected by the verb.

While the questions we have just raised apply to all locative expressions throughout languages, further questions appear in connection with locative *cases*. Particularly interesting facts come from languages which have a rich system of locative cases. In fact, when languages have a rich case system it is usually because they have a lot of locative cases. Their number can go beyond twenty. Languages with elaborate locative case systems are mainly found among the Uralic languages, the Easter Caucasian languages (see [28] and — to a lesser degree — among the Australian languages (see [6]). In all these languages, we find that locative cases are systematically organized along two orthogonal lines: one specifying the location and the other specifying the change.

In this paper we will elaborate the semantics of locative cases of various languages by studying the semantics of locative expressions in general. We shall argue that locative expressions universally consist of two layers, one for the *configuration* and one for the *mode*. The *configuration* describes the way in which several objects are positioned with respect to each other. Configurations can be brought into correspondence with prepositions which do not indicate change of location. Examples are: *at*, *in*, *on*, *between*, *in front of* etc. The *mode* on the other hand describes the way in which an object moves with respect to the named configuration. While there is no plausible bound on the number of configurations that a language distinguishes, the number of modes seems to be limited: there is evidence for the static, the cofinal, the coinitial, the transitory and the approximative mode. A mode is *static* if the object remains in that configuration during event time (e. g. Finnish inessive talossa, in the house); the mode is *cofinal* if the object moves into the configuration during event time (e. g. Finnish illative taloon, into the house); the mode is *coinitial* if the object moves from the configuration

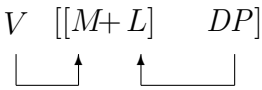
during event time (e. g. Finnish elative talosta, out of the house). The mode is *transitory* if the object moves in and again out of the configuration (e. g. through the tunnel). Finally, the *approximative* mode describes a movement approaching a configuration (e. g. towards the tunnel). [3]

From a semantical and syntactical point of view a locative expression is therefore structured as follows.

$$[M\,[L\ DP]]\ ,$$

where M is a modaliser (specifying the mode), L a localiser (specifying the configuration) and DP a determiner phrase. It may be the case that L precedes DP (as in English) or that it follows it and the same for M. In most languages which we have looked at, L and M end up on the same side of the DP, but they need not (as is the case in Chinese). [4]

Morphologically, however, the segmentation may be different. It is untypical for L and DP to form a unit excluding M. (In fact, as far as we know only Chinese forms an exception to this.) All other combinations however are frequently encountered. Hence, unless all three elements are morphologically free or on opposing sides of the NP, [5] we find that $M + L$ is a unit, which is either an adposition or a case. For a head initial language we therefore assume the following structure:



[3] Mel'čuk [40] lists seven modes. Also his terminology is somewhat different. He uses *essive* for our our *static*, *prolative* for our *cofinal*, *elative* for our *coinitial* and *perlative* for our *transitory*. His list also contains in addition a *recessive* (for movement away from the location), and a *terminative* (for movement up to the location). The recessive is just the inverse of the approximative. We will discuss the difference between terminative and cofinal somewhat later. There are of course infinitely many modes in theory.

[4] To be exact, we have examined the data in the following languages using native speakers: German, English, Finnish and Hungarian. Data from other languages is either from personal communications or from books.

[5] This qualification seems to be needed in the light of the following evidence from Chinese.

(i) zai zhuozi-shang
static table-on

Here, shang is L and zai is L. Nevertheless, while zjuozi-shang is free, shang is not, which follows from the fact that it bears no tone. Full tone forms are shangtou, shangmian or shangbian.

Evidence for this view will be given.

2 Previous Work on Locatives

2.1 Some Preliminaries

There is a tradition to view all cases as locative expressions. This view has been advocated for example by Hjelmslev [21] and [22], by Anderson [2], and Cook [10]. Since we are concerned with the spatial meanings of local cases rather than their metaphorical meanings, this line of research is only of peripheral interest to us here. Within the transformational grammar tradition the major work on locatives is Bierwisch [4], and — in a completely different sense — Bouchard [8]. Wunderlich and Herweg [52] give a survey of the literature on locatives. More recent work on locatives is found in Nam [42] Creary et al. [12], Fong [16] and Zwarts and Winter [53].

Before we begin with our discussion concerning the semantics of local cases, we have to address some terminological and methodological questions. The locative case names are formed typically by a preposition plus the suffix *-essive* or the suffix *-lative* (see [6]). The suffix *-essive* is used exclusively for the static mode, while the others must be expressed by the suffix *-lative*. All other information is provided by the preposition. To denote the configuration we use English prepositions (e. g. 'in', 'on', etc.). The case labels of Hungarian (the most elaborate system of case names we know of) are as follows.

	static	coinitial	cofinal
in	inessive	elative	illative
at	adessive	ablative	allative
on	superessive	delative	sublative

There is a *perlative*, also called *prosecutive*, which denoes the transitory mode of the 'in' configuration. Of course, with the help of more prepositions more case names can be created. The case names of Finnish are the same with the exception that the last row is absent. Typically, if only one series exists, people use the trichotomy *ablative*, *allative*, *locative*. However, 'locative' is too general a name to be useful in our setting. Since we use these labels as names for case functions rather than cases, some discrepancy with the existing terminology may arise.

Sometimes the labels given to cases are misleading and can cause confusion. For example, the Finnish *translative* is no longer a locative case, though the name suggests that it is. Such terminology can arise since other case functions can also be expressed by locatives. [6] For example, possession can be marked by the adessive case (such is the case in Finnish), the goal (which we call destination to avoid a clash in terminology) can be marked by the allative in Finnish and so on. We may therefore claim that the Finnish adessive is also a genitive, the allative also a dative. In this case we regard the use of the locative cases as expressing the idea of possession or giving by means of some spatial metaphor. Our terminology is as follows. If with a suitably neutral verb like to walk a case can be used to express the idea of location, or change of location without some adposition then we call the case a locative case. If some adposition is needed, matters are more difficult. Usually, we observe that adpositions do not select a locative case, [7] but rather that they select some very restricted set of cases. However, the same adposition can choose different cases (as in many Indo–European languages, but also for example in Finnish). The choice of cases may make a difference with respect to the meaning. A very clear cut case is German, where many locative prepositions allow the choice between dative and accusative. Accusative is used for the cofinal meaning and dative for the static meaning. In that case, we are inclined to say that it is the contrast between these two cases that serves to differentiate the two meanings, but the cases themselves do not carry any locative meaning. Hence German has no locative cases but the cases may serve to differentiate between static and cofinal mode.

2.2 Bierwisch (1988)

Bierwisch's article [4] provides a very detailed analysis of local expressions in German. Bierwisch observes that the claims usually hold mutatis mutandis for other languages. This suggests that the regularities found are either uni-

[6] In this way, a non–locational use of an otherwise locative case can take over and the case may cease to be a local case. (See also Merin [41] on the history of but for such a process outside of the domain of cases.) However, its name may persist despite the local function now being obsolete. The converse process is also conceivable though less frequently attested, namely when a case which is not locative turns into a locative case.

[7] Exceptions are the Hungarian postposition át (*through, over*) and kivül (*except*), which govern the superessive. Otherwise, Hungarian postpositions select nominative (which is unmarked).

versal or in fact not syntactic but semantic or cognitive in nature. According to Bierwisch, prepositions carry a feature $\pm$ DIR to specify whether or not they are directional. This is a syntactic feature. They project a phrase as follows. They form a P′ together with their internal argument. Van Riemsdijk [50] has argued following Jackendoff that PPs have a specifier, and it can be of the following type (ignoring a fourth type). [8]

(2.6) NP vier Meter hinter der Tür
four meters behind the door

(2.7) AP sehr weit vor der Tür
very far before the door

(2.8) PP hoch oben über der Tür
high above the door

Bierwisch claims that contrary to this, P′ is in fact the maximal projection. However important that issue might be, it will hardly matter in the sequel.

Locatives can be predicates, arguments and adjuncts. This is exemplified in (2.9) – (2.11):

(2.9) Alfred ist in der Schule. (predicate)
Alfred is at school.

(2.10) Der Brief liegt auf dem Tisch. (argument)
The letter is lying on the table.

(2.11) Ich kaufe das Buch in Berlin. (adjunct)
I am buying the book in Berlin.

Bierwisch then goes on to sketch a semantic representation for locatives using the so–called semantic form language. Instead, we use the somewhat more familiar typed λ–calculus. In content our proposal differs from that of Bierwisch in various aspects. Rather than proposing only a two way distinction between directional and nondirectional PPs, we propose a (minimally) five way distinction. It is only two of the directional PPs (the transitory and approximative ones) which make reference to the path of an object, while the others make reference only to the place of the object at some points of the interval. We also spell out in detail how the directional PPs are derived from their nondirectional counterparts. We will show that locatives have the structure $[M\ [L\ DP]]$, where $[L\ DP]$ denotes a location. This location can

[8] We use Sans Serife font when the sentence is used as an example. Glosses are in Roman font with small caps. Translations are put in italics. If the translation serves also as an example, it is put into Sans Serife.

be defined without reference to the path of motion. The semantics of the full locative PP is then defined by means of the semantics for the different modes, i. e. the different instantiations of M.

Furthermore, we are interested in the question of selection and modification. While Bierwisch argues that directionality is a syntactic feature and therefore eligible for selection, we will see in Section 6 that the facts are more complex. We shall show that a head can govern either the modaliser alone, or the combination of a modaliser and a localiser. As soon as it governs an element, the meaning of that element becomes the identity function. If it governs the modaliser and the localiser, then the meaning of the locative argument is the same as that of the DP it contains. However, the head can select a particular modaliser rather than just selecting the value of the feature DIR. There is only one hard restriction as for the cooccurrence of verbs and PPs. If the event is static no directional PP may be used. Directional verbs do allow nondirectional PPs (contrary to claims of Bierwisch and others).

(2.12) Er rannte auf der Straße bis zur Ampel.
He ran on the road up to the traffic lights.

The reason is that a nondirectional PP simply says that the object remains in the location throughout event time. This is perfectly compatible with an activity, where the object is in motion. However, if the object is not in motion, a directional PP cannot be added, unless of course a different interpretation is chosen. There are some canonical examples where this is so (see also [16]).

(2.13) a trip from Munich to Rome through the Alps
(2.14) a bridge from Buda to Pest
(2.15) Alfred called Holger from London.

In (2.13), the denotation of the DP itself implies that there is some path involved. One approach is to think of the denotation as an event, and then use the analysis for verbs. This is not possible with (2.14). Here we think of moving along the object from one end to the other. This virtual movement defines a path, which may be used to describe the object. (2.15) is once again different. In the case of (2.15) we may think of an unspecified object (e. g. information, sound waves) as travelling from one end of the line to the other. Alfred, who initiates the call, is the origin of the path, and Holger the destination. Such cases of (more or less) fictive motion are treated extensively in Talmy [49] and are not the subject of this paper.

2.3 Creary et al. (1989)

Creary et al. [12] (which is based on [11]) propose a treatment of locative expressions that makes them denote regions. They principally discuss adverbial uses of locatives, as we do here. They build on an insight by Jackendoff [23] that locatives and DPs share a number of properties, in particular the ability to establish discourse referents to which one can refer. The proform there can be used to pick up a contextually salient location, but it can also be used deictically. In that sense, it behaves just like a nominal anaphor. There exist also location quantifiers, such as everywhere, somewhere and nowhere. However, locatives do not induce scope ambiguities.

(2.16) Tina didn't work in New York.
(2.17) Tina didn't drink because of her husband.

We may interpret (2.17) as either saying that Tina's husband was the reason for Tina's not drinking, or — alternatively — as saying that he simply wasn't the reason for Tina's drinking. No such alternative seems to be available in (2.16). It cannot be taken to say that there is an event of Tina's not working that took place in New York; it only says that there is no event Tina's working in New York.

Moreover, Creary et al. argue in line with Jackendoff that locatives are always arguments. This allows them to deduce that iterated locatives must be taken conjunctively, [9] and predicate over the same event, not just several ones.

(2.18) Al works on Mass. Ave., in Boston.

Additionally, the following pattern of upward monotonicity is observed.

(2.19) $$\frac{\text{Al works in Boston.} \quad \text{(In) Boston is in America.}}{\therefore \text{Al works in America.}}$$

So much for the basic claims of the paper. Notice that many of the arguments are valid mutatis mutandis for temporal adverbials. The intersection rule for locatives is also applicable for temporal adverbials. However, similar effects can be reached with almost any major constituent, for example objects. [10]

[9] Actually, that the semantics is that of conjunction must be stipulated rather than being deducible from anything.

[10] The construction we are dealing with here is an *asyndeton*, there is no coordinator present. With a coordinator present, say and, any two like constituents can be coordinated.

(2.20) Al started working on Monday at nine.
(2.21) This year, around July, we have started to work on this project.

There seems to be nothing special to locations with respect to intersectivity.

We agree that locatives denote some particular entity. However, several factors constrain the usefulness of this paper. The study is restricted to static locatives. Moreover, as all other authors, Creary et al. ignore the time dependency of the location of objects. Further, as we will show below, locative expressions cannot be taken to denote regions, not even time dependent regions. What we shall show in Section 5.1 is that they denote time dependent sets of regions. Further, we disagree with Creary et al. that locatives are always arguments. There are three reasons for us to disagree.

1. Locatives can — with some few exceptions — be freely omitted. As a rule, arguments cannot be omitted.

2. Different types of locatives can be used with the same verb. However, if, as Creary et al. [12] claim, locatives fill semantic argument positions, some verbs must make room for several such positions.

3. The semantics of locatives is basically intersective. This is a strong indication that they are basically adjuncts. [11] However, as we shall see, there are a few verbs that take locatives as arguments, in which case their semantics is not necessarily intersective.

2.4 Nam (1995)

Nam [42] presents a detailed study of the meaning of English locatives. His theoretical framework is that of Keenan and Faltz ([27]), who in their book outline the basics of a boolean semantics for natural language. They also briefly touch on the subject of static locatives. In their view, a static locative is an intersective modifier. This explains why the following inferences are valid:

[11] One reviewer has challenged me on this point. While of course nothing forces us to say that locatives are adjuncts in case their semantics is intersective, a theory that treats them as arguments will have to tell us why they have intersective semantics as opposed to any other. I think the distinction between adjunct and argument locatives can even be syntactically demonstrated, but I leave that question aside.

(2.22) $\dfrac{\text{John is walking in the garden.}}{\therefore \text{John is walking.}}$ $\qquad$ $\dfrac{\text{John is walking in the garden.}}{\therefore \text{John is in the garden.}}$

$$\frac{\text{John is in the garden.} \qquad \text{John is walking.}}{\therefore \text{John is walking in the garden.}}$$

Furthermore, Keenan and Faltz already observed that such modifiers show what they call *orientation*. They are modifiers of the predicate, yet they talk about the location of the subject. This is not necessarily so. In the following example, the modifier in the garden is talking about the location of the subject or the object:

(2.23) $\dfrac{\text{John sees Mary in the garden.}}{\therefore \text{John sees Mary.}}$

(2.24) $\dfrac{\text{John sees Mary in the garden.}}{\therefore \text{Mary is in the garden.}}$

(2.25) $\dfrac{\text{John sees Mary in the garden.}}{\therefore \text{John is in the garden.}}$

It is however not possible to have it both ways. Either we construe the modifier with the subject or with the object. Nam basically agrees with these intuitions but takes the analysis further. First, he shows that the analysis also holds for directional locatives. They are intersective modifiers which show orientation. The kind of orientation that verbs show is constrained by the type of verb in question. The results found by Nam, building on Levin [35], are shown in Table 1. ($O + S$ means that the locative is construed with the subject and the object as one location; $O \times S$ means that it is simultaneously construed with both the location of the subject and the object, which may be different. Nam uses *stative* for our *static*, *source* for our *coinitial*, *goal* for our *cofinal*, and *symmetric* for our *transitory*.) Nam remarks the following ([42], p.36):

1. If a non–stative locative combines with a transitive verb, it is always oriented to the object argument. That is, it can be either O, $S + O$, or $S \times O$.

2. If a transitive verb can combine with a non–stative locative, then stative locatives are object–oriented with that verb (that is, either O or $S+O$).

3. Only symmetric locatives can be $S \times O$, that is other locatives are all reducible in terms of unary functions.

Table 1: Orientation of Locatives

Stative	Directional	Symmetric	Source
Motion-Causative Verbs, Verbs of 'Sending/Carrying'			
drag, push, run; send, take			
O	O	O	O
Verbs of Placement, Verbs of 'Hunting'			
place, set, put; watch, hunt			
O	O	O	$\star$
Verbs of 'Combining/Attaching', Verbs of 'Housing'			
mix, tape (music); contain, store, serve			
O	O	$\star$	$\star$
Verbs of 'Perception', Verbs of 'Communication', Verbs of 'Contact'			
find, see; call, cable; touch			
O	$\star$	$S \times O$	$S + O$
Verbs of 'Co-movement'			
escort, accompany, chase, drive, follow			
$S + O$	$S + O$	$S + O$	$S + O$
Verbs of 'Social Interaction'			
meet, embrace, marry, fight, visit			
$S + O$	$\star$	$\star$	$\star$
Verbs of 'Judgement', Psych-Verbs, Intensional Verbs			
criticize, honor; adore; seek, mention			
S	$\star$	$\star$	$\star$

4. There is only one case where PPs exclusively involve subject–orientation: verbs of 'judgement', psych–verbs, and intensional verbs. This suggests that object–orientation is more basic than subject–orientation.

We shall return to this problem area in Section 7. [12] In order to be able to extend the analysis of Keenan and Faltz to directionals, the ontology must be enriched. It is not enough to have just time points, we also must have

[12] An interesting example was provided by one of the referees.

(i) John surfed the net to hotbabes.com.

Clearly, the locative shows subject orientation, although it is not stative. Moreover, it does not belong to any of the verbs mentioned in (4.) of the list.

paths. Nam takes paths to be (finite) sequences of locations. In contrast to Keenan and Faltz, Nam assumes that locative prepositions can also be predicate extensors. This is to say, they can raise the arity of the verb by one. Examples are found in prepositional passives and in languages which incorporate locatives into the verb. The first kind of examples are

(2.26) The bed was bounced on till it broke.
(2.27) This road has been marched along thousands of times.

