

# REFERENCE TO LOCATIONS

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## Abstract

We propose a semantics for locative expressions such as *near Jones* or *west of Denver*, an important subsystem for NLP applications. Locative expressions denote regions of space, and serve as arguments to predicates, locating objects and events spatially. Since simple locatives occupy argument positions, they do NOT participate in scope ambiguities—*pace* one common view, which sees locatives as logical operators. Our proposal justifies common representational practice in computational linguistics, accounting for how locative expressions function anaphorically, and explaining a wide range of inference involving locatives. We further demonstrate how the argument analysis may accommodate multiple locative arguments in a single predicate. The analysis is implemented for use in a database query application.

## 1 Introduction

Locative expressions take diverse forms: *in New York*, *here*, *there*, *nowhere*, and *on a boat he has in Ohio*. They combine with common nouns (*city on the Rhine*), or with verbs or verb-phrases (*work in Boston*), always locating objects and situations in space. Some temporal expressions are similar, but we focus here on spatial locatives.

The analysis was developed for use in an NLP system producing database queries; it is fully implemented and has been in frequent (developmental) use for 18 months. It is important to provide facilities for reasoning about location in database query applications because users typically do not query locative information in the exact form it appears in the database. A database may e.g. contain the information that a painting is in the Guggenheim Museum, perhaps even that it's in the Guggenheim in New York, and yet be helpless when queried whether that same painting is in the US. In our implementation information about location is represented using the logical analysis provided here.<sup>1</sup>

<sup>1</sup>Of course, the information that New York is in the US must be provided by a compatible geographical knowledge base.

## 1.1 Sketch of Proposal

The provides general service: first, in collecting the data relevant to a semantic analysis of locatives; second, in presenting the proposal in a fashion which applies to other natural languages and other logical representations; and third, in noting the consequences of our proposal for the organization of NLP systems, specifically the cooperation of syntax and semantics.

The behavior of locatives in inference and anaphora reflects their semantics. This behavior justifies the hypothesis that (unquantified) locatives refer to regions, while related sequences of locatives refer to the intersection of the regions associated with their components. E.g. the phrase (sequence) *in Canada on the Atlantic Coast* refers to the (maximal) region which is both in Canada and on the Atlantic Coast.

Locative adverbials within a verb phrase will then be seen to contribute to a location argument in predicates which identifies an area within which the predicate is asserted to hold. The view that locatives occupy an ARGUMENT position within a predication is contrasted with the view that they are EXTERNAL OPERATORS (cf. Cresswell [7]), or MODIFIERS ON predications (cf. Davidson [8] or Sondheimer [18]). In fact, however, the analysis of locative phrases as arguments jibes well with the practice of most computational linguists; cf. Allen [1], pp.198-207 and the references there, [1], p.218. The present effort contributes to the justification and explication of this practice.

Our approach is closest to Jackendoff [12]. We follow Jackendoff first, in suggesting that locative phrases are referential in the same way that noun phrases (NPs) are; and second, in taking locative adverbials to function as arguments. But there is a significant foundational problem implicit in the hypothesis that locatives are arguments: locatives, unlike standard arguments in the predicate calculus, appear optionally and multiply. Predicate logic does not accommodate the occurrence of multiple arguments in a single argument position. We solve this technical problem by allowing that multiple locatives CON-

STRAIN a single argument within a predication. This effectively challenges a standard assumption about the syntax-semantics interface, viz. how syntactic elements map into arguments, but leads to an elegant semantics.

In addition to the adverbial use of locatives, we recognize a predicative use illustrated by (1). We return to these in Section 6 below.

- (1) Tom is in Canada on the Atlantic Coast.

## 2 The Logic of Locatives

In this section we collect valid and invalid argument-patterns involving adverbial locatives. A semantics of locatives should explain the entailments we catalog here. We restrict our attention initially to locative phrases in which locations are specified with respect to logical individuals (denoted by proper names, e.g. ‘Boston’, ‘Jones’, or ‘Mass Ave’) because we assume that their analysis is relatively uncontroversial.<sup>2</sup> We begin by noting that any number of locatives may adjoin to almost any verb (phrase);

- (2) Tom works on Mass Ave. in Boston near MIT.

