Natural Language Semantics **7**:1–78 (Spring 1999)

CONCEALED CAUSATIVES

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Abstract

Crosslinguistically, causative constructions conform to the following generalization: If the causal relation is syntactically concealed, then it is semantically direct. Concealed causatives span a wide syntactic spectrum, ranging from resultative complements in English to causative subjects in Miskitu. A unified type-driven theory is proposed which attributes the understood causal relation—and other elements of constructional meaning—to type lifting operations predictably licensed by type mismatch at LF. The proposal has far-reaching theoretical implications not only for the theory of compositionality and causation, but also for the underlying theory of events, space, and time, in natural language discourse.

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1. The Phenomenon

Consider the following spectrum of causative constructions in English:

(1) a. John *caused* [the robber to die] [by shooting her].

b. John *killed* the robber [by shooting her].

(2) John [shot] [the robber dead].

The mapping from syntax to semantics is most transparent in periphrastic causatives, where the causal relation as well as its two arguments are each expressed by a separate constituent, as in (1a). It is somewhat obscured by lexicalizations that conflate the causal relation with its effect argument, e.g., *kill* in (1b). Still, in both sentences the causal relation is contributed by an overt lexical item (*cause* in (1a), *kill* in (1b))—these, then, are ***overt causatives***. Least transparent are ***concealed causatives***, the type represented in (2). Here the causal relation appears to come from nowhere. At least, it cannot be traced to any overt word or morpheme. What is overtly expressed are only the arguments of this relation—that is, the two constituents that are understood to be related as the cause and the effect. The causal relation itself is syntactically concealed.

This mapping spectrum has implications for semantics. Some of them are well-known. Thus it has long been recognized that a causal relation which is syntactically expressed in a less transparent manner is semantically

* This research grew out of joint work with Ken Hale on an unusual causative construction in Miskitu. The analysis of Miskitu presented in section 6 is based on data from Ken's field work, and he kindly proofread this section. For the most part, the syntactic analysis was developed jointly. Also, the crosslinguistic hypothesis that concealed causatives form a natural semantic class emerged from that joint work. I am indebted to Hans Kamp for conversations which had radical impact on my thinking about events, time, and causation. Written reviews by, and discussions with Angelika Kratzer, Fred Landman, and Peter Lasersohn were very helpful. I have also benefited from comments by Edit Doron, Anita Mittwoch, Malka Rappaport, and the participants in colloquia, seminars, and conferences, at CUNY, MIT, Rutgers, Cornell, Tel Aviv University, and the Hebrew University in Jerusalem, where portions of this material were presented. This research was supported in part by the Institute for Advanced Studies at the Hebrew University in Jerusalem.

restricted to be ‘more direct’. This was originally noted by comparing two kinds of overt causatives (periphrastic *cause to die* vs. lexical *kill*; Fodor 1970). Extending the comparison to concealed causatives (such as the resultative *shoot dead*, discussed in Dowty 1979) reveals an even sharper semantic contrast—this is the locus of the main semantic cut. The judgements for the following diagnostic scenarios illustrate the general pattern.

The first scenario is a paradigm case of direct causation. There is a holdup in a bank. John shoots the robber through the heart so that she dies instantly. In this scenario all of the causatives (1)–(2) are judged clearly true. In the second scenario there is an intermediate cause. Suppose that John is not much of a shot. His bullet only grazes the robber’s ear, a trivial wound which unfortunately brings on a heart attack that causes instant death. The concealed causative (2) is now judged clearly false. In contrast, the judgements for overt causatives remain essentially unaffected, ranging from clearly true (for periphrastic (1a)) to basically true but misleading (for lexicalized (1b)).

The general pattern revealed by diagnostic tests of this kind can be described as follows:

(C) *Concealed Causative Semantics*

If a causal relation is syntactically concealed (only its arguments are overtly expressed), then it is semantically direct (no intermediate causes).

This generalization extends to causative constructions in languages that are genetically unrelated and typologically quite different. Also, the causal relation can be syntactically concealed in a wide variety of structures, ranging from resultative complements in English (3) to causative subjects in Miskitu (4).[1] Syntactically, then, concealed causatives do not form a natural class. Nevertheless, the unifying generalization (C) identifies a distinctive semantic profile: the implicit causal relation must be direct.