In (2.26), the preposition on combines with the verb (to) bounce to form a verb (to) bounce on, which is then passivized. While in English the preposition continues to be a separate word, in many other languages it is incorporated into the verb. In Bantu languages this is widespread. Nam cites the following from Chichewa ((2.28) and (2.29)) and Kinyarwanda ((2.30) and (2.31)):

(2.28)	Mbidzi	zi-na-perek-a	msampha	kwa	nkhandwe
	zebra	SP-PAST-hand-ASP	trap	to	fox
	The zebras handed the trap to the fox.				
(2.29)	Mbidzi	zi-na-perek-er-a	nkhandwe	msampha	
	zebra	SP-ASP-hand-APPL-ASP	fox	trap	
	The zebras handed the fox the trap.				
(2.30)	Umwaana	y-a-taa-ye	igitabo	mu	maazi
	child	SP-PAST-throw-ASP	book	in	water
	The child has thrown the book into the water.				
(2.31)	Umwaana	y-a-taa-ye-mo	ammazi	igitabo	
	child	SP-PAST-throw-ASP-in	water	book	
	The child has thrown the book into the water.				

It is noted that the incorporated preposition promotes the locative PP into a direct object. Such verbal particles are also found in German (for example be-, durch-) and Hungarian. We shall discuss them in Section 8.

2.5 Fong (1997)

The dissertation by Fong ([16]) provides a detailed study of directional locatives of Finnish, with some comparisons with French, Mandarin Chinese and English. The basic results of this thesis are as follows. Directional locatives (DLs) can have a more abstract meaning than is generally assumed. That is to say, they do not necessarily refer to paths. English and Finnish differ

in that Finnish DLs can operate on the aspectual (or temporal) structures of the verb, while English DLs cannot. DLs interact with the verb and its aspect in quite subtle ways. The spatial meaning is recovered by mapping the abstract structures into the more concrete, spatial domain. Also, Fong observes that the analysis obtained for DLs does extend to static locatives in Finnish.

Fong uses phase quantifiers introduced by Löbner (see [37]) in the analysis of DLs in general. The idea of a phase quantifier is fairly simple. The truth of propositions is time dependent, so we may view them as functions from the time line to the set of truth values, here $\{0, 1\}$. Given a proposition p, we say that an interval I is *admissible* for p if the truth value changes in I and (the restriction of p to the interval I) is a nonconstant monotonic function from I to $\{0, 1\}$. So, I is the disjoint union of two nonempty intervals J_0 and J_1 such that J_0 is entirely before J_1, and p is false in J_0 and true in J_1. Now, a directional locative preposition like into takes a DP as complement, and the complex denotes a set of admissible intervals. The sentence containing the PP is true if the event time is one of these intervals. Take for example (2.32). The preposition into, for example, denotes the function from propositions (here Jack is in the house) to sets of time intervals. Given p, to$'(p)$ is the set of all intervals admissible for p. So, (2.25) is true iff the proposition Jack is in the house is admissible for the interval specified by the event Jack went.

(2.32) Jack went into the house.

It is probably fair to say that what is studied by Fong is not the semantics of locatives, but a study of what we call modes. The cofinal mode corresponds to the phase quantifier for the proposition that the object which is in motion is in the location given by the PP. The coinitial mode corresponds to the phase quantifier for the negation of that proposition.

Phase quantification is defined on propositions. Therefore this analysis has wider applications. It allows to treat also the essive and the the translative of Finnish, which are not local cases, but talk about an object having a property or acquiring it (see Section 3 for these cases). This suggests that the modes which we find in locatives are of much wider significance. Fong claims that this is not an artefact of the separation between mode and location. Rather, she points out several reasons why DLs are not restricted to spatial movement. First, DPs can also freely be modified by DLs, even though there is nothing in motion, such as (2.20), repeated here as (2.33).

(2.33) a bridge from Buda to Pest

Second, many verbs in Finnish demand a DL even though nothing is moving. Verbs of this kind are unohtaa (*to forget*) and löytää (*to find*). They must be construed with DLs, while in English a static locative is mandatory. Notice that in Finnish you forget into the location, but you find out of it.

(2.34)	Tuovi	unoht-i	kirja-n	auto-on/*auto-ssa/*auto-sta.
	Tuovi	forget-PAST-3SG	book-ACC	car-ILL/car-INESS/car-ELA
	Tuovi left the book in the car			
(2.35)	Tuovi	löys-i	kirja-n	auto-sta/*auto-on/*auto-ssa.
	Tuovi	find-PAST-3SG	book-ACC	car-ELA/*car-ILL/*car-INESS
	Tuovi found the book in the car			

We shall deal with these verbs in Section 6. There are several drawbacks with Fong's proposal. Phase quantifiers seem to be too inflexible to begin with. They match only the cofinal and coinitial mode. But there are other directional locatives (those in transitory or in approximative mode), which cannot be analysed by means of phase quantifiers at all. But even the analysis of the coinitial mode as given by Fong seems questionable. She connects out of with the location in rather than out. However, it is not the same to be not in a location as to be out of it. Consider by way of example (2.36). It would be true under the proposal if there was an event of Jacks going, during which he was in the house and at the end he was not. (For the proposition Jack is in the house must change exactly once in truth value, from 1 to 0.)

(2.36) Jack went out of the house.

As we shall show, this is not what this sentence is saying: it says that the proposition Jack is out of the house changes from being false to being true. This means that from the logic of phase quantification, the elative is a cofinal mode, not coinitial. But this is just contrary to what we must expect. (We will discuss this problem in Section 5.3.)

Fong is right in pointing out that DLs do not need something being moved, but it does not seem to be a fact of Finnish alone. Many languages use DLs as complements of verbs, and there is nothing being moved. [13] For example, the Hungarian verb félni (*to fear*) governs the ablative. What this suggests is not that the ablative of Hungarian can have non–spatial meaning,

[13]Moreover, see Talmy [49] on the issue of fictive motion. I guess some of the verbs in Finnish are difficult to interpret as expressing even fictive motion of the kind Talmy discusses.

but rather that it can be idiosyncratically selected. Idiosyncratic selection empties the semantics of the elements and therefore the verbs is semantically like a transitive verb. We shall argue that not only cases but also modes are open to idiosyncratic selection, and this will generate the facts for the Finnish verbs without any additional assumptions. Fong's own analysis is that the Finnish verbs have a diphasic structure, and this is what makes the DL felicitous. We are not told however exactly what this diphasic structure consists in and how the DL can interact with it.

3 Some Locative Case Systems

In this section we will sketch the locative case systems of Finnish, Hungarian and Tsez. This will supply examples for locatives that we shall analyse later on. Even though the semantical analysis does not depend on the question whether or not locatives are expressed by means of PPs or by means of locative DPs, it will be interesting to note that by this very fact locative cases will be much different from nominative and accusative in that they have an elaborate structure. The consequences of this will be analyzed below in Section 6.

Tsez The Tsez case system is one of the richest case systems. In particular, it has many local cases. It distinguishes seven local functions and four modes. In addition, each local case comes in two varieties, a non–distal and a distal one. The local cases are shown in Table 2 and 3, which are taken from Comrie et al. [9]. The difference between a distal case and a non–distal case is that the former marks the location as invisible or distant (whence the name). This is not explicated further in the cited source, but has been clarified in personal communication by Bernhard Comrie.

Finnish Finnish has six locative cases, corresponding to the configuration 'in' and 'at', using stative, cofinal and coinitial mode. Moreover, there is a nominative, a partitive, an essive, a translative, an abessive, a comitative and an instructive. (See Karlsson [26] for details.) The accusative is claimed not to be a genuine morphological case. Tabe 4 shows the locative cases. Blake [6] adds a third row, consisting of the essive, the partitive and the translative (see the Table 5). The essive specifies a quality, and the translative a change into some quality.

Table 2: The Locatives of Tsez (Non-Distal)

Configuration ↓	Mode → 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 3: The Locatives of Tsez (Distal)

Configuration ↓	Mode → 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

(3.1) Olen Suomessa turisti-na.
be-1.SG.PRES Finland-INESS tourist-ESS
I am in Finland as a tourist.

(3.2) Isä on tullut vanha-ksi.
father-NOM be-3.SG.PRES become-SG.PAST old-TRANS
Father has become old.

The partitive is familiar also from French and Russian. It has a range of uses. It can be used for the subject and for the object. If a subject is in the partitive, its number or size is undetermined. If the object is in the partitive it is only partially affected by the action, the action is non–resultative. The essive, translative and the partitive are clearly not locative cases. However, even if a case is not a locative case, we can nevertheless attribute a mode to it. [14] The essive would for example be in static mode — it denotes that at event time the relevant actant has the property denoted by the DP carrying essive case. The translative is the cofinal variant of the essive; it means that the actant has the said property at the end of the interval but not at the beginning. The coinitial counterpart would therefore say that the actant has the said property at the beginning of the event time but not at the end. Here are some typical sentences where this kind of case would be appropriate.

(3.3) T–shirts have come out of fashion.

(3.4) Harold made a statue from a block of wood.

In the first case, the subject turns from being fashionable into not being fashionable. In the second case the block of wood ceases to be a block of

[14] This is the line taken by Fong [16], though she does not identify the notion of a mode.

Table 4: The Local Cases of Finnish: talo (*house*)

Configuration ↓	Mode → Stative	Cofinal	Coinitial
in	talossa	taloon	talosta
on	talolla	talolle	talolta

Table 5: Analysis of the Finnish Local Cases

Configuration ↓	Mode → Stative	Cofinal	Coinitial
∅	∅-na	-∅-ne	-∅-ta
in	-s-sa (< -*s-na)	-s-se (< -*s-ne)	-s-ta
on	-l-la (< -*l-na)	-l-le (< -*l-ne)	-l-ta

wood. The partitive, however, is clearly not of that kind. [15] [16] There is a certain degree of transparency in the morphology. We repeat in Table 5

[15] I have been informed by Aarne Ranta that there are some uses of the partitive in which it forms a series together with the essive and translative. One type of such series is exemplified by some locative prepositions:

essive	partitive	translative
takana	takaa	taakse
behind	(from) behind	to behind
luona	luota	luokse
at	from	to

(luo is better translated by French 'chez', and the other forms of luo are translated analogously.) In poetic language one also finds taaksi. The base forms, taa and luo may be used in place of taakse and luokse, respectively. The other example is kotona (at home), kotoa (from home), which are in the essive and the partitive, respectively. The corresponding form in the translative, *kotiksi, is however missing. Instead, one has to use the illative kotiin. There are a few more examples, but the number is very small. Hence this is a nonproductive pattern.

[16] Finnish has what could be called a perlative case. This was brought to my attention by Aarne Ranta. Examples (which are formed regularly by affixing -tse) are meritse ('through the sea'), maitse ('through the land') and postitse ('by/through mail').

Table 6: The Local Cases of Hungarian

Configuration ↓	Mode → Stative	Cofinal	Coinitial
in	házban	házba	házból
at	háznál	házhoz	háztól
on	házon	házra	házról

the table given in [6]. We can see that there is a morpheme -s- for the configuration 'in', and a morpheme -l- for the configuration 'at'. [17] There is a morpheme -ta for the coinitial mode, and a morpheme -Da for the stative mode, where D stands for reduplication. (It results according to Blake from an *n.) Only the cofinal mode falls out of the picture. Notice that the configuration is closer to the stem, as expected.

Hungarian The local cases of Hungarian are listed in Table 6. We can see that Hungarian adds to the Finnish locatives another configuration. It differentiates in contrast to Finnish the configurations 'in', 'at' and 'on'. There is also a peculiarity of the Hungarian adpositions that is worth mentioning. First of all, all adpositions are postpositions; moreover, they govern almost without exception the nominative case (but see Footnote 7). Since the nominative has a zero suffix, it is quite hard to distinguish between a postposition and a case suffix. Hungarian locative postpositions also occur in three modes, see Table 7. These adpositions are, from a semantical point of view, no different from the local cases.

[17] The case of the illative needs some argumentation. We can see the -s- when the noun ends in a long vowel. For example, the illative of Espoo is Espooseen. The history of the Finnish (and Hungarian) locative case systems is a fascinating area of its own, which we will not go into, however.

Table 7: Hungarian Locative Postpositions

Configuration ↓	Mode → Stative	Cofinal	Coinitial
under	alatt	alá	alól
above	fölött	fölé	fölül
next to	mellett	mellé	mellől
in front of	előtt	elé	elől
behind	mögött	mögé	mögül
among	között	közé	közül

(3.5) A cica az asztal alatt.
DET cat DET table under-STAT
The cat is under the table.

(3.6) A cica az asztal alá fut.
DET cat DET table under-COFIN run-3.SG.PRES
The cat runs under the table.

(3.7) A cica az asztal alól jön ki.
DET cat DET table under-COINIT come-3.SG.PRES out
The cat comes out from under the table.

4 Ontological Assumptions

In what is to follow, we shall work using some version of type–theory. Recall that type theory has a set of basic types, and some type constructors. Our version is as follows.

Definition 1 *The following are basic types.*

- e, *the type of* ***objects***,
- i, *the type of* ***time points***,
- p, *the type of* ***spatial points***,
- v, *the type of* ***events***,

- *t, the type of **truth–values**.*

The type constructors are $\rightarrow$ and $\times$, which are binary.

A **type** is a term that is built from the basic types using the type constructors. We assume further that $\leq$ is a quasi ordering on the set of types. That is, the following must hold: (a) $\alpha \leq \beta$ and $\beta \leq \gamma$ implies $\alpha \leq \gamma$, (b) $\alpha \leq \alpha$. If $\alpha \leq \beta$ we say that α is a **subtype** of β. For example, we shall assume that v is a subtype of e.

For each type α we associate a space of possible (set theoretic) interpretations $\ulcorner\alpha\urcorner$ in the following way. (If M and N are sets, $M \times N$ denotes the cartesian product of M and N and $M \rightarrow N$ denotes the set of all functions from M to N.)

$$\begin{array}{lcl} \ulcorner e\urcorner & := & E \\ \ulcorner i\urcorner & := & \mathbb{R} \\ \ulcorner p\urcorner & := & \mathbb{R}^3 \\ \ulcorner v\urcorner & := & V \\ \ulcorner t\urcorner & := & \{0,1\} \\ \ulcorner \alpha \rightarrow \beta\urcorner & := & \ulcorner\alpha\urcorner \rightarrow \ulcorner\beta\urcorner \\ \ulcorner \alpha \times \beta\urcorner & := & \ulcorner\alpha\urcorner \times \ulcorner\beta\urcorner \end{array}$$

Further, it is required that if $\alpha \leq \beta$ then $\ulcorner\alpha\urcorner \subseteq \ulcorner\beta\urcorner$. Here, E and V are sets whose precise identity will not matter to us (though we shall have $V \subseteq E$ by the fact that $v \leq e$). They can be arbitrarily given. A proposition is a function from a set of indices (the logophoric centre) to truth–values, and therefore not a basic type in this setup.

Definition 2 *If α is a type, $\alpha^\bullet := \alpha \rightarrow t$ is a type, the type of **groups over** α.*

Definition 3 *In addition to the abovementioned types, also the following are basic types.*

- *r, the type of **regions**. r is a subtype of $p^\bullet$.*
- *j, the type of **intervals**. j is a subtype of $i^\bullet$.*

(Regions are path connected subsets of $\mathbb{R}^3$. See below in this section.) We shall have to take r and j as basic types, since they cannot be generated from the other ones in this setup. However, they are not independent from the

others; for everything of type r is by definition also of type $p^\bullet$ and everything of type j is also of type $i^\bullet$.

There is a bijection from $\wp(N)$ to $N \to \{0,1\}$ defined by $S \mapsto \chi_S$, where $\chi_S(x) = 1$ iff $x \in S$. (χ_S is called the **characteristic function** of S.) Thus, we may alternatively define $\alpha^\bullet := \alpha \to t$, and let everything follow from that. For sets M, N and P there is a natural bijection β from $M \times N \to P$ to $M \to (N \to P)$ given by $\beta(f) := \lambda x.\lambda y.f(\langle x, y\rangle)$. A special instance is $P = \{0,1\}$ ($\beta(f)$ is also called the 'Currying' of the function f). Let $R \subseteq M \times N$ be a relation from M to N. Then $\chi_R : (M \times N) \to \{0,1\}$, and hence $\beta(\chi_R) : M \to (N \to \{0,1\})$. Now, exchanging $\wp(N)$ for $\{0,1\}$ we obtain, finally, a correspondence between relations from M to N and functions from M to $\wp(N)$.

Proposition 4 *Let M and N be sets. There is a bijective correspondence between subsets of $M \times N$ and functions from M to $\wp(N)$ given by*

$$R \mapsto R^\spadesuit := \lambda x.\{y : \langle x, y\rangle \in R\}$$

Thus, these bijections give some freedom in the definition of the actual semantics (this is a restricted form of what has become known as flexible type assignment). We shall make implicit use of this, often not distinguishing between a set and its characteristic function. This should cause no confusion but will make the structures about which we shall talk somewhat simpler.

Before we lay down the formal approach it is worthwile to outline our ontological and semantical assumptions. This might clarify some peculiarities of the present approach. We assume an ontology with things, events and groups thereof. Events are particular things, and they figure in the denotations of — among other — verbs. (See Parsons [44] for a defense of the use of events.) On an event there are certain partial functions defined corresponding to the θ–roles. Consider for example

(4.1) Harry is painting a picture for Mary.

This sentence says that there is an event, e, in which there is an actor called Harry, a beneficiary called Mary and some theme, which is a picture. So, the functions act(or)$'$, ben(eficiary)$'$ and theme$'$ are defined on this particular event e and yield Harry, Mary and the picture, respectively. If I say only

(4.2) Harry painted a picture.

then the function ben$'$ is not necessarily defined on the event to which (4.2)

is referring (though it may be). However, for there to be an event of painting it is necessary that there is an action and an actor, so the function actor' is defined.

We shall assume that verbs typically denote sets of events and nouns sets of things. [18] We shall distinguish semantic adjuncts from semantic arguments. For functor/argument pairs the composition rule is function application. So, if F is a functor and A its argument, then the interpretation of the constituent $[F\ A]$ in the model $\mathfrak{M}$ is $[\![F]\!]^{\mathfrak{M}}([\![A]\!]^{\mathfrak{M}})$. Modifiers must denote the same type of sets as the modifiees. If M is a modifier and E a modifiee, then we have as interpretations in our model $\mathfrak{M}$ two sets, namely $[\![M]\!]^{\mathfrak{M}}$ and $[\![E]\!]^{\mathfrak{M}}$. The constituent $[M\ E]$ is then interpreted by $[\![M]\!]^{\mathfrak{M}} \cap [\![E]\!]^{\mathfrak{M}}$.