A natural question to ask, then, concerns the logical relation between complex clauses like (2) and simpler clauses eliminating one or more of its locatives. To begin, the SIMPLIFYING INFERENCE in (3) is valid:

- (3) 
$$\frac{\text{Al works in Boston.}}{\therefore \text{Al works.}}$$

Using multiple adjuncts doesn’t disturb this pattern of inference, as (4) and (5) illustrate:

- (4) 
$$\frac{\text{Al works on Mass Ave. in Boston.}}{\therefore \text{Al works in Boston.}}$$

- (5) 
$$\frac{\text{Al works on Mass Ave. in Boston.}}{\therefore \text{Al works on Mass Ave.}}$$

PERMUTING locative adjuncts has no effect on truth conditions. Thus the sentences in (6) are truth-conditionally equivalent. Some are less felicitous than others, and they may manipulate discourse context differently, but they all describe the same facts:

<sup>2</sup>We don’t think it matters whether the proper names are taken to be individual constants, as they normally are, or whether they are analyzed as restricted parameters, as situation semantics ([3],pp.165-68) has suggested.

- (6) Al works on Mass Ave in Boston near MIT  
 Al works near MIT on Mass Ave in Boston  
 Al works near MIT in Boston on Mass Ave  
 Al works in Boston near MIT on Mass Ave  
 Al works in Boston on Mass Ave near MIT  
 Al works on Mass Ave near MIT in Boston

Even though the simplifying inference in (3) is valid, we must take care, since the complementary (accumulative) inference (7) is INVALID (but cf. the valid (8)):

- (7) 
$$\frac{\text{Al works in NY.} \\ \text{Al works in Boston.}}{\therefore \text{Al works in NY in Boston.}}$$

- (8) 
$$\frac{\text{Al works in NY.} \\ \text{Al works in Boston.}}{\therefore \text{Al works in NY and in Boston.}}$$

Finally, there is what we call the UPWARD MONOTONICITY of locatives. If a sentence locating something at a region  $R$  is true, and if  $R$  is contained in the region  $R'$ , then a sentence locating that thing at  $R'$  is true:

- (9) 
$$\frac{\text{Al works in New York.} \\ \text{New York is in the US.}}{\therefore \text{Al works in the US.}}$$

- (10) 
$$\frac{\text{The dog sleeps under the table.} \\ \text{Under the table is in the house (region} \\ \text{“under the table” is contained in} \\ \text{region “in the house.”)}}{\therefore \text{The dog sleeps in the house.}}$$

Notice in (10) that the locative phrases are specified with respect not to locations, but to other logical individuals. This is accomplished by the semantics of the prepositions *under* and *in*; our proposal will require that locative PHRASES refer to regions, but not that their subcomponents must.

## 3 Other Semantic Evidence

### 3.1 Scope

Locatives by themselves do NOT induce scope ambiguity with respect to negation, thus the semantic nonambiguity of (11); compare that with (12).

- (11) Tina didn’t work in New York.  
 (12) Tina didn’t drink because of her husband.

The causal adjunct *because of* DOES induce a scope ambiguity with respect to negation. That is why (12) has two readings, one (narrow scope negation) on which Tina’s not drinking is in some way due to her husband, another (wide-scope negation) which denies that Tina’s drinking is because of her husband. (11) shows no analogous scope ambiguity. Thus, locatives appear to behave differently from at least some other adjuncts in that they no show no scope variation with respect to negation.

The simplest explanation of this failure to induce scope ambiguity is to deny that simple locatives have scope, i.e. to deny that they are logical operators or external modifiers. We propose exactly this when we postulate that they are arguments rather than operators. We grant that locatives in sentence-initial position DO display properties which suggest scope, but this needn’t vitiate the argument analysis.<sup>3</sup>

Note that the “commutativity of locatives” shown in (6) is another indication of failure to scope: locatives fail to scope with respect to each other.