(3) John $[_{V'}$ $[_{V}$ shot] $[_{AP}$ the robber dead]].

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[1] The resultative structure in (3) is based on syntactic evidence presented in Stowell 1981, Rothstein 1983, Simpson 1983, Kayne 1984, Hoekstra 1988, and section 5 below. The structures assigned to the Miskitu sentences of (4) are justified in section 6. In particular, the evidence presented there supports the theory of syntactic predication developed in Williams 1980, Rothstein 1983, Stowell 1983, and Bittner & Hale 1996a. In keeping with that theory, the predicate in (4) is analyzed as a phrase of a lexical category (VP_j) and the internal subject, as a coindexed phrase of a functional category (CP_j).

(4) *Miskitu* (Misumalpan: Nicaragua)

a. yang man ra mai=pruk-ri kauh-ram

[[I you ACC 2=hit-OBV.1]$_{CPj}$ [fall]$_{VPj}$]$_{VP}$-PST.2

'I knocked you down.' (NOT: 'You fell because I hit you.')

b. yaptiki taim bani yang ra ai=pruk-an rais pi-sna

[[mother.1 time all me ACC 1=hit-OBV.3]$_{CPj}$ [rice eat]$_{VPj}$]$_{VP}$-PST.1

'My mother always beats me into eating rice.' (NOT: 'I eat rice because my mother always beats me.')

So even when syntactically far apart, concealed causatives still instantiate the same semantic phenomenon. The theory of the syntax–semantics interface in Universal Grammar must therefore be structured so that semantic parallels can be drawn across syntactic distinctions. Ideally, the theory should answer the following questions. Where does the understood causal relation come from? Why is it semantically restricted to be direct (no intermediate causes)? What sort of mechanism can enforce this semantic uniformity across a wide spectrum of syntactic structures converging only on the *absence* of any overt reflex of the causal relation? And how can this mechanism also be flexible enough to generalize across genetically and typologically unrelated languages?

The following discussion begins with the development of a general theory which has the right architecture to answer these questions in a natural way (sections 2–4). The theory is then fleshed out into detailed analyses of resultative complements in English (section 5) and causative subjects in Miskitu (section 6). It is shown that the fundamental semantic kinship of these two constructions follows from universal semantic principles, while the equally striking differences can be attributed to the interaction of these principles with different syntactic structures.

2. TOWARD A THEORY OF CONCEALED CAUSATIVES

2.1 *Three views of resultative complements*

Given that the causal relation in concealed causatives is not contributed by any overt lexical item, where could it come from? For resultative complements, which have been most extensively studied, different accounts have located the source in the lexicon, syntax, or compositional semantics. In lexical accounts the entry of the head verb undergoes a lexical operation which derives the causative meaning and adjusts the subcategorization frame accordingly (*e.g.*, Simpson 1983, Levin & Rapoport 1988, Carrier & Randall 1992). Syntactic accounts enrich the syntactic structure with a silent causative verb (*e.g.*, McCawley 1971, Huang 1988, Sybesma 1992). Finally, in semantic accounts the causal relation is an element of constructional meaning introduced by a compositional semantic rule (formally explicit in Dowty 1979; see also Goldberg 1995, and Levin & Rappaport Hovav 1995).

Lexical accounts are difficult to generalize to other concealed causative constructions because they crucially rely on the head-complement structure of resultatives. It is essential that there be a key lexical head whose basic meaning and subcategorization frame contains all of the relevant information. By manipulating the lexical entry of the head verb it is possible to account for resultative complements. But this account fails to extend to causative subjects of Miskitu, since subjects are not subcategorized by any lexical head.

The syntactic heterogeneity of concealed causatives is also difficult to reconcile with syntactic accounts. Positing a silent causative verb is plausible to the extent that it can be shown that the licensing requirements of this empty category give rise to the expected syntactic patterns—such as the subject-object asymmetries induced by the ECP. But no syntactic pattern of this sort fits even the small sample of concealed causatives illustrated above. The defining syntactic generalization—no overt reflex of the causal relation—clearly will not do. Otherwise, however, resultative complements of English bear little syntactic resemblance to causative subjects of Miskitu. It is in the semantics that the common denominator is found (generalization (C)).