An event usually has a time and a place associated with it. That is to say, there are functions time' and loc', which return for each event e its time and its location. We have already said that these functions need not be defined in all cases, but we are interested in this paper mainly in those events for which they are. The event time is always an interval; we allow no scattering of an event in time. Similarly, we assume that the location of an event is path connected (though not necessarily convex). (See the Appendix for technical definitions concerning spatial and topological concepts.) There is a subtle but important difference to be made between the event location and the location of the participants. In the literature, there have been proposals to link a static locative with the location of some participant, and others which link it with the event (see [52] for a discussion on this). For all those who take the event location as the one modified by the nondirectional locative there is the problem that the event location is technically distinct from the locations of its participants.

The relationship between the location of an event and that of the participants involved in it is rather delicate. The location of an event can be relatively independent of that of the participants (for example beneficiaries), but typically there are some connections. The simple assumption would be that the location of an event must include the location of the other actants. But one must be cautious (see [52] and references therein). If we are playing cards at a table, then the location of this event of playing is one which contains our locations as well as those of the cards. Presumably, we will be

[18] It has to be said though that for the theory to work in all cases we shall assume also that some nouns denote sets of events as well, such as trip and so on. v is a subtype of e, and this complicates some of the definitions following below.

generous and take the table as a whole with it. If at some point I go out into the kitchen to get some food then we would on the other hand not say that the kitchen is part of the location of us playing cards. This problem is discussed in Section 7. Let us stay however with the problem of locations. We assume that there is a function loc', which for a given object returns a function from time points to regions, that is, sets of points. A region must be path–connected. (So, Saturn and its ring are two objects, not one.) In contrast to objects, which are assumed to be potentially moving in space, events do not move at all. Events have a time independent location, which is simply the union of all locations occupied by the participants during that event at their point of activity (plus something more). [19]

This distinction can be motivated to some extent. There are conceptual and linguistics reasons. Conceptually, we think of an event as something that is constituted by objects being in some relation to each other or moving in space, or changing in property etc. So, we set up the objects first and constitute the event with reference to them. [20] The location of the event can change only indirectly in virtue of its objects moving. However, the movement of the objects is what constitutes the event, since the event is something that evolves in time, so in contrast to objects we shall think of the location $\mathsf{loc}'(e)$ of events as a subset of the four dimensional space–time. Then the projection to the first three coordinates is the usual location of the event and the projection to the last the time. [21] 'Proper' objects, in contrast, have as location a function from time points to subsets of the three dimensional space. These two concepts must be kept distinct. They are definitely different in the type theory that we have defined above. Linguistic evidence can also be given. When we ask of an event where it happened, we

[19]Notice that events are also things. This leads us to conclude that the function loc' sometimes returns a region for a given thing (when it is an event), and sometimes a function from time points to regions. In order to implement this in type theory, one must introduce disjunctive types, but we shall refrain from explicitly doing so here. Let us note that this explains why event nominals can be construed with locatives in the same way as verbs; for it is the semantical type (event/object) on which this approach is based, and not on the syntactic one (noun/verb).

[20]See Mandler [38] for arguments from studies on few month old babies. It is suggested that babies at this age have no concept of time, but a fully developed concept of space (and master even abstract concepts such as 'animal'). The notion of 'path' and 'event' only come later.

[21]If $R \subseteq A \times B$, the first projection is the set $\pi_1[R] := \{x : \text{ for some } y : \langle x, y\rangle \in R\}$ and the second projection the set $\pi_2[R] := \{y : \text{ for some } x : \langle x, y\rangle \in R\}$.

get an answer like: 'in Manchester', 'under the tree', 'on the grass' and the like. We do not get answers like: 'from Berlin to Hamburg', 'into the railway station'. So, we refer to a location of an event as an absolutum, a property of the event itself. [22] Naturally, an event may consist in something moving around. In that case the location of the thing that is moving is of course changing through time, but not that of the event. The very moment that a thing remains constant enough a location throughout its lifespan we can refer to its location as an absolutum. We ask of the location of a city, a mountain, or things like that. [23] Thus, whether or not a location is a property of an individual qua individual is a question of its mobility. Moreover, it is a gradual affair. We are not inclined to say that Hamburg is near Jonas, but we rather say that Jonas is near Hamburg. (See Talmy [48].) This is because the second element defines the location with respect to which the first is placed. We are less inclined to think of Jonas as having a location with respect to which we would place a city than to position Jonas with respect to the location of that city.

We have taken groups to be functions from individuals to truth values, which by the remarks above comes down to viewing them to be sets of individuals. (We refer to Landmann [32] and [33] for a defense of the view that groups are sets.) This allows us to iterate the construction of group formation. We will not go into the ramifications of this. In general, if α is a type, then $\alpha^\bullet$ denotes the type of groups/sets of type α. A thing is of type $\alpha^\bullet$ if it is a set of things of type α. So, there will be groups of individuals, of locations, of time points and even groups of events.

[22] One might object that this is just so because we asked with the help of where, which requires a location. But note that in order to ask for the destination of an event (if that were to exist) we would have to use the question *Whereto did it happen?, which is ungrammatical. Therefore, events have a location simpliciter, which does not change over time. They have no origin and no destination.

[23] For example, it is odd to ask Where is Berlin now?, while it is fine to ask Where is your cat now?. I have been challenged by one reviewer that it is sensible to ask Where is the Tour de France now?. I admit that the distinction is not as precise as I would like it to be, but I think it is a real one. One line of defense is to say that we may (re)conceptualize the Tour de France as an object. The change from event to object is an instance of type coercion, which is altogether not uncommon. Trying to say what is an object and what is an event is perhaps as difficult as to say what is a count noun and what a mass noun. Though difficult to apply in particular cases (eg furniture) and even more difficult to apply rigorously (to what degree do we require divisibility: furniture/troops/water/light?), it nevertheless is a sensible distinction to make.

Certain verbs take only groups as actors (meet), others are less strict. Now consider the following sentence:

(4.4) In several cities there were demonstrations against the government.

One may consider this as saying that there was a single event of demonstrating in several cities. However, we want to argue on conceptual grounds that this is wrong. An event is something that takes place in some interval of time and which has a location that is connected. So, if we have demonstrations at various disconnected places then we must assume that these are several events, each constituting a separate event of demonstrating against the government. Now, we may either take the sentence to denote a group of events, each having its own location; or we may in fact associate with the whole group of events a single location. What can that be? The first solution is to take the union of these locations. The other would be to take the group of locations. Both are correct on different occasions. In general, given a function f of type $\alpha \to \beta$, we can associate with it a function $f^\bullet : \alpha^\bullet \to \beta^\bullet$ defined by

$$f^\bullet(X) := \{f(x) : x \in X\} .$$

This is the **group function** associated with f. If $\beta = \gamma^\bullet$, we may on the basis of the group function define the **cumulative function** by

$$f^\circ(X) := \bigcup f^\bullet(X) = \bigcup \{f(x) : x \in X\} .$$

This is the same as with agents. A group of events can have as agent the group consisting of those groups partaking in the individual events; or it can have as agent the group of all those individuals that took part in one of the events. This difference appears in the following sentences.

(4.5) The Smiths and the Toalsters met twice.

We may read this as saying that the Smiths met and that the Toalsters met. Under this reading, there are four events of meeting, two for each family. The agent is the group of the agents of the different events. We may however also have a reading in which, although there is a group of four events, the agent is simply the entire group of the Toalsters and the Smiths.

Finally, we should say something about the nature of space in language. We shall assume that there is a type of entity called *point* and an entity called *region*, which we consider to be a certain set (= group) of points. Although in the natural sciences such a notion is very common, the need for

such a category must be argued for. After all, we rarely speak of regions in an absolute way; we always define them by means of objects that occupy them. (However, Creary et al. [11] and [12], following Jackendoff, argue that locatives and DPs are quite similar in many respects, for example locatives introduce locations to which we can make reference to, for example using there.) Of course, an absolute notion of space makes spatial reasoning much simpler than if we were to construe the space by means of the objects inhabiting it. However, there are also linguistic facts that show the existence of locations (regions) as independent entities. Consider first the word where. We can ask for locations using the word where, but we cannot ask using where for groups or sets of individuals. Otherwise, it would be interchangeable with what or which. Hence, the kinds of objects that the word where asks for are regions. Further, the word there denotes a region. This explains the following contrast. [24]

(4.6a) Dort, wo das Gras noch grün ist, ...
(4.6b) There, where the grass is still green, ...
(4.7a) *Das Buch, wo wir gelesen haben, ...
(4.7b) ? The book, where we have read, ...
(4.8a) *Dort, worin das Gras noch grün ist, ...
(4.8b) *There, wherein grass is still green, ...
(4.9a) Das Buch, worin wir gelesen haben, ...
(4.9b) The book, wherein we have read, ...

What this data shows is that relative clauses involving German wo (like English where) can be used to define a modifier for regions, but not for things. On the other hand, German worin (like English wherein) returns a modifier for things, but not for regions. The same holds for other languages that we have looked at. Interesting supporting evidence for a distinct semantic type of location comes from Australian languages. [25] Although the facts are the same in many Australian languages (see [14] for example), we shall exemplify them with Martuthunira (see [15]). Like many Australian languages it allows case markers to be stacked. The ablative case denotes a temporal relationship ('after') or a locational one ('away from'). When it is used in

[24] In these and all following examples, the (b) sentences are English translations of the (a) sentences. They appear in Sans Serife font since they are also used as examples. Notice that English is less strict in dividing between objects and places than German. We shall return to question words in Section 6.

[25] These facts have been brought to my attention by Alan Dench.

the latter meaning, it needs a location as a complement. Here is an example. The word for person is kanyara. If we want to say *away from the person* we must use the ablative stacked on top of the locative:

(4.10) kanyara-li-nguru
person-LOC-ABL
away from the person

The use of the ablative alone has a different effect:

(4.11) Nhartu-ma-rnu-lwa-rru ngula kanyara-nguru waarruwa-nguru?
what-CAUS-PASSP-ID-NOW IGNOR person-ABL devil-ABL?
What became of them after the time they were people, devils?

So, the ablative can be attached to the stem directly or following the locative. Only in the latter construction does it have a locative meaning (in fact, it then turns into a modaliser signalling coinitial mode). However, it would be a mistake to attribute this to the presence of the locative case. In [15] it is explicitly stated that if a noun is inherently locational, the ablative signals coinitial mode when attached directly to the stem. Consequently, we find

(4.12) Wanthala-nguru-lu?
where-ABL-EFF?
where from?

(This is example (4.65) from [15]. The additional case marker EFF is of no significance here. It can be dropped. [26]) These facts are naturally explained if we assume that certain nominals denote locations, while most nominals denote things.

There is additional evidence from Chinese that is interesting in other aspects, too. [27]

[26] Alan Dench (p.c.)

[27] I owe this data to one of the referees.

(4.13) zai zhuozi-shang
STATIC table-on
on the table

(4.14) cong men-houmian
COINITIAL door-behind
behind the door

(4.15) dao huochezhan
COFINAL train station
to the train station

(4.16) wang Beijing
APPROX Beijing
toward Beijing

As we can see there are nouns that need a localiser (shang, huomian) to define a location, before they can be combined with a modaliser. Others, however, do not need a localiser. Cities and buildings are of this kind. However, with respect to buildings it is only the localiser li that is dispensable (see [1]). Generally, cities do seem to display special behaviour. For example, they are used in German with nach in the cofinal mode, which cannot take other complements. Notice that the Chinese data shows that the modaliser and the localiser can be at opposite sides of the DP.

5 Semantical Analysis

In this section we shall sketch a Montagovian analysis of locatives. Primarily, we are interested in the proper type theoretic analysis of localisers and modalisers. It does therefore not provide an in depth definition of the meaning of particular such elements. For the complications the reader is instead referred to the compilation Bloom et al. [7].

We will motivate the basic idea with a simple example.

(5.1) The cat appeared from under the table.

The preposition consists of two parts, namely from and under. The structure is

(5.2) [from [under [the table]]]

The PP under the table defines some location by means of a noun phrase (the table) and a preposition. The noun phrase is called the **landmark**. We

call prepositions like under as well as its denotation a **localiser**. (This will hardly cause confusion, we hope.) The phrase (5.1) however says that there is some movement with respect to the named location during the event time, which can be characterized as follows. At the beginning of the event time, the object is fully contained in the location and at the end of the event time it is outside the location (whether fully outside or not — see below). We call the preposition from a **modaliser** what it denotes the **mode**. So, the structure of a locative expression is as follows: $[M\ [L\ DP]]$. We propose to call the constituent $[L\ DP]$ a **location phrase** (**LP**), and the entire complex $[M\ [L\ DP]]$ a **mode phrase** (**MP**). The term *locative (expression)* can mean either of the two.

5.1 Localisers

The semantics of localisers has recently been studied by Joost Zwarts and Yoad Winter [53]. What we will have to say is quite compatible with their analysis. Two basic differences stand out, however. Our analysis is centered around what they call *non–projective* localisers. Non–projective localisers need only the landmark to determine the location, while projective ones need something else, typically the deictic centre or pivot (see Sells [47] or Bouchard [8] on the notion of a pivot). For example, outside is non–projective, while behind is projective. Some remarks on projective localisers are nevertheless given below. On the other hand, we also include time dependency in the semantics of localisers, which is necessary, as we will show below.

Our fragment is purely extensional. We use the type–theoretic language of the previous section. We need however some additional machinery. An *interval* is a subset of the reals; so the type j of intervals is a subtype of the type $i^\bullet$. We call a *region* a path–connected subset of the three-dimensional space. Hence the type r of regions is a subtype of the type $p^\bullet$. Next, a **parametrized region** is a function from time points to regions; it is an object of type $i \to r$. A **neighbourhood** is a set of regions, hence an object of type $r^\bullet = p^{\bullet\bullet}$. (Actually, in topological theory a neighbourhood of x is an open set containing x. For want of a better name we have called sets of regions a neighbourhood. The reader is once again warened that we implicitly identify subsets of a set A with their characteristic function, so regions aren't really sets according to our type theory, but we act as if they are.) A **parametrized neighbourhood** is a function from time points to

neighbourhoods and so of type $i \to r^\bullet$. We assume that there is a function loc' of type $e \to (i \to r)$. It returns for any given object a function from time points to regions; this region is the location of the object at the given time. Since many objects do not have a location (think of ideas, for example), we shall assume that loc' is a partial function, although at least in this paper we shall not deal with objects having no locations. [28]

First we turn to the localisers. Examples of localisers are in, at, on, between, under. Non–examples are because (since it does not denote any spatial

[28]It has been suggested by some reviewer that we should actually talk of objects inhabiting space–time regions rather than functions from time points to regions. However, there are reasons not to choose this definition. First, let me note that although the space time–continuum is not isomorphic to the product of $\mathbb{R}^3$ with $\mathbb{R}$, on any scale we reason normally in it is. It would complicate matters beyond necessity if we were to talk about the Minkowski space (or even Riemannian manifolds for that matter). Second, the time coordinate is intuitively (as well as physically) different from the spatial coordinates. Thermodynamically, time flows in the direction of increasing entropy. This means that we cannot choose in which way time goes, but we can choose (more or less) freely in which direction we go. This is reflected in the intuition that the time coordinate is given, and the space coordinates are derived from that. Thirdly, it is not the same to say that an object inhabits a path–connected region in the Minkowski space than it is to say that its spatial location is path connected at any moment of time. Otherwise, a colliding pair consisting of an electron and a positron will constitute a single object, which is not the way we conceptualize things. It seems preferrable here to leave matters at an intuitive level rather than trying to catch up with the facts in physics, which matter only at extreme ends of the scale anyway. However, matters are once again different for people living inside a toroidal space station (as concerns their notion of up and down as opposed to ours). But I guess their problems can be handled using the apparatus below.

Another problem that has been raised is the fact that using flexible type assignment allows to switch, say, from subsets of space–time to functions from the time–line to subsets of space (or even functions from space points to set of time points) and back. So we can have it either way. Although in principle possible, I wish to suggest that elements nevertheless do have a *basic* type, and that a change in type assignment must be motivated by the context, and requires mental processing. That this difference cannot so easily be accounted for here is partially due to the particular type system chosen. For example, I would prefer a group to be a set rather than a function, but have opten for purely technical reasons no to. This change in the setup means that speaker and hearer have to do some 'reediting' of the types, seemingly at no cost. Also, the type systems generally gloss over conceptual divergences. It is nowadays quite common to define a function from A to B as a subset of $A \times B$. However, I think that cognitively speaking this is a mistake since it eliminates the idea of a function actually 'doing something', or 'giving us a value'. In that sense, viewing an event as inhabiting the four dimensional space–time continuum is cognitively different from it being a function from time to spatial region, no matter how similar they seem to be on a technical level.

relationship) and out and into (because there is some change of location involved). Moreover, we do not consider any temporal prepositions (to keep matters simple). Localisers are based on local relations. A **local relation** is simply a binary relation on the set of regions. So, if R is the set of regions, a local relation is a subset of $R \times R$. From a syntactic point of view, however, $[P\ DP]$ is already a constituent. So, we replace the binary relation by a different construct. There is a natural bijection between subsets of $R \times R$ and functions from R to subsets of R. Namely, if $H \subseteq R \times R$, then let $H^{\spadesuit}$ be defined as in Proposition 4. So, we take as the meaning of a localiser a function from regions to sets of regions, that is, neighbourhoods. We shall show below that this cannot be reduced further. The localiser on is not correctly analyzable as a function from objects to regions. [29] There is an additional complication arising from the fact that the localiser does not take a region but an object as its argument. Furthermore, this object can move in space (for example, a car). Now given a function N from regions to neighbourhoods, we finally define the corresponding localiser $N^{\heartsuit}$ as follows.

$$N^{\heartsuit} := \lambda x.\lambda t.N(\mathsf{loc}'(x)(t))$$

This is a function of type $e \to (i \to r^{\bullet})$. Applied to an object it yields a parametrized neighbourhood. This means that a localiser is a function from individuals to neighbourhoods which are changing through time.