### 3.1.1 Scope versus Focus

In evaluating the claim that no SCOPE AMBIGUITY is possible in (11), it is important not to be confused by the possibility of interpreting the FOCUS of negation in various ways. The association of negation with a focused element is a well-discussed, if not not a well-understood, phenomenon in the literature (see Jackendoff ([11], pp.229-78), Chomsky ([4], pp.199-208), and Rooth [17] for discussions of focus). The crucial point about focus is that it affects arguments and adjuncts alike, and that ambiguities involving the association of negation with focus affect both. For example,

- (13) Elizabeth Browning didn’t adore Robert.

The focus can be either on *adore* or on *Robert*, giving different presuppositions,<sup>4</sup> even though the proper name *Robert* is never analyzed as scope-inducing.

## 3.2 Preposed Locatives

PREPOSED locatives do show properties that resemble scope. Cf. Thomason and Stalnaker ([21], p.205):

<sup>3</sup>It is worth emphasizing that we are making a semantic point here—there may be a syntactic (attachment) ambiguity in (11), but it’s not one that has any semantic significance.

<sup>4</sup>Relevant here is Horn’s [10] notion of metalinguistic negation, which accounts for purely contrastive or contradicting negation. The issues Horn discusses are also orthogonal to the ambiguity in (12), since the ambiguity persists outside of contrastive contexts.

- (14) In that restaurant, if John is asked to wear a tie, he wears a tie.

Here the preposed locative does not belong exclusively to either the antecedent or the consequent of the conditional; rather, the sentence says: *if John is asked to wear a tie in that restaurant, he wears a tie in that restaurant*. Thomason and Stalnaker argue hence that the locative must be treated semantically as a sentence operator. Cf. Cresswell ([7], p.217) points out another example where the result of preposing a locative is not a simple paraphrase of its “source”:

- (15) At our house, everyone is eating.  
Everyone is eating at our house.

Here there is a reading of the first which can be paraphrased *Everyone at our house is eating*, where the quantifier is restricted to people at our house. The most important point to make here is that “preposing” generates new readings, readings unavailable for unpreposed adverbial locatives. So if these examples are evidence for a sentence-operator semantics for locatives, then it’s a semantics limited to locatives found in this position. The “wide-scope” readings occur only for locatives in this “topic” (sentence-initial) position.<sup>5</sup> It would be semantically implausible to regard the preposed adverbials here as mere stylistic variants of nonpreposed elements.<sup>6</sup>

But we note further that locations can be restricted by discourse context alone:

- (16) Joan lived in LA. She often went swimming.

We naturally interpret Joan as swimming in LA; and such effects can extend indefinitely through discourse.

We propose to analyze both Thomason and Stalnaker’s example and Cresswell’s example as RESTRICTING TOPIC locatives that restrict some location roles in the sentence to follow. In the case of (14), the restriction applies to the locations of both the antecedent and consequent clauses of the conditional sentence; in the case of (15), the restriction

<sup>5</sup>Note that this is not normally the case for sentence-operator adverbials; *The number of the planets is necessarily nine* is semantically ambiguous between a wide- and narrow-scope reading of *necessarily*.

<sup>6</sup>It is syntactically implausible as well to regard restricting topic elements as stylistic variants of unpreposed elements, since some preposed elements can only occur preposed:

Of the dogs at the show, only Schnauzers were affected.

applies to the quantifier *Everyone*, limiting its domain to those individuals at “our house.”<sup>7</sup> This has the consequence that there is a class of restrictive topic-position modifiers that cannot be analyzed as preposed adverbials.

### 3.3 Analogy with NPs

Jackendoff ([12], Chap.3) is partially devoted to articulating the strong semantic analogy between locative phrases and noun phrases. The analogy includes quantification, a distinction between definite and indefinite reference, deictic reference, and anaphora. Jackendoff’s programmatic point is that the semantic status of locatives is therefore the same as that of NPs: they both refer and both function as arguments.

It is noteworthy that locatives have explicitly quantificational forms, as in:

(17) Bill sang everywhere Mary sang.