The fact that the salient descriptive generalization for concealed causatives is best stated in semantic terms—the understood causal relation must be direct—points to a semantic account. That is, it lends initial plausibility to the view that the causal relation is an element of constructional meaning introduced by a semantic rule. This basic view can be made formally precise in a variety of ways, not all of which generalize to concealed causatives with different syntactic structures. In fact, the semantic approaches that have been proposed for English resultatives are even more construction-specific than the lexical and syntactic accounts. Still, the semantic analysis of Dowty (1979) captures important insights that the fully general theory should preserve.

Dowty's analysis is stated in the Montagovian rule-by-rule framework. A pair of rules accounts for the syntax (S26) and semantics (T26) of resultative phrases headed by transitive verbs (e.g., the phrase bracketed in (5a)), by initially deriving a complex causative predicate (5b–c). This complex is assigned the syntactic category of a transitive verb (TV), and so it combines with an object term (*the robber*) by the verb-object rule of PTQ.

S26. If $\delta \in P_{TV}$ and $\alpha \in P_{ADJ}$, then $F_{26}(\delta, \alpha) \in P_{TV}$, where $F_{26}(\delta, \alpha) = \delta\alpha$

T26. $F_{26}(\delta, \alpha)$ translates into: $\lambda\mathcal{P}\lambda x\, \mathcal{P}\{\hat{}\lambda y\, [\delta'(x, \hat{}\lambda QQ\{y\})$ CAUSE BECOME $\alpha'(y)]\}$

(5) a. John [*shot* the robber *dead*].

b. *shoot dead*, TV, 26

shoot, TV *dead*, ADJ

c. $\lambda\mathcal{P}\lambda x\, \mathcal{P}\{\hat{}\lambda y\, [\text{shoot}'_*(x, y)$ CAUSE BECOME $\text{dead}'(y)]\}$

Another pair of similar rules extends this account to resultative verb phrases headed by intransitive verbs (IV):

S27. If $\delta \in P_{IV}$ and $\alpha \in P_{ADJ}$, then $F_{27}(\delta, \alpha) \in P_{TV}$, where $F_{27}(\delta, \alpha) = \delta\alpha$

T27. $F_{27}(\delta, \alpha)$ translates into: $\lambda\mathcal{P}\lambda x\, \mathcal{P}\{\hat{}\lambda y\, [\delta'(x)$ CAUSE BECOME $\alpha'(y)]\}$

(6) a. The dog [*barked* me *awake*].

b. *bark awake*, TV, 27

bark, IV *awake*, ADJ

c. $\lambda\mathcal{P}\lambda x\, \mathcal{P}\{\hat{}\lambda y\, [\text{bark}'(x)$ CAUSE BECOME $\text{awake}'(y)]\}$

The Montagovian rule-by-rule framework has important virtues, not least the clarity of the empirical predictions. However, its construction-specific rules as well as the insistence on the rule-by-rule correspondence between syntax and semantics obscure certain generalizations. The class of concealed causatives is a case in point because the unifying semantic generalization (C) cuts across syntactic distinctions and extends to unrelated languages. Dowty's rules for resultative complements in English are too construction-specific to make any predictions for causative subjects in Miskitu. In fact, we do not even have to look this far. Coordination of resultative complements already falls outside of the scope of Dowty's theory:

(7) John [wiped [$_{AP}$ [$_{AP1}$ the table clean] *and* [$_{AP2}$ the glasses dry]].

The rules fail to predict that coordination is well-formed and that it leaves the understood causal relation unaffected. This is a problem because the causal relation is introduced as a semantic correlate of complex predicate formation in the syntax. Since this syntactic operation does not generalize to coordinated complements, the fact that the semantics does generalize is difficult to capture in the Montagovian rule-by-rule framework.

In spite of these problems, Dowty's basic insight—the understood causal relation comes from a semantic operation deriving a complex causative predicate—can be extended to the entire class of concealed causatives. The problems can be traced to aspects of the Montagovian framework which make it difficult to express semantic generalizations independently of the syntax. By shifting to a type-driven framework, we can factor out the unifying semantic pattern, recognizing semantics as autonomous enough to speak with its own voice.