Here is an example. Let r be a region. Denote by $\iota(r)$ the convex hull of r minus the region r itself. So, if r is the location of a box, [30] $\iota(r)$ is what we call the *inner* or *inside* of that box. Then, let $i(r, s)$ iff $s \subseteq \iota(r)$. The function $i^{\spadesuit}$ acts as follows. Given a set r, it returns all sets s such that $i(r, s)$, that is, the set of all s such that $s \subseteq \iota(r)$:

$$i^{\spadesuit}(r) = \{s : s \subseteq \iota(r), s \text{ a region}\}$$

[29] This will show why we start with spatial relations and define the local functions on the basis of them. If we take the interpretation of localisers to be some sort of function from objects to regions, there is no a priori intuition that leads to the correct guess once we encounter problems with on. Doing it our way shows a way out, however. We also believe that spatial relations are intuitively more basic than the local functions, even though type theoretically things cannot be analyzed this way.

[30] By location we mean only the location occupied by the solid constituting the box. If b is a box of cigars, its location is where you find wood, not where you find the cigars. This is why you must form the convex hull, to give you what we normally consider the location of the box. After that you substract the location of the solid.

Using this function, the semantics of in becomes

$$\begin{aligned}
\mathsf{in}' &= i^{\spadesuit\heartsuit} \\
&= \lambda x.\lambda t.i^{\spadesuit}(\mathsf{loc}'(x)(t)) \\
&= \lambda x.\lambda t.\{r : i(\mathsf{loc}'(x)(t), r), r \text{ a region}\} \\
&= \lambda x.\lambda t.\{r : r \subseteq \iota(\mathsf{loc}'(x)(t)), r \text{ a region}\}
\end{aligned}$$

This means the following. in' needs as input an object x and a time point t and returns a set of regions, namely those which are contained in the inside of x at time t. The latter is defined to be the convex hull of the location of x at t minus the location of x at t. So, in the car is true of John at t iff John is contained in the inside of the location of the car at t.

It is easy to see that this is a function of type $e \to (i \to r^{\bullet})$. So, in' is a function from objects to parametrized neighbourhoods. [31] In a similar vein, we can now analyse a lot of other spatial concepts, like at, near, on, under. What we need in addition to the usual set theoretic notions is a metric, and an orientation in form of a definition of verticality. The metric is for example needed to define the meaning of at and near. Let $d(\vec{x}, \vec{y}) : \mathbb{R}^3 \times \mathbb{R}^3 \to \mathbb{R}$ be the usual distance metric (see Appendix). Then for subsets $r, s \subseteq \mathbb{R}^3$ put [32]

$$d(r, s) := inf\{d(\vec{x}, \vec{y}) : \vec{x} \in r, \vec{y} \in s\} .$$

Furthermore, the **diameter** of r is

$$\delta(r) := sup\{d(\vec{x}, \vec{y}) : \vec{x}, \vec{y} \in r\} .$$

(This is defined only if r is bounded.) We say that r **touches** s if $r \cap s = \varnothing$ and $d(r, s) = 0$. In that case we also say r is **at** s, in symbols $\alpha(r, s)$. r is

[31] This applies only for singular DPs. For plural DPs we assume that the semantics of in is a function of type $e^{\bullet} \to (i \to r^{\bullet\bullet})$, taking groups of objects to parametrized groups of neighbourhoods. The semantics can be standardly generated as follows. If f is of type $e \to (i \to r^{\bullet})$, the corresponding plural, $P(f)$, is of type $e^{\bullet} \to (i \to r^{\bullet\bullet})$, where

$$P(f) := \lambda x^{\bullet}.\lambda t.\{f(y)(t) : y \in x^{\bullet}\} .$$

Now, there are prepositions that take groups only, for example between and among. For them we must assume that the semantics is of type $e^{\bullet} \to (i \to r^{\bullet})$. Namely, they are functions from groups of objects to parametrized neighbourhoods. We will not go into the details here.

[32] Notice that vector arrows are used to denote space points (= vectors), while ordinary variables denote objects of other types (for example regions).

near s, in symbols $n(r,s)$, if $d(r,s)$ is small in comparison to $\delta(r)$ and $\delta(s)$. [33]

$$\begin{array}{lcl} \mathsf{at}' & = & \lambda x.\lambda t.\{r : \alpha(r, \mathsf{loc}'(x)(t)), r \text{ a region}\} \\ \mathsf{near}' & = & \lambda x.\lambda t.\{r : n(r, \mathsf{loc}'(x)(t)), r \text{ a region}\} \end{array}$$

The vertical orientation is given by a vector field V on the space, that is, by means of a continuous function $V : \mathbb{R}^3 \to \mathbb{R}^3$. Its intuitive interpretation is that for a vector $\vec{x}$, $V(\vec{x})$ points towards the center of gravity, that is, in the direction to which $\vec{x}$ is attracted, and the length of $V(\vec{x})$ is the gravitational strengh. (So, on the surface of the earth, $V(\vec{x})$ is a vector pointing towards the gravitational centre of earth, and whose length is g. If $\vec{x}$ is the centre of earth, $V(\vec{x}) = \vec{0}$.) Now, we say that $\vec{x}$ is **above** $\vec{y}$ if the difference $\vec{x} - \vec{y}$ is a negative multiple of $V(\vec{y})$. [34] We usually coordinatize the space (locally) in such way that $V(\vec{x}) = \langle 0, 0, -1\rangle$ for points close to the surface of the earth. Then, given this, $\vec{x} = \langle x_1, x_2, x_3\rangle$ is above $\vec{y} = \langle y_1, y_2, y_3\rangle$ if $x_1 = y_2$, $x_2 = y_2$ and $x_3 > y_3$. Further, we write $a(s,r)$ if (0) $r \cap s = \varnothing$, (1) for some $\vec{y} \in s$ there exists an $\vec{x} \in r$ such that $\vec{y}$ is above $\vec{x}$, (2) s is outside of the convex hull of r (that is, $\iota(r) \cap s = \varnothing$), and (3) r does not touch s. [35] Likewise, we write $u(s,r)$ if (0) $r \cap s = \varnothing$, (1) for some $\vec{y} \in s$ there exists an $\vec{x} \in r$ such that $\vec{y}$ is under $\vec{x}$, (2) s is outside of the convex hull of r, and (3) r and s do not touch. The rest is analogous to the case of in. Namely, we put

$$\begin{array}{lcl} \mathsf{above}' & := & a^{\spadesuit\heartsuit}\,, \\ \mathsf{under}' & := & u^{\spadesuit\heartsuit}\,. \end{array}$$

It then follows that

$$\begin{array}{lcl} \mathsf{above}' & = & \lambda x.\lambda t.\{r : a(r, \mathsf{loc}'(x)(t)), r \text{ a region}\}\,, \\ \mathsf{under}' & = & \lambda x.\lambda t.\{r : u(r, \mathsf{loc}'(x)(t)), r \text{ a region}\}\,. \end{array}$$

[33] This needs to be made precise, though. We shall not an attempt to do that, since we are only peripherally interested in identifying the meaning of individual localisers.

[34] Suppose we define $\vec{x}$ is above* $\vec{y}$ iff $\vec{x} - \vec{y}$ is a negative multiple of $V(\vec{x})$. Then, since $V(\vec{x})$ need not be a multiple of $V(\vec{y})$, the two relations need not be identical. For all realistic purposes however they are, and we shall henceforth ignore this point.

[35] Earlier, I had conjectured that r can only be above s if for *every* $\vec{x} \in r$ there is a $\vec{y} \in s$ such that $\vec{x}$ is above $\vec{y}$; and dually for under. This contradicted O'Keefe [43], whom I have now followed. Notice that in the original conception, under and above would both be transitive. But from the fact that A is above B one could not infer that B is under A. Now it is the converse: the latter property holds, but neither relation is transitive. For conflicting intuitions see Levelt [34].

In the above examples it was not apparent that we needed the notion of a neighbourhood rather than that of a region. In fact, in the literature it is always assumed that this reduction is possible (see [12] as a case in point). To dismantle this, let us look at the German preposition auf. The pair auf/an (*on*/*at*) more clearly than in English distinguishes vertical contact from horizontal contact.

(5.3) Das Bild hängt an der Wand.
*The picture is hanging at the wall.

(5.4) *Das Bild hängt auf der Wand.
The picture is hanging on the wall.

(5.5) Das Auto steht auf der Straße.
The car is on the road.

(5.6) Das Auto steht an der Straße.
?The car is at the road.

(5.5) is used when the car is literally on the road. (5.6) is appropriate when it is parked off the road but next to it. (But it is likewise used when the car is properly parked on the road. We shall not discuss these complications, however.) Let us try to define the concept of German auf. For illustration, we shall confuse it with English on and think of it the latter as requiring vertical contact. We define $f(r, s)$ for regions r and s in the following way. $f(r, s)$ iff (1) for some $\vec{x} \in r$ there is a $\vec{y} \in s$ which is under $\vec{x}$, (2) r is not contained in the convex hull of s and (3) r and s touch. From this, the denotation of auf is defined as above. So, if an object is *auf* another object the two regions of the objects must touch. The question is whether there is a function O from regions to regions such that x is on y at t iff $x \in O(\mathsf{loc}'(y)(t))$. Such a function does not exist. Let us take an example. Let c be a bird cage, τ a table, and b a bird. Suppose O has the desired properties. Then for an object to be on the table at t, its location must be fully contained in the region $O(\mathsf{loc}'(\tau)(t))$. Suppose that c is on the table, and the bird inside it. Then the location of c at t is fully contained in $O(\mathsf{loc}'(\tau)(t))$. But so is the location of b. Hence the bird is on the table, no matter where inside the bird cage it is. This cannot be.

We can continue with more localisers in a similar fashion. To define left and right, in front, behind we not only need a vector defining verticality, we need two more vectors: v_f, to define 'front', and v_r, to define 'right of'. Moreover, the definition of these prepositions displays additional complexities, which get reflected in the semantic types (they must be different from

$(e \to (i \to r^\bullet)))$. Where before we were asked to compute the set of difference vectors from figure to landmark and see whether they point (roughly) in direction of the verticality vector, right of offers two choices. We define an **origin** for the coordinate frame. [36] The origin of the coordinate frame need not be the landmark. If it is, matters are as before. If it is not, then the following definition is employed. (See Levelt [34] and Levinson [36].) The difference vector $p_f - p_\ell$ of the positions of figure and landmark must point into a direction not more than $\pi/4$ different from that of v_f. Then figure is in front of landmark for a Hausa speaker. For an English speaker this must be true of $p_\ell - p_f$. Finally, it must be determined what fixes the value of v_f and v_r. In some languages, the coordinatization is strictly absolute (it never changes with respect to the earth's coordinate systems of north and west). This is the case in Guudu Yimithirr, an Australian language, and Tzeltal, a Mayan language. Such languages obviously have no equivalent of right and in front of! (This is called the **absolute perspective**. See the collection [7] for more data on this.) If the origin is always the landmark we speak of **intrinsic perspective**. Finally, **relative perspective** obtains when the origin is the speaker or some other agent different from the landmark. Once again, relative perspectives can be **egocentric** (origin is speaker) and **allocentric** (origin is not the speaker). Now, the value of v_f and v_r are computed according to some inherent features of the object that serves as the origin (this is the case in Indo–European languages). The case of in front of, which features in many contributions of [7], is a case in point.

The semantics of localisers we have given above are but approximations, and there are many instances where they fail to do justice to our intuitions. Moreover, there invariably are borderline cases. For example, when is some object x *at* an object y, and when is it *on* y? Further, look at the following example.

(5.7) There is a thumbtack (stuck) in my salad bowl.

Here, in refers to the actual region occupied by the solid at the given moment of time, and not its inside. Problems of this kind are discussed in Herskovits [20]. It is difficult to imagine how a strictly compositional account would handle this problem, and we shall have to leave it aside.

[36] In this discussion we treat objects as points, to keep matters simple.

5.2 Modalisers

Now we turn to the mode. We shall classify the modes according to the sets in which a certain proposition is true. We will begin with the directional modes and then discuss the static mode. Take two intervals I and J such that $J \subseteq I$. We say that J **properly begins** I, in symbols $\mathsf{pbeg}'(J, I)$, if $J \neq I$ and if for all $s \in I$ there is a $t \in J$ such that $t \leq s$. We say that J **properly ends** I, in symbols $\mathsf{pend}'(J, I)$, if $J \neq I$ and for all $s \in I$ there is a $t \in J$ such that $s \leq t$. This is defined for all sets of reals. If J and I are intervals, then this captures the usual intuitions: J properly begins I if J is an initial part of I different from I, J properly ends I if it is a final part of I different from I. Notice that the definitions do not specify whether J or I are open intervals. There is moreover an extreme case to be noted. If $I = [s, t]$ and $s < t$ then the one point interval $[s]$ properly begins I, and the one point interval $[t]$ properly ends it.

Now, let x be an object, I an interval and L a parametrized neighbourhoods. Then put

$$\mathbb{I}(x, L) := \{t : \mathsf{loc}'(x)(t) \in L(t)\} .$$

This is the set of time points t such that the location of x is a member of $L(t)$. We say that x is **statically in** L **during** I if $\mathbb{I}(x, L) \cap I = I$. x is **coinitially in** L **during** I if $\mathbb{I}(x, L) \cap I$ properly begins I. x is **cofinally in** L **during** I if $\mathbb{I}(x, L) \cap I$ properly ends I. It follows from the definitions above that the intersections with I must in all cases be intervals. (However, $\mathbb{I}(x, L)$ need not be an interval!) This allows us to define the following modes.

$$\begin{array}{lll} \mathsf{cf}^*(x, L, I) & \text{iff} & \mathsf{pend}'(\mathbb{I}(x, L) \cap I, I) , \\ \mathsf{ci}^*(x, L, I) & \text{iff} & \mathsf{pbeg}'(\mathbb{I}(x, L) \cap I, I) , \\ \mathsf{tr}^*(x, L, I) & \text{iff} & \mathbb{I}(x, L) \cap I \neq I \wedge \mathbb{I}(x, L) \cap I \neq \varnothing \\ & & \quad \wedge \neg \mathsf{cf}^*(x, L, I) \wedge \neg \mathsf{ci}^*(x, L, I) . \end{array}$$

Using the metric, we can also define the approximative mode in the following way:

$$\begin{array}{l} \mathsf{ap}^*(x, L, I) \text{ iff } \lambda s.d(\mathsf{loc}'(x)(s), L(s)) \\ \qquad \text{is monotone decreasing and nonconstant on } I . \end{array}$$

(For the interested reader we just note that the recessive mode mentioned earlier in Footnote 3 has an analogous semantics where 'decreasing' is replaced by 'increasing'.) Here, we put $d(r, L(t)) := inf\{d(r, s) : s \in L(t)\}$. As usual, a function from $I \subseteq \mathbb{R}$ to $\mathbb{R}$ is **monotone decreasing** if for all x, y

from I: if $x \leq y$ then $f(x) \geq f(y)$. Now let us take a locative expression. We shall assume that the interval I is the event time. Moreover, we shall assume that there is a function $\mathsf{time}' : v \to i^\bullet$, which returns for each event its time. (Again, notice that we are assuming events to take place not at any sets of reals, but rather at intervals.) We assume that there is a specific object, called the **mover**, which is an object about which the event predicates that it moves. We will be concerned below in Section 7 with the identification of the mover. We shall assume here that there is a partial function $\mu : v \to e$ that returns for an event the mover. (It will be necessary to lift that function to be of type $v \to e^\bullet$.) Now, with these things defined we can write down the final definitions.

$$\begin{array}{lcl} \mathsf{ci}' & := & \lambda L.\{\mathcal{E} : \mathsf{ci}^*(\mu(\mathcal{E}), L, \mathsf{time}'(\mathcal{E}))\} \\ \mathsf{cf}' & := & \lambda L.\{\mathcal{E} : \mathsf{cf}^*(\mu(\mathcal{E}), L, \mathsf{time}'(\mathcal{E}))\} \\ \mathsf{tr}' & := & \lambda L.\{\mathcal{E} : \mathsf{tr}^*(\mu(\mathcal{E}), L, \mathsf{time}'(\mathcal{E}))\} \\ \mathsf{ap}' & := & \lambda L.\{\mathcal{E} : \mathsf{ap}^*(\mu(\mathcal{E}), L, \mathsf{time}'(\mathcal{E}))\} \end{array}$$

Here, $\mathcal{E}$ is an event variable and L a variable for parametrized neighbourhoods. Notice that we have defined the modes in such a way that they take a parametrized neighbourhood and return a set of events. Technically, we have made the directional PPs into (semantic) adjuncts. There are of course other solutions. So, consider the example (5.1). The expression from under the table is now rendered as follows. The parametrized neighbourhood, L, is in this case the set of all regions which are contained in the region of points under the table at any given moment. The event is the event of the cat emerging, and the mover is the cat. We have coinitial mode, so the proposition the cat is under table is true for some initial segment of the interval, and the proposition some part of the cat is not under the table is true at some point t during event time.

We may define the static mode, st', in the same way as all the directional modes. We have however argued that static locatives are oriented towards the location of the event. Therefore, we shall define the static mode as follows:

$$\mathsf{st}' := \lambda L.\{\mathcal{E} : (\forall t \in \mathsf{time}'(\mathcal{E}))(\mathsf{loc}'(\mathcal{E}) \subseteq L(t))\}$$

This means that st' returns for a parametrized neighbourhood L the set of all events whose location is contained at each time of point t in their lifespan in the neigbourhood $L(t)$.

5.3 Discussion

The definitions set up in the previous parts have to be justified and explained. We shall repeat for convenience our example (5.1).

(5.1) The cat appeared from under the table.

By our definitions, (5.1) is true just in case there was an event $\mathcal{E}$ of emerging in the past such that (a) at some beginning of $\mathcal{E}$, the cat was under the table, (b) the cat was not always under the table during event time. Let us see what is right about this proposal and what possibly needs revision. First, in the literature (for example in the works by Bierwisch, Nam and Fong discussed above) it has not been taken into account that the landmark may be moving in time. (Bierwisch [5] acknowledges that time dependency must be represented, but leaves the matter at that.) Therefore, it is not legitimate to speak of its location simpliciter. Consider by way of example the contrast between (5.8) and (5.9).