This suggests that quantified locatives have the same relationship to simple locatives as general NPs (such as *every small country*) have to singular NPs (such as *the smallest country*, *a small country*, and *Honduras*). Though SIMPLE locatives show no scope variation with respect to other scope operators, quantified locatives (such as *everywhere* and *nowhere*) clearly do. But this scope is due to the quantification, not to the locative function. Since locatives occupy argument positions in predications, quantified locatives are simply quantifications over those predications, exactly analogous to nonlocative quantifications.

Second, we find similarly noteworthy the indefinitely referring locative *somewhere*. We note that its particular reference (like that of *someone*) is available for subsequent anaphoric use. That is, (18) may be understood to claim that Ed works where Al works.<sup>8</sup>

(18) Al lives somewhere on the Ohio,  
and Ed works there.

Third, we note that deictic locative reference is possible (using *here* or *there*), just as deictic nonlocative reference is (using pronouns or demonstratives). We address the fourth and final reminder of the analogy between NP and locative reference, locative anaphora, in Section 3.4, immediately below.

<sup>7</sup>We don’t claim to offer a complete analysis of these topic-locatives (nothing we have said makes it clear how these restrictions are enforced, or what the constraints on them are); but we offer a plausibility argument that these are cases of a somewhat different color.

<sup>8</sup>This contrasts with examples of locative anaphors with simple locative antecedents, examined below in Section 3.4. Cf. (19).

### 3.4 Anaphora

Viewing simple locatives as analogous to singular NPs, we obtain a simple account of the anaphoric potential of locatives by taking them to denote spatial regions. The functioning of locatives as antecedents for the locative pro-form *there* then provides additional evidence that simple locatives are in a class with singular NPs. Consider:

(19) Al lives on the Ohio, and Ed works there.

(19) makes the claim, not that Al lives in the same place Ed works, but that he lives on the same river that Al works on. Thus the reference of both *on the Ohio* and *there* appears to be the entire spatial region which is ON the Ohio (as opposed to any particular subregion of it). This region is uniquely (though vaguely) determined in a given context by the name of the river and the particular preposition *on*. We are, in effect, claiming that the PP *on the Ohio* acts as a sort of definite description of a particular spatial region. Anaphoric reference back to it is reference back to that same region.

A further note is worthwhile here. If the locative phrase *on the Ohio* in (19) refers to the entire region which may be so described (as we’ve just argued), then the LOCATION role of the predicates LIVE and WORK must be construed as specifying a region ‘within which’ a relation is somewhere instantiated. Indeed, we postulate this as a general property of location roles within all predicates.

### 3.5 Regional Intersection

Next consider a more complicated version of (19):

(20) Al lives on the Ohio in Kentucky,  
and Ed works there.

In (20) one may understand *there* as referring to the intersection of the regions ‘on the Ohio,’ and ‘in Kentucky’ (and again, NOT to the particular subpart of that intersection where Al lives). In fact, this reading is preferred. (*There* may also be understood to refer to one of the component superregions, and our analysis is fully compatible with this possibility.) Let’s consider how best to supply the intersective reference for the pronoun *there*.

In (20) the two locative expressions in the first clause simultaneously constrain the same location role. In general, each successive locative in a clause further narrows the region filling the location role:

(WORK agent:Ed  
(21) loc:( $\cap_r$ reg:{ON(Ohio),IN(Kentucky)}))

‘ $\sqcap_{\mathcal{R}}$ ’ is the intersection operation over regions. Cf. Section 5.2 for formal discussion.

Now, since the filler of a Location role is always a single region, the anaphoric potential illustrated in (20) is explained. It would remain unexplained if each locative introduced a distinct predication.

## 4 Syntax/Semantics Mapping

We employ a syntax/semantics interface that’s innovative in two respects: first, we allow that adjuncts (locatives) be interpreted as arguments, rather than operators. Cf. McConnell-Ginet ([14],p.167ff) for a similar proposal about manner adverbs. Second, we allow that multiple locatives (in the same verb phrase) jointly determine a single location argument via the intersection of regions. Thus we allow several syntactic dependents corresponding to a single semantic argument. This challenges a standard working assumption about the syntax-semantics mapping made in a number of frameworks,<sup>9</sup> but it leads to a neater semantic account: by allowing several locative specifiers to constrain a single role, we account more easily for the permutability of locatives, and we provide the right range of anaphoric antecedents.