2.2 *Causative type lifting*

The rule-by-rule correspondences in the Montagovian framework crucially rely on the assumption that the syntactic category determines the logical type. This assumption is problematic because it leads to a theory of syntactic categories that is not motivated on independent syntactic grounds. There are also counterintuitive semantic predictions—for example, for coordination of transitive verbs (Rooth & Partee 1982). Giving up this assumption has led to type-driven semantic theories, in which two meaningful sisters can be combined only by interpreting one as a functor (type of the form $\tau\upsilon$) and the other as an argument (type τ). If the initial types fail to match, they may be adjusted by certain semantic operations. Just what operations are permitted depends on the theory, but it is agreed that one of the options is type lifting (see, e.g., Rooth & Partee 1982, van Benthem 1984, Groenendijk & Stokhof 1984, Partee 1987, Jacobson 1992, and Hendriks 1993, for different developments of this idea).

Viewed from this perspective, concealed causatives turn out to conform to a second semantic generalization:

(T) *Causative Type Mismatch*

- $\lambda x_e\ ((\alpha(x) \wedge \Delta\varphi) \cap it_1 \propto it_0)$

  α_{et}:[$\propto$] $\qquad \varphi_t$

- $\lambda y_e \lambda x_e\ ((\alpha(x, y) \wedge \Delta\beta(y)) \cap it_1 \propto it_0)$

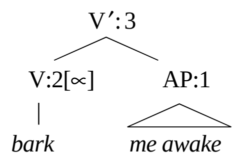
  α_{eet}:[$\propto$]! $\qquad \beta_{et}$

That is, somewhere in the structure there is a characteristic type mismatch. Either a property (type *et*, assuming the simple theory of types of Church 1940) must be combined with a proposition (type *t*) into a new property; or else a relation (type *eet*) must be combined with a property (type *et*) into a new relation. A plausible hypothesis, therefore, is that the type-lifting operator which resolves this mismatch (*low causative* [$\propto$] or *high causative* [$\propto$]!) fills in, as the default semantic link, the direct causal relation (denoted by '$\propto$'; the *change-of-state* operator 'Δ' is similar to 'BECOME', and *dynamic intersection* '$\cap$', to '$\wedge$'. The formal language used here, *ELA*, extends Dekker's 1994 predicate logic with anaphora *PLA*. It is defined in Appendix 1, and its special features are discussed in sections 4–5.)

Transparent examples of this type-lifting operation are provided by intransitive-based resultatives (8), and transitive-based resultatives with the head of the resultative complement incorporated into the main verb (9):

(8) a. The dog [$_{V'}$ barked [$_{AP}$ me awake]].

b.



1 $\textbf{awk}(i)$

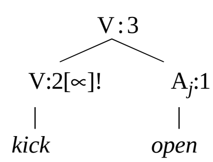
2 $\lambda x_e\, \textbf{brk}(x)$

$\lambda q_t\, \lambda x\, (.\textbf{brk}(x) \wedge \Delta q.\cap it_1 \propto it_0)$

3 $\lambda x\, (.\textbf{brk}(x) \wedge \Delta\textbf{awk}(i).\cap it_1 \propto it_0)$

(9) a. John [$_{V'}$ kicked open$_j$ [$_{AP}$ the door t_j]].

b.



1 $\lambda z_e\, \textbf{opn}(z)$

2 $\lambda y_e\, \lambda x_e\, \textbf{kck}(x, y)$

$\lambda Q_{et}\, \lambda y\, \lambda x\, (.\textbf{kck}(x, y) \wedge \Delta Q(y).\cap it_1 \propto it_0)$

3 $\lambda y\, \lambda x\, (.\textbf{kck}(x, y) \wedge \Delta\textbf{opn}(y).\cap it_1 \propto it_0)$