(5.8) Während des ganzen Rennens fuhr Häkkinen vor dem Auto von Schumacher.
Throughout the entire race, Häkkinen was driving in front of Schumacher's car.

(5.9) Am Anfang des Rennens fuhr Häkkinen vor das Auto von Schumacher.
At the beginning of the race, Häkkinen was driving to in front of Schumacher's car.

In German, vor (as many other local prepositions) governs the dative if used in static mode, and the accusative if used in cofinal mode. (5.8) is an instance of vor governing the dative, (5.9) an instance of vor governing the accusative. What (5.8) means is that at all time points of the race, the location of Häkkinen (in fact, the position of his car) was in front of the location of Schumacher's car. Hence, the relationship between the cars remains constant throughout the interval. But the location of the cars clearly keeps changing all the time. In (5.9) this is different. Here, the relation of in-front-ness is reached only at the end of the relevant interval. In both examples, the landmark is moving, and so there is no absolute location relative to which in-front-ness holds for Häkkinen's car. Hence, it is clear that we must compute the local relationship at each moment. [37]

[37] There is an interesting connection with cognition. In experiments quoted in [45] it is shown that if one moves the landmark (say, a big box) rather than some small object

What is not so clear, however, is at what intervals which relationship must hold. Our definition distinguishes cofinal and coinitial on the one hand from approximative and transitory. In the cofinal and coinitial cases the intersection $\mathbb{I}(x, L) \cap I$ is required to be an interval, while in the transitory and approximative modes it is not. So the cofinal and coinitial modes act pretty much like phase quantifiers in the sense of Löbner, and so there is no disagreement with the intuitions of Fong. This also explains why adding a cofinal or coinitial locative tends to make an activity or process into a telic event. Approximative and transitory locatives on the other hand require only a process, and they can be added in any number. So it is fine to say

(5.10) The train went from Berlin through Magdeburg and then through Hannover to Bielefeld.

Moreover, in a process of running you can actually pass through a location many times. There is a subtlety involved here which is worthwhile noting. The previous examples concern different locatives which talk about the same object and the same event but different time points or intervals. But you can have two locatives talk about the same stretch of time. For example, if I start my journey to Munich in Potsdam then I also start it near Berlin, So I can start the same journey simultaneously in different regions. (5.11) is therefore acceptable, though (5.12) is preferred.

(5.11) I drove all the way from Potsdam, from near Berlin.
(5.12) I drove all the way from Potsdam, near Berlin.

Creary et al. [12] notice the same effect with respect to static locatives. (5.13) is perfectly acceptable.

(5.13) I was born in Potsdam, near Berlin.

Thus, there seem to be only mild prohibitions against using two locatives to constrain the location of an object in an event even when talking about the same stretch of time.

The notion of path is intimately connected with the parameter set. We have consistently construed parametrized neighbourhoods as functions from the real line to the set of neighbourhoods. Many authors prefer finite linear orders. (See [42] for a case in point.) This allows to abstract away from many

(a ball inside or next to it) people nevertheless perceive the small object as moving (in the opposite direction). Thus, what counts in the perception of movement is also the relationship with the landmark, not necessarily the absolute position.

accidental facts. However, nothing we say here is incompatible with such a view. If one prefers the latter view then definition of the set of parameters must be changed accordingly. [38]

The last problem concerns the question whether it is enough just to require that the cat is not under the table rather than requiring that it must have completely been not under it at the end. This seems to be correct with respect to under, on and at. There is however a delicate complication with in and out of, respectively. The four relations, in, out, not in and not out form a four grade system. Consider the sentences (5.14) – (5.17).

(5.14) Jack went into the house.
(5.15) Jack came to me from inside the house.
(5.16) Jack went out of the house.
(5.17) Jack came to me from outside the house.

It is clearly not the same to say that you are in the house and that you are not outside of the house. You might just be standing in the door. Likewise, to be outside of the house is not the same as to be not inside the house. All four notions involved are clearly different. (5.14) can be true if Jack is standing in the entrance of the house, so initially he is neither in the house nor outside of it. Likewise, if I am standing in the door and Jack is approaching me from inside the house, (5.15) can be true even if Jack never leaves it. Analogous arguments hold for (5.16) and (5.17). Now consider the illative and elative of Hungarian and Finnish. The illative is appropriate for (5.14) and the elative for (5.16), but the situation is not clear with respect to (5.15) and (5.17). However, the way we have set up the semantics, (5.15) would be the canonical situation for the coinitial mode with localiser in. But it is not, as we have noted also with Fong [16]. What this suggests is that we have to take degrees of being in a location as the truth values, and consider continuous functions into that set (it is the interval $[0, 1]$). Technically, this requires us to have a measure μ on the topological space. [39] Given μ and two

[38] The topology is needed to define continuity of movement. The topology on a finite space will be chosen to be the discrete topology. The reason is that any topology over a finite set is isomorphic to a topology of a discrete space. Second, if $\langle X, \mathbb{X}\rangle$ is not discrete there are points x and y which are contained in the same open sets. A function $f : X \to Y$, with Y the point set of a Hausdorff space (eg $\mathbb{R}^3$) can be continuous given this topology only if $f(x) = f(y)$, not a welcome condition.

[39] A **measure** on the space $\langle X, \mathbb{X}\rangle$ is a partial function $\mu : \mathbb{X} \to \mathbb{R}^+$ such that $\mu(\varnothing) = 0$, and $\mu(\bigcup_{i\in I} A_i) = \sum_{i\in I} \mu(A_i)$ for any finite or countable family $(A_i)_{i\in I}$ of pairwise disjoint members of $\mathbb{X}$. A is *measurable* if μ is defined on A. The details are however not needed

measurable regions r and s, where $\mu(r) \neq 0$, the **degree of containment** $\gamma(r, s)$ of r in s is defined by

$$\gamma(r, s) := \mu(r \cap s)/\mu(r)$$

Now let us look at the function $f := \lambda t.\gamma(\mathsf{loc}'(\mu(\mathcal{E}))(t), L)$. Cofinal mode means: f has value 1 at the end of $\mathcal{E}$, but it was < 1 at some point before. Coinitial means: at the end (!) of the interval, the value is 0, but it was > 0 before. I am inclined to say that (5.16) requires Jack to have been in the house at the beginning. Be that so or not, the semantics of coinitial mode seems to need rethinking with respect to these borderline cases.

We remark here that the modes do not require quantification over paths, just over locations at individual time–points. Arguably, there are instances in which one needs to make reference to the path as a whole. In English this is the case with the preposition along. [40]

(5.18) The tourist walked along the river.

To walk along the river means to walk close to wherever the river is, throughout the interval. Moreover, by default one more or less walks in one direction. I have also found a language where this function is expressed by a case. Csúcs [13] reports that Votiac (a Finno–Ugric language; the modern official name is Udmurt) has a case called *transitive*. It expresses that the movement goes through or along an object. The examples he gives are

(5.19) ul'čaj-eti avtobus koškiz.
street-TRANS bus went
The bus went along the road.

(5.20) so uknoj-eti učke val.
the window-TRANS he looked
He looked through the window.

(5.21) sur-eti
river-TRANS
along the river

Similarly with

(5.22a) The train went through the tunnel.

(5.22b) The train went in and out of the tunnel.

---

here.

[40] I owe this point to Regine Eckardt.

(5.22b) allows the train to exit the tunnel at the same side where it entered, while (5.22a) requires the train to pass through the tunnel and exit at the other side. Therefore, [6] speaks of the transitory mode as encoding the path, while the cofinal and the coinitial mode encode only the destination and the origin. But matters are more complex than that. I think that one can hardly say more than that the transitory mode encodes that the object has been in the configuration during some interval properly contained in the event interval. The additional meaning that the transitory mode may carry with it is much harder to pin down (if it exists). For example a police constable in search for a suspect can say

(5.23) I walked through the whole house but I could not find anyone.

Here through means something like: the path more or less covers the whole house, anything that was in the house could have seen from one point of the path. It does not mean: he left the house through a different door than the one through which he entered it.

The present semantics can also deal with the distal/non–distal cases of Tsez. The distality marker says something like 'the location is invisible or far from here'. Since our sources are not explicit on the exact meaning of the distal marker, we shall sketch one plausible analysis to show that the semantics can accommodate such a marker easily. The idea is that a parametrized neighbourhood is distant if any region contained in it has distance greater than ℓ from here at this moment. Let now' denote the present moment, and here' the deictic centre. Then the distality marker -āz denotes dist', which is the following property of parametrized neighbourhoods. [41]

$$\mathsf{dist}' := \{L : \text{ for all } r \in L(\mathsf{now}') : d(r, \mathsf{here}') > \ell\}$$

An example of a locative case not falling into the present schema is the *terminative*. It specifies that the movement went right up to the destination. It is sometimes hard to distinguish it from the allative. We think that the difference is mostly aspectual. Here is an example from Votiac and Hungarian.

[41] Clearly, one would need to accommodate the fact that distality is most likely computed at event time, and with respect to some deictic centre different from the speaker's own. However, to implement this idea too much extra work is needed, but it is probably clear how such an implementation would go if the relevant parameters are present. Similarly if we want to account for the notion of visibility from the deictic centre.

(5.24) arama-oź biźimi Votiac
a liget-ig futottunk Hungarian
meadow-TERM we ran
We ran up to the meadow.

For a discussion of these cases see Kracht [31].

5.4 Adnominal and other Uses of Locatives

So far we have been dealing with adverbial uses of the locatives but there are other types as well. One other type is the adnominal locative, exemplified with (5.25) and (5.26).

(5.25) The man at the metro entrance looks dangerous.
(5.26) The book on the table belongs to John.

Here, the locative is used like a relative clause, in fact it occupies the same place. Notice that with DPs like the one above we cannot use directional locatives, but with event denoting DPs we can.

(5.27) The trip into the Himalayas was dangerous.
(5.28) The escape from the prison went according to plan.
(5.29) The shooting (of the ball) into the net was professional.

With directionals we can actually deal with locatives as if they were used adverbially. If we assume (for simplicity) that the nominals denote sets of events then the semantics of the directional adverbials remains unchanged. The interpretive rule is the rule for adjuncts, the only difference being that the syntactic type of the modifiee is now nominal, not verbal.

What remains then is to treat the adnominal use of static locatives. They modify events and objects alike, but semantically the two are different. While a trip in the Himalayas is some event which takes place in the Himalayas at its own event time, a man at the metro entrance is some object who is at the metro entrance at reference time. Hence, the said location must be inhabited by the entity at different times; for events it is their own time, for objects it is the reference time. This brings us back to the discussion in Section 4 about the difference between objects and events. We have claimed then that events do not have a changing location, unlike objects. This difference shows up here with respect to adnominal locatives. If events were like objects, then (5.30) would be fine as an alternative to (5.31). But it is not.

(5.30) *The Tour de France in Paris is very fast.
(5.31) The Tour de France is very fast in Paris.

The reason is that the event referred to, namely the Tour de France, has a location that is not contained in Paris. But suppose today is the day when the Tour de France is in Paris. Even then it is not appropriate to use (5.30). However, suppose that there are two race cars, of which one happens to be in Paris and one in Rome. Even if these cars change locations all the time, it is perfect to say (5.32) to mean that the car which happens to be now in Paris is fast.

(5.32) The race car in Paris is very fast.

Remains to treat another type of denotation for locatives, namely that of a location proper. [42] Suppose that Felix is a cat. Then (5.33) arguably predicates some property of a location (or, as we say, a parametrized neighbourhood), namely that it is scary for a mouse to be there.

(5.33) Under Felix is a scary place to be for a mouse.

One way of analyzing this is to allow for free standing location phrases (LPs). LPs denote parametrized neighbourhoods and therefore are exactly the kind of objects we need here. Moreover, expressions that are LPs are systematically ambiguous; they might also be seen as static locatives. An alternative proposal is to say that it is not the static locative which is basic but in fact the LP. Hence a static locative actually denotes a parametrized neighbourhood unless it is used adverbially. [43] However, we hold that what we find are nominal adjuncts derived from LPs. Thus we assume that there is an empty operator a-loc′, which turns an LP into a nominal adjuncts, since the semantics of the LP does not match the adjunct rule. This operator turns a

[42] I owe it to one of the referees to have insisted on this issue.

[43] There are some facts that seem to militate against this view. For example, German nach in the meaning *to* can only combine with truly location denoting phrases (place names, dort (*there*), Haus (*home*)). If auf dem Tisch denotes a parametrized neighbourhood there is no reason why it should not combine with nach. If we assume, however, that auf dem Tisch if denoting a parametrized neighbourhood is a static marked DP, then this can successfully be explained: we simply assume that cities and the other exceptional words are syntactically dative marked (only the fact that we say nach Hause shows that the case involved here is the dative and not any other). However, this argument needs to be carefully worked out.

parametrized neighbourhood into a parametrized property of individuals. [44]

$$\mathsf{a\text{-}loc}' := \lambda L.\lambda t.\{x : \mathsf{loc}'(x)(t) \in L(t)\}$$

It may be thought that however useful it is to distinguish between an adverbial use of a locative and an adnominal use, in practice this distinction does not matter. This is not so. In Finnish and Hungarian, a locative expression cannot be used adnominally. (5.34) and permutational variants thereof are ungrammatical. (5.35) is ungrammatical if taken to mean (5.36), instead it means something like *the book is good to read on the table*. Correct translations of (5.36) into Finnish and Hungarian are (5.37) and (5.38).

(5.34) *Kirja pöydällä on hyvä.
book table-ADE is good.

(5.35) *A könyv az asztalon jo.
DET book DET table-SUPER good.

(5.36) The book on the table is good.

(5.37) Pöydällä oleva kirja on hyvä.
table-ADE be-PART book is good.

(5.38) Az asztalon levő könyv jo.
DET table be-PART book good.

Neither Hungarian nor Finnish allow a locative to be used adnominally, as this data exemplifies. Instead, a different construction must be used such as a combination with a participle of 'to be'.

We finally end up with three possible denotations for a static locative.

1. It can denote a set of events.
2. It can denote a parametrized set of objects.
3. It can denote a parametrized neighbourhood.

The first two can be derived from the third by either applying a mode or by applying the operator $\mathsf{a\text{-}loc}'$ (which can be thought of the adnominal equivalent of the operator st'). Therefore, we are inclined to assume the following analysis. Syntactically, we take the first two as proper mode phrases, having

[44] Actually, we assume that all predication is parametrized, to account for the time dependence ot predication. Hence, an expression like car denotes a function from time points to sets of objects.

the structure $[M\ [L\ DP]]$, with M either forming an adverbial or an adnominal locative, while the third kind of locative is an LP, thus having the form $[L\ DP]$. LPs seem to occur in rather restricted environments. [45]

1. LPs can be complements of a modaliser.
2. LPs can occur in a copular construction.
3. LPs can occur sentence initially.

We have seen examples of the first two kinds. Creary et al. [12] discuss the sentence initial use of locatives.

(5.39) In this restaurant, nobody is allowed to smoke.
(5.40) In Berlin, Claver was running faster than ever.

In these sentences, the initial location phrase seems to set the locational parameter to which some of the elements may implicitly or explicitly refer. In the first example, the quantifier 'nobody' effectively ranges over all pairs of people x and time points t, such that x is in the restaurant at t. In the second example, the location phrase identifies the location of the event of Claver's running. To account for such uses, we need to incorporate a theory of context variables. This is clearly beyond the scope of this paper. Nevertheless, it seems clear that the sentence initial locative expression is syntactically a location phrase.

6 Selection

In this section we shall discuss questions of selection of mode and configuration. The reader is made aware of the fact that we do not consider the morphological distinction (affix/clitic/adposition) as relevant for the mechanics of selection and of semantical composition. That is to say, whether an NP

[45] A reviewer has suggested the following counterexamples.

(i) [Restaurant patron to maître d'hôtel]: I prefer in the corner to out in front.
(ii) I consider behind the furnace to be the scariest place in the house.

I am not sure that this evidence is not compelling. For example, contrast (i) with (iii) and (ii) with (iv).

(iii) I prefer Berlin/*in Berlin to Hamburg/*in Hamburg.
(iv) I consider Berlin/*in Berlin to be the scariest place on the world.

Here the preference for a proper NP complement over an LP is clear.

is marked for a case feature in syntax cannot be predicted from the morphological realization of that feature. [46] We have argued earlier that local cases consist of two layers, whence the complex of verb and local PP is structured as follows:

$$[V\ [M\ [L\ DP]]]\ .$$

Moreover, from a semantical point of view, *DP* denotes an object, [*L DP*] a parametrized neighbourhood, and [*M* [*L DP*]] a set of events. In case of syntactic selection, this complete match disappears. This has rather interesting consequences for syntactic theory.

We shall argue that the verb has three possibilities of entering a relationship with a locative. It can enter (a) a relationship with the entire complex [*M* [*L DP*]], or (b) with only [*L DP*] or, finally, (c) it can enter a relationship only with *DP*. This means syntactically that it either takes a locative adverbial as an adjunct (Case (a)), or it selects an LP (Case (b)) or it selects a DP as its complement (Case (c)). We give examples. Take the verb walk. As the examples below show, we can modify the sentence John is walking by numerous locative PPs, be they static or directional. These facts can be reproduced in any language we know of.

(6.1) John is walking on the roof.
(6.2) John is walking to the shop.

In this case, the locative is an adverbial, and typically an adjunct because it enters with its full meaning. Now we look at the other extreme, Case (c):

(6.3)	Andrew	thinks	about	Mary.
(6.4)	Andreas	denk-t	an	Maria.
	Andreas	think-PRES-3SG	on	Maria-ACC
(6.5)	András	gondolkod-ik	Máriá-ra.	
	András	think-PRES-3SG	Mária-ALL	

In all these cases, the verb selects a particular locative. In (6.4), the verb denken selects an with accusative, which is a DP in allative case (see previous footnote). However, neither Andreas nor Maria can be said to be moving. Of course, we can make up explanations as to why we find the allative (see Talmy [49]). For example, we may think that the thoughts of Andreas are moving to Maria. But if we look at the English equivalent we find a totally different local expression. This suggests that the explanation can only be

[46] This may need extensive argumentation. However, all we really need at this point is the possibility to treat all of the different manifestations terminologically alike.

found in retrospect, once we know which locative to expect. The Hungarian example (6.5) differs from the German not in choice of case but in its morphological realization. Let's take a different example.