## 5 Formal Aspects

Here we describe the logical expressions into which locatives (and sentences containing them) are translated, and the semantic interpretations of the logical expressions.

### 5.1 Overview of NFLT

Our logical formalism is called NFLT.<sup>10</sup> It is a modification and augmentation of standard predicate calculus, with two modifications relevant here: predicates and functors of variable arity, and a semantic interpretation in terms of situation-types.

#### 5.1.1 Predicate and Function Expressions

Predications and functional terms in NFLT have an explicit rolemark for each argument; in this respect NFLT resembles semantic network formalisms and differs from standard predicate calculus, where the

<sup>9</sup>This doesn’t contradict Montague’s semantic theories, but it abandons the favored “functional application” mode of interpretation. Cf. Montague [15], p.202. Neither verb (phrase) nor locative is interpreted as a function applying to the argument supplied by the other.

<sup>10</sup>Cf. Creary and Pollard [6] for conceptual background, literature references, and more complete presentation of NFLT.

roles are order-coded. For example, atomic formulas in NFLT are constructed of a base-predicate and a set of rolemark-argument pairs, as in the following translation of *Tom works in Boston*:

$$(22) \quad (\text{WORK agent:TOM} \\ \text{location:(IN theme:BOSTON)})$$

The explicit representation of roles permits each predicate- and function-symbol in NFLT to take a variable number of arguments, so that different occurrences of a verb are represented with the same predicate-symbol, despite differences in valence (i.e. number and identity of attached complements and adjuncts).<sup>11</sup>

### 5.2 Functional Location Terms

Functional location terms are functional terms denoting regions. These are of two general sorts, simple and intersective. The simple ones consist of a prepositional functor applied to an appropriate argument, while the intersective ones consist of a regional intersection functor applied to a set of regions. As an example, consider the following location term, which might serve as the translation (in a given context) of the iterated locatives *on the Ohio in Kentucky near Illinois*:

$$(23) \quad (\sqcap_{\mathcal{R}} \text{reg:}\{\text{ON3(OHIO)}, \\ \text{IN(KENTUCKY)}, \\ \text{NEAR1(ILLINOIS)}\})$$

This is a complex location term whose components are simple functional location terms. NEAR1 should denote (e.g.) a function that maps Illinois onto a region beginning at its borders and extending out a short distance.

The functor of an intersective location term denotes the regional intersection function, which maps  $R_1, R_2, \dots, R_n$  onto their intersection  $R$ . More formally, we postulate that spatial regions, partially ordered by the subregion relation (written  $\sqsubseteq_{\mathcal{R}}$ ), form a LATTICE. The intersection of regions is then their lattice-theoretic MEET (written  $\sqcap_{\mathcal{R}}$ ), the greatest lower bound with respect to  $\sqsubseteq_{\mathcal{R}}$ .

The commutativity and associativity of  $\sqcap_{\mathcal{R}}$  justify specifying its arguments via sets. The order-indifference of set specification accounts for the permutability of locatives illustrated in (6).

We will also make use of the following familiar lattice theorem:

<sup>11</sup>In order to save space, we shall write  $\text{IN(Boston)}$  for  $(\text{IN theme:BOSTON})$ , however.

$$(24) \quad \left( \begin{array}{l} \sqsubseteq_{\kappa} \text{ sub: } (\sqcap_{\kappa} \text{ reg: } \{R_1, R_2, \dots, R_n\}) \\ \text{sup: } (\sqcap_{\kappa} \text{ reg: } \{R_1, R_2, \dots, R_m\}) \end{array} \right), \\ \text{where } 1 \leq m \leq n.$$

According to (24), an intersective location term  $T$  always denotes a subregion of the region denoted by the result of deleting some (but not all) of the argument-terms of  $T$ .