As we will see, this account is flexible enough to generalize to concealed causatives with quite different syntactic structures. That is, a concealed causative characteristically involves a type mismatch that can be resolved by a causative type-lifting operator—[$\propto$] or [$\propto$]!—the source of the understood causal relation (generalization (T)). That is why the causal relation is syntactically concealed. It does not come from the basic meaning of any terminal node, but rather from a semantic adjustment operation that resolves an initial type mismatch which could be anywhere in the LF tree. Since the source is unique—the causative type lifting family—so is the causal relation thus introduced, $\propto$. Concealed causatives, therefore, form a natural semantic class (generalization (C)). The class is syntactically varied because type lifting is sensitive only to logical types, not to syntactic categories, X-bar levels, etc. Causative type lifting, therefore, can apply in a wide variety of syntactic structures. It is also available in typologically unrelated languages because type lifting is an integral component of the Universal Grammar. Thus, the cluster of properties characterizing the class of concealed causatives receives a natural account.

Intuitively, this account is similar to Dowty's—the understood causal relation is introduced by a semantic operation that links the overtly expressed arguments into a complex causative predicate. The similarity is especially clear given the Montagovian category-to-type correspondence that Dowty assumed. However, it is precisely by recognizing the independence of logical types from syntactic categories that the type-driven recasting of Dowty's idea succeeds in extending it from resultative complements to other syntactic varieties of concealed causatives. Only then can the unifying semantic generalization (T) be factored out from incidental details of the syntactic structure.

Furthermore, the type lifting approach reveals that concealed causation is not an isolated phenomenon. Other elements of constructional meaning can also be attributed to type-lifting operations (cf. Carlson 1977, Partee 1986, 1987). That is, causative type lifting can be seen as part of a general theory of constructional meaning. In the next section a theory of this kind is outlined within the type-driven framework of Cross-Linguistic Semantics (=: XLS, developed in Bittner 1994a, b, 1997a, b, 1998). A formally precise statement is given in Appendix 2.

3. TYPE-DRIVEN THEORY OF CONSTRUCTIONAL MEANING

3.1 *Parallels between type lifting and movement*

In XLS—a transformational theory of semantics—type lifting plays a similar role to movement in syntax and assimilation in phonology. All three are adjustment operations in different domains of Universal Grammar. In each domain the input is a representation with ill-fitting parts—suboptimal sound combinations, misplaced syntactic constituents, or mismatched meanings. The adjusted output representation is closer to the ideal defined by the filtering component. The adjustment may be achieved, in part, by introducing certain 'filler elements'—assimilated phonological features, silent syntactic objects (such as gaps, indices or additional landing sites), or logical constants.

Indeed, the type-lifting system of the semantic XLS theory (Table 1) is point-for-point parallel to the system of movement operations in the syntactic GB framework (Chomsky 1981, 1986, and many others).

Table 1. *Type lifting system,* $^{\Uparrow}\mathrm{ME} := \cup_\tau\{[\cap]_\tau, [\cap]!_\tau, [=]_\tau, [=]!_\tau, [\exists]_\tau, [\exists]!_\tau, [\propto]_\tau, [\propto]!_\tau, [\forall]_\tau, [\forall]!_\tau, [()]_\tau, [()]!_\tau\}$