(6.6)	Peter	is	afraid	of	mice.
(6.7)	Peter	hat	Angst	vor	Mäusen.
	Peter	has	fear-ACC	in front of	mouse-PL-DAT
(6.8)	Péter	fél		az	egerek-től.
	Peter	afraid-PRES-3SG		DET	mouse-PL-ABL

The verb to be afraid takes genitive in English. In German we find the expression vor (*in front of*, in static mode) and in Hungarian the ablative. Whatever explanation can be given for the choice of local expressions, we shall advance here the thesis that if an element is fixed regardless of the meaning of the entire sentence, then it has no interpretive impact. Since this a very important and general observation, we shall work out the details of this principle, which we call the *Emptiness Principle*. [47]

> Emptiness Principle. Suppose that X is a syntactic marker in the constituent C. Suppose further that the presence and form of X in C is determined purely by nonsemantic rules (for example

[47]It has been suggested by one referee that this is not a principle of grammar but rather a way to figure out when a use of a preposition is semantically vacuous. Another reviewer has problems with its adequacy: on the surface it looks as if agreement features do have a meaning. We shall adress the second problem first. In [29] we argue at length that the idea that for example plural agreement on the verb means that the subject is plural is simply false. I give just one example. The word trousers is syntactically plural but semantically ambiguous between individual and plurality. Nevertheless, it triggers plural agreement on the verb regardless of its meaning. Moreover, when we refer back to the entity, plural must still be used no matter whether the object is an individual.

(6.i) My trousers are too small. I must have washed them too hot.

If we used this pair of trousers or this piece of clothing instead of trousers, singular would have to be used throughout in case (6.i) talks about a single pair of trousers. The problem is resolved only if we assume that the head noun alone (trousers) specifies whether we have an individual object or a plurality, and that all agreement features are semantically vacuous.

This helps also to understand the role of the Emptiness Principle. We have stated it in such a way that it is most general and neutral with respect to the theory we choose. We could say, for example, that simply any feature for which a head subcategorizes is semantically vacuous on the corresponding argument. This is what we shall propose further below. However, this way of saying it it will loose some of its generality. For example, the semantics of the anaphor in (6.i) will not be accounted for.

selection, agreement, Sandhi). Then the meaning of X is empty, namely the identity function.

The mechanism by which we can implement this pinciple is given in [30]. We shall explain the basics of it. Language is considered an algebra of signs, where a sign is a triple $\sigma = \langle E, T, M\rangle$. Here, E is the **exponent** of σ (for our purposes a string), T the **syntactic type** and M the **meaning** of σ (for our purposes a closed λ–term). There are in addition various functions of varying arity, which map tuples of signs to signs. Montague grammar has basically two functions, right and left application:

$$\begin{array}{lcl}\langle E_1, \alpha/\beta, M_1\rangle \bullet_r \langle E_2, \beta, M_2\rangle & := & \langle E_1^\frown E_2, \alpha, M_1(M_2)\rangle \\ \langle E_1, \beta, M_1\rangle \bullet_l \langle E_2, \beta\backslash\alpha, M_2\rangle & := & \langle E_1^\frown E_2, \alpha, M_2(M_1)\rangle\end{array}$$

To give one more example, Combinatory Categorial Grammar has infinitely many operations (of forward and backward function composition). We shall assume here that in addition to the left and right application there are a few more functions. The first is a function that adds a case feature. We assume here that the basic types consist of feature structures (in GPSG–style, say). In particular, they may contain pairs $[\textsc{case} : \gamma]$, where γ is some case. We assume here that cases are in fact sequences of exponents of basic signs. Since the latter are strings, we assume that cases are sequences of strings to keep matters simple. (Concatenation is denoted by $\cdot$, which is slightly distinct from $^\frown$.) The following functions are defined on feature structures. If α is a category, then $[\textsc{case} : \bullet\cdot\sigma]\alpha$ is defined as follows. If α is a basic category and contains the feature $[\textsc{case} : \rho]$, then $[\textsc{case} : \bullet\cdot\sigma]\alpha$ is the results of replacing that feature by $[\textsc{case} : \rho\cdot\sigma]$. For composite categories we define:

$$\begin{array}{lcl}[\textsc{case} : \bullet\cdot\sigma](\alpha/\beta) & := & ([\textsc{case} : \bullet\cdot\sigma]\alpha)/([\textsc{case} : \bullet\cdot\sigma]\beta) \\ [\textsc{case} : \bullet\cdot\sigma](\alpha\backslash\beta) & := & ([\textsc{case} : \bullet\cdot\sigma]\alpha)\backslash([\textsc{case} : \bullet\cdot\sigma]\beta)\end{array}$$

Then here is the definition of the operations that add a case feature.

$$\begin{array}{lcl}\langle E_1, \alpha/\beta, M_1\rangle \,Ⓢ_r\, \langle E_2, \gamma, M_2\rangle & := & \langle E_1^\frown E_2, [\textsc{case} : \bullet\cdot E_1]\gamma, M_2\rangle \\ \langle E_1, \gamma, M_1\rangle \,Ⓢ_l\, \langle E_2, \beta\backslash\alpha, M_2\rangle & := & \langle E_1^\frown E_2, [\textsc{case} : \bullet\cdot E_2]\gamma, M_1\rangle\end{array}$$

Finally, we shall assume as usual that heads select arguments with a particular case feature. Since there is no other way to add the case feature but by

using the functions Ⓢ$_l$ and Ⓢ$_r$, the Emptiness Principle now follows. [48] It might be thought that this system overgenerates massively, because it allows any element E to become a case marker. However, unless there is a head selecting an argument with case E, there is no way to get rid of it.

This setup has various advantages worth mentioning. First of all, there is no need to posit for each individual element two distinct signs, one which functions as a case marker but is void of meaning and the other functioning as a full element with its meaning. There is always only one sign which can be composed in different ways. This eliminates the need for positing two kinds of prepositions, as is done for example in HPSG. Moreover, it allows for any preposition to become a case marker as soon as there is a head selecting it. There is no need to additionally make it semantically ambiguous. Second, elements can be added in the form of case markers more freely than if they are composed using left or right application. The idea is that many restrictions are restrictions concerning the mapping between semantics and syntax/morphology. They tell us how a particular idea can be expressed. For example, further down we shall discuss the choice of localisers determined by the landmark DP and the relationship expressed. These restrictions simply do not apply if an element adds itself as a case marker. To give an example, the DP die Konferenz (*the conference*) can (more or less) only be used with the localiser auf, likewise with die Hochzeit (*the wedding*), at least if the idea of personal presence is to be expressed. This is a property of the head noun, to which we will turn below. However, when a verb selects a particular combination of modaliser and localiser, then this restriction no longer applies. This is so — we claim — since the verb syntactically selects a DP whose case is a particular sequence $L \cdot M$.

(6.9) Ich ging im September auf/*in/*an/*vor die Konferenz.
*I went in September to/*into/*above/*in front of the conference.*

(6.10) Ich denke oft an/*in/*vor/*auf die Konferenz.
*I am often thinking about/*in/*in front of/ *to the conference.*

So, not only does the verb denken require another localiser, the use of that locally is actually fully permitted. Likewise, with the verb sich fürchten (*to*

[48] It should be said in all fairness to the reader that the exact details of this setup can become quite gruesome if we want to deal with agreement and word marking. Some of it is discussed in [30]. On the other hand, we have seen so far no consistent account of case marking that can handle this variety of facts in such a way that the syntax, the morphology and the semantics come out right.

fear) only vor is appropriate, with verliebt sein (*to be in love*) only in.

In our present context suppose that we have a string of the form V M L D, where V is a verb, M a modaliser, L a localiser and D a DP. In Montague Grammar, the meaning of this string is as follows:

$$\mathsf{V}'(\mathsf{M}'(\mathsf{L}'(\mathsf{D}'))) \ .$$

However, in our approach the matter is different. Suppose that the verb V selects both M and L. Then the meaning of these elements is empty, and we have instead

$$\mathsf{V}'(\mathsf{D}') \ .$$

Notice that this is also reflected in the type. If L' is the identity function, the semantic type of L D is that of D, and not that of a parametrized location. Similarly with M'. Syntactically, however, we are dealing with a DP that is case marked with the sequence $L \cdot M$. Now take a look at the examples above. The allative in (6.4), the ablative in (6.5), and the cases of (6.6) – (6.8) are purely syntactically determined. By the Emptiness Principle, they carry no meaning. Hence, the semantic type of the verb is that of an ordinary transitive verb. This is what we meant by saying that the verb enters a relationship with the *DP*, and not with the locative.

Now, the interesting fact in connection with locatives is Case (b): the verb enters a relationship with the complex [*L DP*]. This means, in our proposal the following. Syntactically, the verb selects an LP in a particular mode; semantically, it takes a (parametrized) neighbourhood as its argument. In this situation the localiser enters with its normal meaning, but the mode does not. The mode is syntactically fixed; it appears as a case marker. We have already met examples of such verbs. In Section 2.5 we have discussed the Finnish verbs unohtaa (*to forget*) and löytää (*to find*). For convenience, we repeat the examples (2.34) and (2.35).

(6.11) Tuovi unoht-i kirja-n auto-on/*auto-ssa/*auto-sta.
Tuovi forget-PAST-3SG book-ACC car-ILL/car-INESS/car-ELA
Tuovi left the book in the car

(6.12) Tuovi löys-i kirja-n auto-sta/*auto-on/*auto-ssa.
Tuovi find-PAST-3SG book-ACC car-ELA/*car-ILL/*car-INESS
Tuovi found the book in the car

What remains to be seen is that these verbs do not select particular cases in Finnish, but rather only the mode. If this so, we expect that the verb

unohtaa is selects a complement in cofinal mode, while static and coinitial mode are impossible; löytää on the other hand is expected to select coinitial mode and to reject both static and cofinal mode. In English static mode is mandatory in all cases. (6.13) and (6.14) show that this is borne out.

(6.13) Tuovi left the book $\left\{ \begin{array}{ll} \text{on} & /^{*}\text{onto} \\ \text{under} & /^{*}\text{to under} \\ \text{at} & /^{*}\text{to} \end{array} \right\}$ the car.

(6.14) Tuovi unohti kirjan $\left\{ \begin{array}{ll} \text{autolle} & /^{*}\text{autolla} \\ \text{auton alle} & /^{*}\text{auton alla} \\ \text{auton luokse} & /^{*}\text{auton luona} \end{array} \right\}$

Thus, these verbs select semantically speaking a parametrized neighbourhood, and therefore syntactically select only the mode. The examples also show that the issue whether or not the mode and localiser are expressed morphologically as an affix or as adposition is simply irrelevant (see also [30] on this issue). If the mode is semantically vacuous and therefore syntactically freely assignable, we expect to find variation across languages. The Finnish example above is just one of many (see [16] for many more). Uralic languages in general have a tendency to favour directional cases with many verbs that in Indo–European languages select static mode. [49]

A similar case is provided by the verbs meaning 'arrive'. English to arrive and German ankommen select static mode.

(6.15a) Wir kamen in London an.
(6.15b) *We arrived into London.
(6.16a) We arrived in London.
(6.16b) *Wir kamen nach London an.

The same holds for Hungarian. In Finnish cofinal mode is mandatory.

(6.17a) *Saavuimme Lontoossa.
arrive-PAST-1.PL London-INESS
(6.17b) Saavuimme Lontooseen.
arrive-PAST-1.PL London-ILL

It is not unplausible that some semantic explanation can be found. We may say, for example, that to arrive is an achievement. Its event time is punctual,

[49] See [19]. The Uralic languages differ in the degree to which they prefer directionals over static locatives. In Hungarian it is less strong than in Finnish and in Saami (see [46] for examples in Saami).

and so it does not tolerate any nonstatic mode. The Finnish counterpart would then be analyzed as non–punctual, that is, an accomplishment verb.

Fong [16] explains the difference between Finnish and English in the following way. A Finnish directional locative (DL) requires the event structure to be diphasic, that is to say, to consist of two consecutive phases. (These phases roughly correspond to the situation at the beginning of event time and the one at the end. Static verbs are monophasal; there is only one phase, corresponding to the situation throughout the whole event time (which does not change).) In a diphasic structure, the two phases need actually not be distinct according to Fong, so no actual movement is necessary. In English, however, there is an element that needs to be moved in space. While this theory predicts that English DLs cannot occur when there is no movement, it does not predict that they must occur in Finnish with a verb denoting a diphasic event. Why do we have to use the cofinal mode with unohtaa? The fact is, namely, that motion verbs, for example run, do tolerate nondirectional locatives, since it is compatible with there being a movement that this movement is static with respect to some location, for example to run on the road. Further, it is not explained by Fong's theory that a Finnish DL invariably expresses the fact that movement occurred if its mode is not selected. Namely, if it is only required that the verb is diphasic but not that the phases are distinct, (6.19) will also be felicitous if Tuovi has been walking in the room all the time.

(6.18) Tuovi meni huoneeseen.
*Tuovi walked into/*in the room.*

However, this is contrary to fact. (6.18) implies that Tuovi has not been in the room before the event. [50]

Hence, Fong's theory must be rejected at this point. Rather, Finnish DLs denote what English DLs denote, and in the same way. However, Finnish verbs much more frequently occur with directional mode when there is no movement (or no obligatory movement) involved. In our view, this is simply a case of mode selection. Notice that Fong's theory has another drawback. If

[50] Paul Kiparski (p.c.) is nevertheless convinced that the theory of Fong is basically correct in that the concepts expressed by the verbs allow us to predict the mode of an argument in question and that the semantics falls out correctly. I fail to see how this is possible. One thing however does seem quite plausible. Only the choice between static and directional seems arbitrary in Finnish. The choice between cofinal and coinitial has some rationale behind it. However, this still needs thorough investigation.

the contrast between Finnish and English lies in the meaning of the locatives in the way explained, we would not expect a lot of variation within and across languages with respect to selection of DLs. But there is. Hungarian is much closer to English than to Finnish, in that the directionals occur less frequently. However, there are also some differences.

(6.19) Hova/*hol bújsz, ha jön a farkas?
whereto/*where do you hide, when the wolf comes?
Where will you hide when the wolf comes?

The verb bújni (*to hide*) needs cofinal mode, be there a movement or not. In English and German, the static mode is used, although I find cofinal mode in German stylistically marked but not ungrammatical. [51]

The reader may be puzzled about the fact that we assume that cases can be stacked. However, there are languages in this world where this phenomenon is attested beyond doubt (see Melcuk [39]). Nevertheless, it is not clear that we need to assume such an analysis in the languages under investigation here. The Section 3 has offered morphological evidence for this. For the skeptical reader we offer a last piece of evidence. There are words in the languages analyzed in this paper that denote parametrized neighbourhoods; hence they are unquivocally syntactic LPs. These words are the equivalents of English here/there and the question word where. They can only be selected by a verb denoting a function over parametrized neighbourhoods, so that we expect that these words do not inflect for the localizing dimension. Indeed, the paradigms of these words are defective in Finnish and Hungarian: they only inflect for mode. This is the clearest in Hungarian. You have hol 'where', hova 'whereto' and honnan 'wherefrom'. Likewise in English, you cannot say whereat, whereunder and so on. [52] If we do not assume a layering of the cases themselves into a localiser and a modaliser, there would be no way to relate the paradigms of these words to the paradigms of the nominal elements, to which they are — however — clearly related. [53]

[51] A census at our coffee table established a clear vote for the static mode and against the directional mode.

[52] Finnish is a delicate case, since the question word for asking for locations is formed from the question word for objects (mi) by using the inner locative cases. So we find missä 'where', mistä 'wherefrom' and mihin 'whereto'. But millä unequivocally means 'at which object', not 'where'. See [31] for more facts.

[53] The facts are however still more complex than this. German seems to have a full set of question words based on wo 'where', such as wovor, worüber, woran and so on. At closer look we see that we have a stuation almost as in Finnish. German wo is ambiguous

If a verb selects only the mode, the location is defined only by means of the localiser and the DP. There is, perhaps surprisingly, a subtle interaction between the DP and the localisers. Inside the constituent [*L DP*], the DP serves as a landmark by which the localiser defines the location. The same location can be expressed by means of different localisers, given different landmarks (you can be at the same time *in the house*, *outside of the cupboard*, *on the chair*, *under the lampshade* and so on). Now suppose we are given a region and some object, which is the correct localiser? Questions like this are addressed in Herskovits [20]. We shall be content with noting a few problem areas here. For example, when do we say that we are *near* a house, and when are we *at* the house? These are questions of delimition of closeness and of distance in general. Many other localisers depend on the shape of objects, for example in. The question is how much curvature the object needs to have to allow for something to be *in* it rather than just *on* it. The salad can be *in* a bowl but not *in* the plate! (Moreover, as Anatoli Strigin has pointed out, you say in Russian that *the soup* is *in* the plate (sup v tarelke), but that *the potatoes* are *on* the plate (kartoschka na tarelke). Hence, the choice of localiser also depends on the type of the located object in addition to that of the landmark.) With other physical objects the intuition become somewhat more stretched. Why are we *in the garden* and not *on the garden*, but we can be *on the ship* while not *in the ship*? The answer is not easy. Notice that it is not really a mistake to say that you are *in the ship*, only the question is what that exactly means. At least in German this does not sound deviant but it focusses rather on the physical side of being in it (for example as a blind passenger, locked up together with the bananas). The unmarked localiser to describe being on or in a ship is *on*. I find the case of a garden harder, even though it ought to be easy to say what it would mean that I am *on* the garden. You simply cannot say it like that.

So, we have cases where a noun determines the localiser more or less

between a pro–DP and a pro–LP. The two are morphologically and syntactically different. As a pro–DP wo is interchangeable with was, however not as a pro–LP. For example, instead of asking Woran denkst Du? 'What are you thinking about?' we can ask An was denkst Du?. However, there is no *her was in place of woher. German actually has no independent set of modalisers. Prepositions invariably signal both mode and localiser, using the dative/accusative contrast to distinguish static from cofinal. In the case of question words, it uses a distinct set of markers, namely her and hin, which originally signal whether the direction of movement is towards or away from the speaker (or deictic centre).

strongly, depending on factors other than shape. The intuitions are more or less uniform across the languages that I have been able to test (German, English, Hungarian and Finnish). It seems therefore that they are rather cognitively determined. However, there are also instances where the determination is arbitrarily fixed in the language, without a clear morphological or syntactical explanation. In these cases the selection of localiser is in the lexicon. One case are the names of cities in Hungarian. That one is in a city can be expressed either by the superessive or the inessive. The inessive is the default. There are however a lot of (notably Hungarian) places that require the superessive.