### 5.3 Located Predications

This is a fact about situations being located in space: if an event or state occurs or obtains within a region  $R$ , then it occurs or obtains within any region  $R'$  containing  $R$ :

$$(25) \quad \left( \begin{array}{l} (\sqsubseteq_{\kappa} \text{ sub: } R \text{ sup: } R') \\ \wedge (PRED \dots \text{ loc: } R) \\ \Rightarrow (PRED \dots \text{ loc: } R') \end{array} \right)$$

This is simply a statement of upward monotonicity for the location arguments of relations. The schemata (24) and (25) together justify the inference schema

$$(26) \quad \frac{\left( \begin{array}{l} \text{(WORK agt:TOM} \\ \text{loc: } (\sqcap_{\kappa} \text{ reg: } \{R_1, \dots, R_n\}) \end{array} \right)}{\dots \left( \begin{array}{l} \text{(WORK agt:TOM} \\ \text{loc: } (\sqcap_{\kappa} \text{ reg: } \{R_1, \dots, R_m\}) \end{array} \right)}, \\ \text{where } 1 \leq m \leq n.$$

This accounts for the correctness of the locative-simplifying inferences in (4) and (5).

The other sort of simplifying inference given in Section 2 was that exemplified in (3), the inference from Tom's working in Boston to Tom's working. In NFLT this inference is formulated thus:

$$(27) \quad \frac{\text{(WORK agt:TOM loc: IN(BOSTON))}}{\dots \text{(WORK agt:TOM)}}$$

Both the premise and the conclusion of (27) are interpreted as denoting situation-types; each is true if there exists a situation of the type it denotes. Since every situation of the type denoted by the premise is necessarily also of the type denoted by the conclusion, the truth of the premise necessarily entails the truth of the conclusion. This accounts for the validity of (3) in the situation-theoretic framework of NFLT. In a fixed-arity framework, one would represent the conclusion as existentially quantifying over a location argument-position; the inference would then be existential generalization.

We recall that (7), repeated here for convenience, is invalid, while the similar (8) (right) is valid:

$$\frac{\begin{array}{l} \text{Tom works in NY.} \\ \text{Tom works in Boston.} \end{array}}{\therefore \text{Tom works in NY in Boston.}}$$

$$\frac{\begin{array}{l} \text{Tom works in NY.} \\ \text{Tom works in Boston.} \end{array}}{\therefore \text{Tom works in NY and in Boston.}}$$

The reason is that the premises of the former may locate two different 'working' events while its conclusion refers to one. The conclusion of the latter, on the other hand, may refer to distinct 'working' events. Its translation into NFLT is:

$$(28) \quad \left( \begin{array}{l} \text{(WORK agt:TOM loc: IN(NY))} \wedge \\ \text{(WORK agt:TOM loc: IN(BOSTON))} \end{array} \right)$$

This conclusion is nothing more than the conjunction of the premises.

## 6 Adnominal Locatives

We propose above that the ability to induce scope effects is a litmus test for distinguishing arguments and operators. This test, together with anaphoric evidence, suggests a heterodox treatment of adnominal locatives. In a nutshell, these locatives might be arguments as well.

(29) Few cars in Ohio rust.

$$(30) \quad \left( \begin{array}{l} \text{(FEW x (CAR instance:x loc: IN(OHIO))} \\ \text{(RUST thm:x))} \end{array} \right)$$

There is a reasonable competing (predicative) analysis of the use of adnominal locatives, however.

$$(31) \quad \left( \begin{array}{l} \text{(FEW x ((CAR instance:x) \wedge} \\ \text{(LOCATED thm:x loc: IN(OHIO))} \\ \text{(RUST thm:x))} \end{array} \right)$$

Note that in both formulations there is reference to a region, and that the locative cannot participate in scope ambiguities.<sup>12</sup>

<sup>12</sup>We leave as an exercise for the reader to show that the well known (semantically significant) attachment ambiguity between adverbial and adnominal locatives may be represented here:

Tom evaluated a car in Ohio.

## 7 Other Proposals

### 7.1 External Operator Analysis

Cresswell ([7], p.13) poses the problem of analysis for adverbial modification thus:

There are two basic approaches to the analysis of adverbial constructions [...] One is to follow Richard Montague and treat them as sentential operators of the same syntactical category as *not*. The other is to follow Donald Davidson and represent them in the predicate calculus with the aid of an extra argument place in the verb to be modified [...]

We suspect that Cresswell would classify the tack taken toward locative adverbials in this paper as an “extra argument” analysis, but we shall note below some important differences between our approach and Davidson’s.

We find fault with the operator analysis of locative adverbials since it inherently attributes a scope to locatives which, as Section 3.1 shows, isn’t reflected in natural language semantics. It is also clear that the simplifying and commutative inferences for locatives noted in Section 2 are not predicted by the external operator analysis. Locatives wouldn’t necessarily have these properties any more than negation or the modal adverbs. Finally, we note as problematic the comportment of the operator analysis with the anaphoric evidence, particularly where multiple locatives are concerned.

### 7.2 Davidsonian Analyses

Davidson [8], and, following him, Bartsch [2] and Sondheimer [18] have proposed that adverbial modification is best represented using an unexpected argument place within a predicate. Bartsch ([2], pp.122-39) and Sondheimer [18] focus on locative constructions, so we concentrate on those works here. Sondheimer ([18], pp.237-39) provides the following analysis:

John stumbled in the park under a tree.  
(32)  $\exists e(Stmbl(J, e) \wedge In(e, p) \wedge Under(e, t))$

The standard logic textbook representation of an intransitive verb such as *stumble* uses a ONE-PLACE predicate, where Sondheimer, following Davidson, uses the TWO-PLACE predicate signifying a relation

between an individual and an event. This is the “extra argument place” that distinguishes Davidsonian treatments. It is worth noting that this approach accounts for the logical properties of locatives that we noted in Section (2) above. The simplification and commutativity of locatives follow from the propositional logic of conjunction.

The most important differences between Davidsonian analyses and our own are the ability to account for locative anaphors, and the treatment of scope. As presented in Section 3.4 above, our treatment provides correct regional antecedents for the locative anaphor *there*. On the other hand, Davidsonian treatments make no explicit reference to regions at all (to which anaphors might refer), and further provide no mechanism for referring to the intersective regions that were seen to be required in the analysis of (20).

Our analysis places simple locatives within the scope of all sentence operators. The Davidsonian analysis creates multiple propositions, and scope-inducing elements such as negation can then be analyzed as including some, but not all of these propositions within their scope. For this reason, Davidsonian treatments are much less specific in their predictions vis-à-vis scope (than the one proposed here). Bartsch ([2], p.133) indicates e.g. that she would allow sentential negation to have scope over some of the conjuncts in logical forms such as (32), but not others; and Sondheimer ([18], p.250) seems to have a similar move in mind in his discussion of *almost* as in *I almost locked him in the closet*. As indicated in Section 3.2 above, we regard such renderings as confusions of scope and focus.

### 7.3 Other Works

Jackendoff ([12], Chap.3,9) argues that reference to places be recognized in semantic theory, thus allowing that locative phrases refer in the same way that NPs do, and that they function as arguments. But Jackendoff never examined inferences involving locatives, nor did he attempt to deal with the *prima facie* difficulties of the argument analysis—the fact that locatives occur optionally and multiply. It is the latter facts which make the argument analysis technically difficult. Finally, where we have been precise about the semantics of the location role, emphasizing that it specifies a region WITHIN WHICH a relation must hold, Jackendoff was less exact. On the other hand, Jackendoff’s analysis of PATH EXPRESSIONS is intriguingly analogous to that of locatives, and offers opportunity for extension of the work here.

Colban ([5]) analyzes locatives in situation semantics, and would like to have the operator/argument

issue both ways: he allows that locatives might be external modifiers or arguments. But he offers no evidence to support this postulate of ambiguity. Ter Meulen ([20], also working within situation semantics, provides a means of referring to the location of complex events, such as the event of two detectives solving a crime. She crucially requires a reference for locative expressions, and her proposals seem compatible with ours.