(6.20) Superessive: Budapest-en, Szeged-en, ...
Inessive: Párizs-ban, Berlin-ben, ...

We emphasize that it is only the localiser that is fixed. If you say that you are going to Budapest you use the sublative, but the illative for Paris. The same holds for Finnish. Some cities require adessive/allative/ablative (eg Tampere) while for the most part they require inessive/illative/elative (eg Helsinki). In English, German and Latin, to be in a city is construed with (the language equivalent of) in, in French with à, whose meaning is rather abstract. [54] In Hungarian, the place names ending in -falu and -falva (both mean 'village') differ in whether they take the inessive (-falu) or the superessive (-falva). Finally, Hungarian has two words for wedding, one to be construed with the inessive (lakodalom) and the other with the superessive (esküvő).

7 Orientation

In this section we will be concerned with the orientation of locatives, in particular with the specification of the mover in an event. Before we do so, we shall spend a few thoughts on the distinction between argument and adjunct status of a locative. Nam, in agreement with Keenan and Faltz, assumes that locatives are intersective modifiers. [55] This means that the

[54] Notice that the default is 'in' in *all* of the languages mentioned here.

[55] It would take too much to explain the technical details of boolean semantics. Suffice it to say that the meanings of syntactic constituents form boolean algebras. A *modifier* for a boolean algebra $\mathfrak{B} = \langle B, 1, 0, -, \wedge, \vee \rangle$ is a function $f : B \to B$. It is *restrictive* if $f(x) \leq x$ for all $x \in B$, and *intersective* if $f(x) = x \wedge f(1)$ for all $x \in B$. Intersective modifiers are restrictive.

following inferences are valid for a subject oriented PP. (See also Creary et al. [11].)

$$\frac{\text{X Vs in L.}}{\therefore\ \text{X is in L.}} \qquad \frac{\text{X Vs in L.}}{\therefore\ \text{X Vs.}} \qquad \frac{\text{X Vs.} \quad \text{X is in L.}}{\therefore\ \text{X Vs in L.}}$$

We notice that although this applies only to static locatives, analogous inferences for directional locatives can be given as well:

$$\frac{\text{X Vs to L.}}{\therefore\ \text{X moves towards L.}} \qquad \frac{\text{X Vs to L.}}{\therefore\ \text{X Vs.}} \qquad \frac{\text{X Vs.} \quad \text{X moves to L.}}{\therefore\ \text{X Vs to L.}}$$

This theory is correct in many cases, but highly problematic. First of all, notice that Nam omits the time parameter. This makes the intuitions fuzzy, for as we shall show, the purported inferences are highly time dependent. Second, it is not true that locatives are always adjuncts. In case they are not, these inferences may be blocked completely.

For example, the following problem was noted by Bierwisch ([4]):

(7.1) Ich arbeite in Dresden, aber ich wohne in Berlin.
I work in Dresden, but I live in Berlin.

This would be downright contradictory if from the first sentence we are entitled to conclude that I am in Dresden, and from the second that I am in Berlin. However, the two verbs differ with respect to the entailments. If I work in Dresden then I really must be there; therefore, the following is contradictory:

(7.2) *Heute habe ich in Dresden gearbeitet, aber ich war den ganzen Tag in Berlin.
Today, I worked in Dresden, but I was in Berlin the whole day.

On the other hand, (7.3) is fine:

(7.3) Gestern habe ich in Dresden gearbeitet, aber ich wohne schon seit einer Woche in Berlin.
Yesterday I was the whole day in Dresden, but for one week already I live in Berlin.

We conclude that the inference from working somewhere to being there is valid, but the inference from living somewhere to being there is not.

In order to discuss the problem, we shall first note that there are verbs which take a location as an argument — at least semantically speaking. If

so, none of the inferences needs to be valid. Particularly striking cases are the German verbs wähnen and wünschen: [56]

(7.4) Peter wähnte Maria in Paris.
Peter believed Mary to be in Paris.

(7.5) Peter wünscht sich die Maria an seine Seite.
Peter wants Mary by his side.

In (7.4), Peter merely believes that Mary is in Paris, she need not at all be there. In (7.5), Peter wishes Mary to come to his side, but she need not go there. In both cases, there is no valid inference concerning the location or change of location of Mary. However, both sentences do talk about the location of Mary, be it only inside some intensional operator. Hence, we conclude that the location of Mary is — semantically speaking — an argument, and not an adjunct. We conclude that therefore it is a syntactic argument as well. [57] There is also another argument against the thesis that locative

[56]Especially these verbs invite a small clause analysis, in which the locative expression forms a small clause with the object and so is no longer part of the main clause. A small clause analysis successfully explains why the locative is object oriented. Inference patterns are dependent on the main verb. For example, the inference from (7.i) to (7.ii) is valid, unlike (7.4) and (7.5).

(7.i) Peter wußte Maria in Sicherheit.
Peter knew Mary in safety.
Peter knew Mary was safe.

(7.ii) Maria war in Sicherheit.
Mary was safe.

The difference between a small clause analysis and locatives as arguments can be made semantically manifest. For example, if we take the small clause analysis, then the locatives are inside the scope of the main verb and therefore subject to perspectival shift. For example, (7.4) might be true if Mary is in Marseille, but Peter erroneously thinks that Marseille is called Paris. This might be an argument for preferring the small clause analysis in intensional contexts. We have not looked at the matter deeply enough, though, to make any prediction which of the two analyses is preferrable. A very interesting example of a construction where we do not have a small clause, but nevertheless the locative is not an intersective modifier is given in [11]:

(7.iii) George IV ruled in England.

(7.iv) George IV ruled in Europe.

Evidently, (7.iii) does not imply (7.iv), from which one concludes that the locative is not intersective.

[57]This is corroborated by the fact that the mode is selected by these verbs. For example, the verb wähnen selects static mode, wünschen selects cofinal mode. That it appears to have cofinal meaning is a mere accident. Its meaning is roughly that Peter wants Mary to

PPs are simply intersective modifiers. Consider the following example.

(7.6) *William observed Mary into the house.

Suppose, directional locatives show object orientation with respect to transitive verbs (indeed, most of them do). It is logically compatible that William observes Mary while she is going into her house. Nevertheless, the sentence is ill–formed. This shows that we need some theory of admissibility of PPs. One explanation is to assume that the PP is an argument, as do Creary et al. In this case, we have to explain the consistent behaviour with respect to their free omission. Another explanation, which we favour, is to say that with the exceptions noted above, locative PPs are syntactical adjuncts. However, an adjunct is not always admissible. In fact, directional PPs are admissible only if the event denoted by the modified verb has a mover. If it does not, the PP cannot be added. On the other hand, while directional PPs are quite selective, static PPs are more liberal. We shall discuss this below.

We have discussed in the previous section that verbs which semantically select a localiser, syntactically select a specific mode. The interpretation of the mode is therefore nullified. It follows that the inferences regarding the mode are nullified as well. Take the Finnish verb jäädä (*to remain*).

(7.7) Tuovi jäi huoneeseen.
Tuovi stay-PAST-3SG room-SG-ILL
Tuovi stayed in the room.

If the directional locative were truly a cofinal locative, it would be correct to infer from (7.6) that Tuovi moved into the room.

Tuovi jäi huoneeseen.
∴ Tuovi meni huoneeseen.

But this is contrary to fact. On the other hand, it *is* correct to conclude from (7.6) that Tuovi was in the room.

Tuovi jäi huoneeseen.
∴ Tuovi oli huonessa.

If we apply the Emptiness Principle, this falls out immediately, since the DL is semantically like huonessa in this sentence. Hence, whatever is subject

be at his side, although she is not and knows that she is not. That she has to move to get there is an inference from these facts.

to syntactic selection must be left out of consideration. The inference is therefore valid with respect to static mode. Hence it compares with the English inference:

Tuovi stayed in the room.
$\therefore$ Tuovi was in the room.

That this inference is correct is a consequence of the meaning of stay. The locative PP is an argument, not an adjunct, since it is syntactically selected.

Now, if a locative PP is an argument and the verb is extensional, we find that the locative PP behaves just like an intersective modifier. Examples are verbs of movement. In other cases, there is a delicate interaction between the verb meaning and the PP in question. Let us return to the question of the inferences for adjuncts. The verb to play takes a locative adjunct. Nam's thesis is that the locative behaves like an intersective modifier, licensing the inferences above. Now here is an example. Suppose we are playing bridge at the table. My partner wins the bid, I am dummy and go into the kitchen to get some food for us. Someone seeing an empty chair wants to take it away. My partner says:

(7.8) You can't take that chair away, Marcus is playing cards on it.

This is a sensible remark to make, even though I am plainly not sitting on that chair. It seems that in order for me to play cards somewhere, I need not be there all the time, even though not being there at all would not count as playing. Nor would it be correct to say that while I am in the kitchen, I am playing in the kitchen. So, my relationship with the event of playing is rather involved. My presence is not needed all the time for it to exist. However, it is clear that the game has a location that I cannot change by moving around. Nevertheless, if I was never at the table during the game it is hard to imagine that I have been playing at all.

We shall solve the paradox by assuming that although I am participating in the event of playing qua event of playing, I may not be really participating in it all the time. So, we may say that at certain times I am **active** in the event, while at others I am not. I am an acting participant only at those time points at which I am active, and the location of the event will only be taken to include my location at these time points. We may also assume that the event is further structured into subevents (like the event of playing bridge is naturally structured). It is part of the meaning of the verb or type of event what it means to be active in it. The same observations can be made for directional locatives. If I am driving from Berlin to Hamburg, I may make

several stops on the way. During these stops I am not moving, I am at rest. So, whether or not I am moving, depends on the time point. But considering the event of my trip to Hamburg, I am the agent throughout the entire event. These distinctions complicate the inferences for verbs taking a locative argument but which are extensional with respect to the location. There is in fact little of concrete value that can be inferred from a locative adjunct for a given moment of time unless the verb meaning and world knowledge are taken fully into account. Verbs vary greatly with respect to the requirement they impose on the participants with respect to their location. In order for me to live in Berlin I rarely need to be there. So, if I am telling you that I am living in Berlin, you cannot infer at all where I am right now. However, if I am telling you that I am playing cards in Berlin right now, to conclude that I am in Berlin is reasonably safe. Many factors come into play here: how long is the duration of such an event typically? How fast does the object move in general? Is the object required to be located at the event during event time? It is only the last question that is genuinely linguistic, so we shall not bother with the first two.

With this being said, we now turn to the question of argument orientation. Recall from Section 2.4 the data on orientation. We reproduce the table in Table 8. Notice that this table makes use of grammatical functions, namely subject and object. However, it can be demonstrated that orientation is not a matter of the grammatical function but of something deeper. As a proof we shall show that it does not change under operations changing the grammatical function.

The verbs to bring and to fly show object orientation with respect to directional locatives. We expect therefore that when they are passivized, they show subject orientation. This is borne out.

(7.9) Fred brought the bottles from the cellar to the holiday home.
(7.10) The bottles were brought from the cellar to the holiday home.
(7.11) Fred flew the airplane from Berlin over the Alps to Rome.
(7.12) The airplane was flown from Berlin over the Alps to Rome.

Similarly, standard passive as well as the kriegen–passive of German do not alter the linking of directional locatives. This shows that grammatical functions do not alone determine the orientation. Furthermore, impersonal passives allow for locative PPs. Since the PPs must be construed with an object, and there is no argument present, we conclude that grammatical functions cannot be uniquely responsible for orientation.

Table 8: Orientation of Locatives

Stative	Directional	Symmetric	Source
Motion-Causative Verbs, Verbs of 'Sending/Carrying'			
drag, push, run; send, take			
O	O	O	O
Verbs of Placement, Verbs of 'Hunting'			
place, set, put; watch, hunt			
O	O	O	$\star$
Verbs of 'Combining/Attaching', Verbs of 'Housing'			
mix, tape (music); contain, store, serve			
O	O	$\star$	$\star$
Verbs of 'Perception', Verbs of 'Communication', Verbs of 'Contact'			
find, see; call, cable; touch			
O	$\star$	$S \times O$	$S + O$
Verbs of 'Co-movement'			
escort, accompany, chase, drive, follow			
$S + O$	$S + O$	$S + O$	$S + O$
Verbs of 'Social Interaction'			
meet, embrace, marry, fight, visit			
$S + O$	$\star$	$\star$	$\star$
Verbs of 'Judgement', Psych-Verbs, Intensional Verbs			
criticize, honor; adore; seek, mention			
S	$\star$	$\star$	$\star$

(7.13) Es wurde im Rathaus getanzt.
it was in-DEF town hall danced
People danced in the townhall.

(7.14) Es wurde aus allen Richtungen geschossen.
it was from all directions shot
People shot from all directions.

On the other hand, there are actants other than subject and object that are eligible for orientation.

(7.15) Fred was drilling with a drill through the box.

(7.16) Fred schoss mit einem Stein durch das Fenster.
(lit.) *Fred was shooting with a stone through the window.*

In (7.15) and (7.16) it is the instrument which is moving.

So, grammatical functions do not determine the orientation. A more plausible candidate are the θ–roles. This has been proposed in the literature by Jackendoff and Gruber (see [24] and [18]). They identify the element that is being positioned in space as the *theme*. [58] This proposal needs some clarification. First of all, notice that verbs are more selective with respect to directional locatives. In general, there can be at most one argument towards which a directional locative can be oriented, while static locatives normally can be oriented towards several arguments (typically, either subject or object). Since this is in conflict with the results of Nam shown in Table 8, we shall give some arguments for it. Take the verb to drive. Nam claims that a directional locative may be oriented towards the subject or towards the object. Consider (7.17).

(7.17) The dogs were driving the herd to the river.

At the end of the event (7.17) we know that the herd is at the river, and we may infer from that that the dogs are somewhere near it, but this conclusion is not inevitable. In this particular case we think that the verb is better classified as a motion causative. Now what about the other verbs? Suppose that we have a genuine verb of co–movement; then the subject and the object are moving along (more or less) the same path. In this case, subject orientation

[58] Though we disagree with this idea, a solid argument against it would require fixing it against a theory of θ–roles. For example, we need to know if a letter is a theme in (7.20) (it is not a mover) or der Stein (it is an instrument) is a theme in (7.16), and second whether an argument can have two θ–roles. With respect to the fuzziness of the concept we shall not try harder here. We hope that the subsequent details will suffice to discredit this idea.

and object orientation more or less coincide. This is the case with escort and accompany. Suppose you say (7.18).

(7.18) John accompanied Mary into the classroom.

Then at the end of John's accompanying Mary, both are in the classroom. (Or, try to the doctor instead of into the classroom. Below we shall tell a slightly different story, however.) By contrast, follow is once again different.

(7.19a) Die Polizei folgte den Verbrechern bis zum Stadtrand.
(7.19b) The police followed the gangsters to the edge of the city.

The intuition is that when the event closes, we only know that the police is at the end of the city. Where the gangsters are we do not know. Certainly, follow is not a motion causative, but a true verb of co–movement. Hence, the intuitions of Nam cannot be taken over without modification. We shall propose a model–theoretic definition of the notions of *mover*.

Definition 5 *An **event type** is a formula $\delta = \delta(y, x_0, \ldots, x_{n-1})$ where y is an event variable and x_i $(i < n)$ are variables of an appropriate type.*

Definition 6 *Let $\mathfrak{M}$ be a model. An **anchored event** is a sequence $\mathcal{E} = \langle e, \langle a_i : i < m\rangle\rangle$, where e is an event in $\mathfrak{M}$, and a_i are objects of $\mathfrak{M}$ of any type. $\mathcal{E}$ is an **anchored event of type** δ, if*

$$\mathfrak{M} \models \delta(e, a_0, \ldots, a_{n-1})$$

*The a_i are called the **participants of** $\mathcal{E}$. Similarly, the variables x_i, $i < n$, are called **participants of** δ.*

So, the event type is nothing but a specification of some conditions on the event and some objects. The extra structure of objects is needed, because we need to fix roles for the objects participating in the event. For example, let us define an event type 'watching'. It is a formula $\alpha(x_0, x_1)$, saying for example that x_0 looks attentively at x_1. The event e in which John is watching Mary while Mary is watching John is actually one in which John watches Mary. So, we have that $\langle e, j, m\rangle$ is of type watching, just as $\langle e, m, j\rangle$ is of type watching.

Definition 7 *Let $\delta = \delta(y, \vec{x})$ be an event type. x_i is an **eligible mover** of δ if $\delta(y, \vec{x})$ implies that x_i is moving during the time of e.*

A note of clarification. We assume that we have fixed a logical language containing constants for various concepts and how they interrelate. We can then rephrase the condition as a logical implication $\delta(y, \vec{x}) \rightarrow \mathsf{moves}'(x_i, \mathsf{time}'(y))$.

Notice that eligible movers are fixed at the level of event types, not of individual events. A single anchored event can be classified under different event types. Verbs denote (sets of) event types, not particular events. The definitions have a number of consequences. First, the denotations of verbs are insensitive to syntactical encoding. For example, if we passivize a verb, then this does not change the event type that this verb denotes. Rather, it changes the assignment of grammatical functions to participants of the event. Hence, eligible movers are insensitive to passivization. Second, whether or not something is an eligible mover only depends on the question whether it is logically speaking necessary for it to move if the concrete event has that type. For example, the event of me eating a sandwich while I am walking on the road, is an event of type eating, and it is an event of me walking. However, I am not an eligible mover in the event of type eating, since from the conditions under which this event qualifies as an eating event one cannot deduce that I am moving. On the other hand, I *am* a mover in this event insofar as it is a walking event, since for me to walk logically implies that I move.

We have answered the question of what an eligible mover is. We still need to define the notion of a *mover*. Without going into much detail, it seems safe to assume the following. Language has a small set of semantic roles, among the role of a **mover**. A semantic role ρ can be viewed here as a function from event types to variables such that $\rho(\delta(y, \vec{x})) = x_i$, where x_i occurs in the list $\vec{x}$. Additional requirement must be satisfied. The semantic role μ, for example, must satisfy that $\mu(\delta(y, \vec{x}))$ is an eligible mover of the event type. This construction leaves a number of problems unadressed. They have to do with the arbitrary choice of the mover and second with the problem of comitative constructions. Notably comitative constructions pose delicate questions to semantics. For example, if I say that the detective followed the mafia boss *with his colleague*, then the detective may be foregrounded here and play the role of subject, but it appears that it is not the detective alone but he and his colleague who are the movers. In some languages, the verb must be plural (or dual, if the language has a dual; see Baker [3] for these facts). It seems that the encoding in terms of subject/non–subject is independent of the event to which one is referring, and is determined by factors such as focus, context or the like. Further, if the sentence John and

Mary are watching each other we have two individuals which both figure as actor and theme. Having said this, we can state our next principle.

> Non–Static Orientation. A directional locative is oriented towards the mover.

Let us test this definition with a few examples. First, no non–eligible mover is a mover. This explains the ungrammaticality of the following sentences.

(7.20) *John is writing (the letter) into Hamburg.
(7.21) *John is hammering (the axe) into Hamburg.

Next, not all eligible movers are movers. This was shown in (7.17), (7.18) and (7.19). Further, the sentences showed that either the active subject or the active object may be movers.

Now we shall turn to static locatives. Here the situation is quite different. Our basic claim is the following.

> Static Orientation. A non–directional locative is oriented towards the event.

This means that the static locatives constrain the event location, not the location of any of the participants. The question however now is: what exactly is the event location? We have spoken earlier about the fact that event location and participant location are not linked in a uniform way. The following may occur.

1. Event location and participant location are completely independent. This is the case with beneficiaries.

2. The participant location and the event location are not independent.

As a rule, in the second case the participant must be located in the event location at event time. However, we allow for exceptions in those cases where the set of participants of the events is in flux. One example is that of playing bridge. If I am dummy, I can go out into the kitchen to get food without the event location extending likewise to the kitchen. The game remains with the others. However, the example of a game also shows that events can have a location that is independent of its subjects and is determined only by the location of the requisites. We may play bridge on the table, for example. Games seem to be somewhat explicit in the use of location. Most of them can be located more or less accurately, like motion events. An opposite extreme

are events which are not constituted by any actions but rather by sensations. Where are they located? Take as a case in point experiencer verbs. Since the sensation is where the experiencer is we expect the location of the event to be located with the experiencer.

The idea behind all this is that some event types are associated with an observable scene. This scene will not contain those participants whose relation to the event must be inferred (such is the case with beneficiaries). In other cases, the event type makes direct reference to a location, so that the relationship between the participants and the event type is anyway clear.

There is a third type to be discussed; namely, many verbs do not denote a single event, but two events typically related by causation. The general schema is this: there is a complex event, say e, which consists of two events, e_1 and e_2. Moreover, e_1 causes e_2. As it appears, the locative has in principle a choice to modify the causing event (e_1) or the caused event (e_2).

(7.22) John frightened Mary in the water.
(7.23) John frightened Mary in the shower.

(7.22) says that John is doing something (e_1) which causes fear in Mary (e_2). The location of e_1 contains that of John, the location of e_2 that of Mary. (7.22) can be read either as saying that John is in the water, or that Mary is in the water. To bring this out fully, we look at (7.23). We may think of Mary being in the shower and John doing something nasty to her, not being in the shower; or conversely, John being in the shower but not Mary. It is of course also conceivable that both are in the shower.

A similar problem arises with respect to directional locatives. One evident example are what Nam calls motion causatives. (See Vogel [51] for an outline and a critique of these proposals.) Assume that verbs of motion are basically intransitive and that transitive verbs of motion are actually causatives. A causer, however, is generally not a mover. Hence the basic meaning of the motion causatives is as exemplified with the transitive verb to roll:

$$\lambda y.\lambda x.\mathsf{cause}'(x, \mathsf{roll}'(y))$$

The motion causative roll inherits the mover from the embedded, caused event. Since the causing event has no mover, this is the only possible choice anyway. However, there are complex events where we have two eligible movers. This is the case when an event of motion causes another event of motion. The verb to kick has in addition of the meaning 'to hit using one's leg', another meaning, namely, to 'cause motion by means of kicking'. In the

latter meaning, there are two eligible movers: the kicking leg and the object that is being kicked. However, it turns out that the leg — though eligible — is not the mover. (7.24) does not mean that the leg of John ends up in the net after kicking.

(7.24) John kicked the ball into the net.

The generalization in these cases seems to be this: the mover of the complex event is generally the mover of the caused event. Interesting is the the verb to shoot. Only if it means *cause to fly* it tolerates a directional PP modifying the undergoer. In the other meaning (*kill by shooting*) only a coinitial PP can be used, simply because there is no mover present in the event. [59]

(7.25) Alfred shot the arrow through six pieces of cardboard into the target.
(7.26) ?Alfred shot the rabbit into the forest.
(7.27) Alfred shot the rabbit from the balcony.
(7.28) Alfred shot into the forest.

So, (7.25) says that the arrow is moving through six cardboards and then into the target. In (7.26), under the shoot–to–kill reading neither Alfred nor the rabbit are movers, and the sentence is ungrammatical. (However, there is an eligible mover, the projectile.) In (7.27), Alfred is the origin of the shooting but not himself moving. Apparently, it is the bullet that is moving, whence (7.28) is ok. One explanation for this phenomenon is that shoot might behave like a verb of communication. Verbs of communication are address, speak to, ring up. They generally take a coinitial locative, which denotes the source; the adressee is usually not expressed by a locative. However, as a reviewer has pointed out, the following are acceptable, too:

(7.29) John shouted/yelled into the forest.

Apparently, transitivity is an additional factor here. We must leave that issue unresolved. [60]

[59] Of course, (7.26) is perfect when we understand the rabbit as being the projectile. This is not the intended reading of that sentence, however. Therefore, we have placed a question mark.

[60] Fong [16] gives an example of a Finnish sentence with a cofinal locative.

(i) Metsästäjä ampui karhu-n metsään kuoliaa-ksi.
hunter-∅ shot bear forest-ILL dead-TRA
The hunter shot the bear dead, and it remained in the forest.

Here, metsään literally means 'into the forest'. But here the illative means that the bear remained in the forest after shooting it. It is clear that the illative is completely void of

8 Verbal Affixes

In Section 2.4 we have already given examples of verbal affixes in Bantu languages. These affixes may or may not promote a locative argument or adjunct into a direct object. If they do, they are called **promotional**. German and Hungarian have similar affixes. However, while Hungarian affixes are not promotional, German is a mixed case. Examples of prefixes are

Hungarian	German	
be(le)-	hinein-/herein-	into
ki-	heraus-/heraus-	out of
át-	hindurch-	through

The Hungarian verb ugrik (to jump) can take any of these prefixes. Similarly the German verb springen (to jump). So we have beleugrik (to jump into), kiugrik (to jump out of) and átugrik (to jump through). Neither of these verbs is transitive. Here are some Hungarian examples with German counterparts.

(8.1) Paul beugrott a vízbe.
Paul INTO-jump the water-ILL
Paul sprang in das Wasser hinein.
Paul jumped into the water.

(8.2) Paul kiugrott a vízből.
Paul OUT OF-jump the water-ELA
Paul sprang aus dem Wasser heraus.
Paul jumped out of the water.

(8.3) Paul átugrott a kereken át.
Paul THROUGH-jump the hoop through.
Paul sprang durch den Reifen hindurch.
Paul jumped through the hoop.

The German data looks different only because the prefixes are separable, and the verb second movement leaves them at the end of the sentence. In a subordinate clause the two are together.

(8.4) Ich sah, wie Paul in das Wasser hineinsprang.
I saw how Paul into the water INTO-jump

Further, the verbal prefixes can also function in German as postpositions. In that case they act as modalisers. We have expressions like

any modal meaning.

(8.5) vom Brett herab, aus dem Haus heraus
down from the board, out of the house

In this case the difference between the use of herab as a postposition and its use as a verbal prefix only shows up in writing. (Is is also audible as a different stress pattern.) The modaliser is written as a separate word. Additional complications are offered by the following examples. [61]

(8.6) Erwin sprang vom Brett herab in das Wasser.
Erwin jumped from the board HERAB into the water.

As we have said above, German also has promotional prefixes that make a verb transitive by turning a directional PP into an accusative complement. Examples are:

ent-	*origin*
durch-	*path*
be-	*destination*

So we have the following alternatives ((8.7) versus (8.8) and (8.9) versus (8.10)).

[61] These postmodifiers do pose interesting questions. Consider the sequence of prefix, say heraus-, and a verb, or alternatively of a directional PP and the postmodifier heraus. In both cases, the directional PP is fixed both in configuration and mode. Hence we have

(i) Ich sah, wie Erwin aus dem Haus herauskam.
I saw, how Erwin out of the house OUT OF-came

(ii) *Ich sah, wie Erwin von dem Haus herauskam.
I saw, how Erwin from the house OUT OF-came

(iii) *Ich sah, wie Erwin in das Haus herauskam.
I saw, how Erwin into the house OUT OF-came

This is interesting since it suggests that verbs select a directional PP in its directional meaning while at the same time selecting both mode and configuration. We will not explore this further. There is an alternative approach to this data. We may assume that German has locative cases, which are realized by prepositions (therefore in the syntax) but not by cases (ie morphologically). Then, heraus can be said to select the elative in German, which is realized by the preposition aus.

(8.7) Erwin kletterte auf den Baum.
Erwin climbed onto the tree

(8.8) Erwin bekletterte den Baum.
Erwin BE-climbed the tree

(8.9) Erwin sprang durch den Reifen.
Erwin jumped through the hoop

(8.10) Erwin durchsprang den Reifen.
Erwin THROUGH-jumped the hoop

These prefixes are not productive to the same degree. They are moreover not separable. Prefixes are promotional exactly when they are separable. In Kinyarwanda, one can also turn a directional PP into a direct object, likewise a stative PP. (See [17] for relevant examples.) The verbs formed with these particles do not seem to tolerate any other directional PP.

(8.11) ?Ich sah, wie Erwin von Berlin die Alpen durchflog.
I saw how Erwin THROUGH–flew the Alps from Berlin.

(8.12) ?Ich sah, wie Erwin nach Rom die Alpen durchflog.
I saw how Erwin THROUGH–flew the Alps to Rome.

However, these verbs do tolerate those locative PPs instead which are formed in German using the postfixes her (coming from) and hin (going to) or aus (away).

(8.13) Ich sah, wie Erwin von Berlin aus die Alpen durchflog.
I saw how Erwin THROUGH-flew the Alps coming from Berlin.

(8.14) Ich sah, wie Erwin nach Rom hin die Alpen durchflog.
I saw how Erwin THROUGH-flew the Alps going to Rome.

It is not clear to us what exactly motivates these facts. However, the postpositions to locatives as well as the verbal prefixes formed with the help of her and hin cannot be added other than in purely locative meanings.

It is noticeable that the affixes are local adpositions. Hence, we have the plausible scenario that these adpositions have been more and more associated with the verb rather than the locative PP. At the end of this process, the verb became transitive and the former locative PP a transitive object. However, there are a few things to note about this. First, we have said above that languages avoid to have phrases denote locations. (Again, notice the exceptional status of Chinese here. I have nothing to say about this case and must leave the issue undecided. For the languages that I have studied, this tendency is in my view fully noticeable.) Hence, we shall expect that even

if M and L are two elements, it will not happen that M alone becomes a verbal affix, leaving L behind.

$$V\ [M\ [L\ DP]] \not\rightarrow [V\ M]\ [L\ DP]$$

It is interesting to see what happens if we attempt to do this. Suppose we dissociate from under the table by postposing the location.

(8.15) *The sticker was removed from by Mary under the table.

Then we seem to have incorporated the mode only, leaving behind a locative expression. However, under the table is now oriented towards Mary, and it is a static locative. It means that Mary was being under the table while removing the sticker.

Another observation is that the promotion of locative to object precedes passivization. Kinyarwanda has an locative to object promotion, but also affixes which promote the object or the beneficiary to subject. The affix -ho marks locative to object promotion.

(8.16)	Íntebe	y-iicar-i-w-é-ho	umugabo	n-uúmwáana.
	chair	it-sit-BEN-PASS-ASP-LOC	man	by-child
	The chair was sat on for the man by the child			
(8.17)	Umugabo	y-iicar-i-w-é-ho	íntebe	n-uúmwáana.
	man	he-sit-BEN-PASS-ASP-LOC	chair	by-child
	The man was sat-on-the-chair-for by the child			

If passive could apply before locative promotion, we would expect that the object of the verb meaning *to send* is eligible for promotion. But it is not.

(8.18)	Ishuûri	ry-oohere-j-w-é-ho	igitabo	n-úmwáalímu.
	school	it-send-ASP-PASS-ASP-LOC	book	by-teacher
	The school was sent the book to by the teacher.			
(8.19)	*Igitabo	cy-oohere-j-w-é-ho	ishuûri	n-úmwáalímu.
	book	it-send-ASP-PASS-ASP-LOC	school	by-teacher
	The book was sent to the school by the teacher.			

Notice however that the passive morpheme is closer to the stem than the locative suffix. Notice namely that if the relational changes were analyzed on an inside out basis, we must expect that the direct object is promoted, not the locational object. How this paradox can be resolved is not clear to us at this point.

9 Conclusion

In this paper we have been concerned with the spatial, that is to say, non–metaphorical meaning of locative expressions. Following Jackendoff, we have assumed that locative expressions are structured as follows:

$$[M\ [L\ DP]]$$

where M is a modaliser, L a localiser and DP a DP. While there is a large number of localisers, there is a handful of modalisers, specifying the way of movement. The modaliser and the localiser typically form a morphological unit, which is either a case or an adposition. Directional locatives can only be construed with the (typically unique) entity that constitutes the event by moving, while static locatives are construed with the event location, which in turn is linked to a certain set of participants of that event. When a verb selects a locative complement, it can do so either by selecting both the mode and the configuration or by selecting the mode alone. The Emptiness Principle predicts that in the first case the verb acts semantically like a transitive verb, while in the second case it takes a parametrized neighbourhood as its argument. In the second case, the localiser is free. This explains the variation across languages with respect to mode selection of such verbs (for example Finnish/English jäädä/remain, saapua/arrive, unohtaa/forget).

Several issues had to be touched on lightly if at all. We have noted that the pair illative/elative is different from the pairs allative/ablative and sublative/delative. Furthermore, the definitions of movers and active participants of events, although capturing most of the cases we know of, are not sufficient in a number of cases. Also, their definitions need a considerably stable intuition concerning the notion of an action and the constitution of an event, which are far from clear at this stage. There is considerable fine tuning necessary to account for the variety of local expressions that exist. For example, German distinguishes two types of directional locatives, eg von and von ... her, durch and durch ... hindurch. What distinguishes these two we have not been able to determine. Likewise for most of the German verbal prefixes (heraus-, hindurch- etc).

We shall finally note that the analysis presented here can be extended to other domains. As already observed by Fong in [16], the contrast between essive and translative of Finnish can be analysed in the same way as the pair inessive/illative. Verbs selecting a cofinal mode consistently go with the translative, while verbs selecting static mode go with the essive. For example,

jäädä selects cofinal mode, pysyä static mode with locatives. Consequently, the former goes with the translative, the latter with the essive.

(9.1)	Kuningatar	jä-i	leske-ksi/*leske-nä
	queen	remained	widow-TRANS/ *widow-ESS
(9.2)	Kuningatar	pysy-i	*leske-ksi/leske-nä
	queen	remained	*widow-TRANS/ widow-ESS

The queen remained a widow.

This suggests that the notion of *mode* has wider application that just for the analysis of locatives. Further, the notion of configuration could be used in the analysis of temporal expressions (and temporal cases, which exist, for example, in Hungarian). Each of these questions merits a deep analysis, which is however out of the scope of this paper. Moreover, we hope to have shown in this paper that the structure and behaviour of *cases* in languages can be a very complex matter.

10 Appendix

In this appendix we have collect all necessary mathematical notions. A **topological space** is a pair $\mathfrak{X} = \langle X, \mathbb{X}\rangle$, where X is a non–empty set and $\mathbb{X} \subseteq \wp(X)$ a collection of subsets of X containing $\varnothing$ and X and which is closed under finite intersection and arbitrary union. A set $S \subseteq X$ is **open** in $\mathfrak{X}$ if $S \in \mathbb{X}$. Let $\mathfrak{Y} = \langle Y, \mathbb{Y}\rangle$ be another topological space and $f : X \to Y$ a function. f is **continuous** if for every $U \in \mathbb{Y}$ the set $f^{-1}(U) := \{x \in X : f(x) \in U\}$ is open in $\mathfrak{X}$. Particular topological spaces are the n–dimensional euclidean spaces $\mathbb{R}^n$. Here, let for $\vec{x}, \vec{y} \in \mathbb{R}^n$ the **distance** between $\vec{x}$ and $\vec{y}$ be

$$d(\vec{x}, \vec{y}) := \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$$

The open ε–ball around $\vec{x}$ is the set $K_\varepsilon(\vec{x}) := \{\vec{y} : d(\vec{y}, \vec{x}) < \varepsilon\}$. A set is open in $\mathbb{R}^n$ if it is the union of open balls. This union need not be finite. Any subset of $\mathbb{R}^n$ is topologized with the restriction of the topology. So, if $U \subseteq \mathbb{R}^n$, we take as open sets of U all sets of the form $O \cap U$, where O is open in $\mathbb{R}^n$. This applies in particular to the unit interval $I := \{y : 0 \leq y \leq 1\}$ in $\mathbb{R}$. A **path** in a topological space is a continuous function $f : I \to \mathfrak{X}$. We call the set $\{f(x) : x \in I\}$ the **range** of f. A subset S of X is **path–connected**

if for any $x, y \in S$ there exists a path $f : I \to S$ such that $f(0) = x$ and $f(1) = y$.

Let $\vec{x}, \vec{y} \in \mathbb{R}^n$. Then define a path $f : I \to \mathbb{R}^n$ by $f(t) := (1-t)\vec{x} + t\vec{y}$. This is a path from $\vec{x}$ to $\vec{y}$, called the **connecting line** from $\vec{x}$ to $\vec{y}$. $\vec{x}$ and $\vec{y}$ are also called the **endpoints** of f. The **convex hull** of a set X consists of all points that are on some connecting line with endpoints in X. A set is **convex** iff it is identical to its convex hull.

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