Talmy [19], Herskovits [9], and Kautz [13] theorize about the INTERPRETATION of locative expressions, and especially how this is affected by the sorts of objects referred to in locative expressions. Much of this latter work may be regarded as complementary to our own, since we have not attempted to characterize in any detail the manner in which context affects the choice of functional denotation for particular locative prepositions.

## 8 Conclusions

### 8.1 Claims

1. Locative expressions (e.g. *north of Boston near Harry*) denote regions of space. The denotations may be referred to anaphorically.
2. Locative expressions are used adverbially to constrain a location argument in a relation defined by a verb. Thus simple locatives fail to show scope (like proper names).
3. Relations are upwardly monotonic at location arguments: if a relation holds at  $R$ , then it holds at every containing  $R'$ .
4. When multiple locatives are used, the intersection of their denoted regions plays a location role. This describes the truth conditions and anaphoric potential of such uses, and predicts correctly the permutability and omissibility of locatives.

### 8.2 Qualifications

We don't claim that all reference to regions is through upwardly monotonic location arguments. On the contrary, regions can stand in relations in a variety of other ways. To take an obvious case, the subregion relation is upwardly monotonic (transitive), but only in one (superregion) argument—it's not upwardly monotonic in the first (subregion) argument. Here are two more fairly transparent examples of reference to locations that don't involve the location ar-

guments of predicates, and therefore aren't upwardly monotonic:

$$(33) \quad \frac{\text{Tom likes it in Mendocino.}}{\therefore \text{Tom likes it in California.}}$$

$$\frac{\text{George VI ruled in England.}}{\therefore \text{George VI ruled in Europe.}}$$

We claim that the regions referred to in (33) aren't location arguments, but rather theme (or patient) arguments. There are other examples of monotonicity failing that are less easily dismissed, however:

$$(34) \quad \frac{\text{It is the tallest in Palo Alto}}{\therefore \text{It is the tallest in California.}}$$

$$\frac{\text{He is alone in the dining room.}}{\therefore \text{He is alone in the house.}}$$

The apparent location argument of these relations (and of all superlatives) is especially interesting because it not only fails to be *upwardly* monotonic, it even turns out to be *downwardly* monotonic. We wish to deny that these phrases denote regions which play location roles—more specifically, we allow that the phrases denote regions, but we distinguish the semantic role that the regions play. In the case of LOCATION arguments, the intended semantics requires that the relation hold *somewhere* within the region denoted. In the case of (34), however, the relation can only hold be said to hold if it holds *throughout* the region denoted. It is this implicit (universal) quantification that explains the failure of upward monotonicity, of course. We symbolize this sort of role as *throughout*, and represent the downwardly monotonic (34) in the following way:

$$(35) \quad \text{(TALLEST thm:x throughout:In(Palo-Alto))}$$

(We emphasize that this is intended to illustrate the distinction between the various semantic roles that locations play—it is not preferred as a serious analysis of the superlative.)

### 8.3 Future Directions

We'd like to improve this account in several ways: first, we'd like to understand the interface between the syntax and semantics more rigorously. Section 4 explains what is unusual about our views here, but the model of syntax/semantics cooperation it suggests is something we'd like to explore. Second, we need an account of preposed locatives, as Section 3.2



admits. Third, we'd like to describe the relationship between predicates relating objects and regions on the one hand with regions occupied by the objects, as Section 6 shows. Fourth, we'd be interested in exploring the relation between our work on the semantics of locatives with work on the contextually dependent interpretation of locatives, such as the work by Herskovits [9] and Retz-Schmidt [16].

## 9 Acknowledgements

We're indebted to Carl Pollard for the suggestion to use the algebraic operator ' $\sqcap_{\mathcal{R}}$ '. We'd like to thank him, Barbara Partee, David Dowty, and our colleagues in the Natural Language Project at Hewlett-Packard Laboratories, especially Bill Ladusaw, for discussion and criticism of the ideas presented here.

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