	From	*To*	*Definition*
$[\cap]_\tau$	τ	$\tau\tau$	$\lambda v_\tau\, \lambda u_\tau\, [u \cap v]$
$[\cap]!_\tau$	τt	$(tt)t$	$\lambda P_{\tau t}\, \lambda W_{tt}\, W(\cap P)$
$[=]_\tau$	τ	τt	$\lambda v_\tau\, \lambda u_\tau\, [u = v]$
$[=]!_\tau$	τt	$\tau\tau t$	$\lambda P_{\tau t}\, \lambda v_\tau\, \lambda u_\tau\, (P(u) \wedge v = v)$
$[\exists]_\tau$	τt	$(\tau t)t$	$\lambda P_{\tau t}\, \lambda Q_{\tau t}\, \exists v_\tau(P(v) \wedge Q(v))$
$[\exists]!_\tau$	τet	$(\tau t)et$	$\lambda A_{\tau et}\, \lambda Q_{\tau t}\, \lambda u_e\, \exists v_\tau(Q(v) \wedge A(u, v))$
$[\propto]_\tau$	τt	$t\tau t$	$\lambda P_{\tau t}\, \lambda q_t\, \lambda v_\tau\, (.P(v) \wedge \Delta q. \cap it_1 \propto it_0)$
$[\propto]!_\tau$	τet	$(\tau t)\tau et$	$\lambda A_{\tau et}\, \lambda Q_{\tau t}\, \lambda v_\tau\, \lambda u_e\, (.A(u, v) \wedge \Delta Q(v). \cap it_1 \propto it_0)$
$[\forall]_\tau$	$\tau\tau t$	$e(\tau\tau)t$	$\lambda R_{\tau\tau t}\, \lambda t\, \lambda f_{\tau\tau}\, \forall v_\tau(v \in \mathrm{Dom}\, f \rightarrow \mathrm{At}(t, R(f(v), v)))$
$[\forall]!_\tau$	$(\tau t)\tau et$	$e((\tau t)\tau)et$	$\lambda C_{(\tau t)\tau et}\, \lambda t\, \lambda h_{(\tau t)\tau}\, \lambda u_e\, \forall Q_{\tau t}(Q \in \mathrm{Dom}\, h \rightarrow \mathrm{At}(t, C(u, h(Q), Q)))$
$[()]_\tau$	$\tau\tau t$	$(\tau\tau)\tau\tau t$	$\lambda R_{\tau\tau t}\, \lambda f_{\tau\tau}\, \lambda v_\tau\, \lambda u_\tau\, R(u, f(v))$
$[()]!_\tau$	$(\tau t)\tau et$	$e((\tau t)t)(\tau t)et$	$\lambda C_{(\tau t)\tau et}\, \lambda t\, \lambda \mathscr{P}_{(\tau t)t}\, \lambda Q_{\tau t}\, \lambda u_e\, \mathscr{P}(\lambda v_\tau\, \mathrm{At}(t, C(u, v, Q)))$

Both systems of adjustment operations derive output that outranks the input on the relevant hierarchy—the c-command hierarchy in syntax, the type hierarchy in semantics. Types are ranked primarily by order, with ties partly resolved by rank (definition D5 in Appendix 2). Intuitively, a meaning of a higher type is more abstract. In both systems parallel locality constraints confine any adjustment (by 'Move α', or rule T) to either one cyclic domain—IP or DP in syntax, scope of function application in semantics—or at most two. Also, each kind of adjustment is performed by a family of operations that accept input of different categories in syntax, or different types in semantics. Thus, parallel to the cross-categorial nature of syntactic movement, semantic type lifting is cross-type.

The two systems further share a highly symmetric internal organization. In both, adjustment operations are sorted according to the 'weight' of the input into levels, forming a closed hierarchy. In syntax 'weight' is measured by the bar-level of the category to be moved—level 0 (X^0 movement) or level 2 (XP movement). In semantics the measure is the rank of the initial type (see under '*From*' in Table 1). The lowest level begins at rank 0 (families [∩] and [=]), the intermediate level at rank 1 ([∃] and [∝]), and the top level at rank 2 ([∀] and [()]). At each hierarchical level two kinds of outputs can be derived by two families of operations, one more 'argument-oriented' than the other. In syntax this is the familiar distinction between A-movement and A′-movement (Chomsky 1981, Li 1990).

Similarly, in semantics type lifting families are either *rank-oriented*, adding an argument and thus increasing the initial rank by 1 (as [=], [∝], and [()]), or *order-oriented*, increasing the order rather than the rank (as [∩], [∃], and [∀]). Finally, the operations of each family come in two varieties, one slightly more complex than the other. Thus, syntactic movement may involve either just substitution into a base-generated position, or an extra adjunction operation which creates a landing site (Chomsky 1986). Likewise, in semantics type lifting may be either *low* $[\ldots]_\tau$ or *high* $[\ldots]!_\tau$, with the high variant applying to input of the next higher rank than its low counterpart.

These symmetry patterns as well as the parallels between syntax and semantics presumably reflect very general principles transcending domain divisions of the Universal Grammar. Whatever these principles may be, they effectively confine the system of adjustment operations, in syntax as well as semantics, to a rigid template. It is difficult to modify or expand either system, be it movement or type lifting, without breaking the symmetry patterns of this system or the isomorphism to the twin system in the other domain. So even though type lifting has the power to introduce substantive elements of meaning (‘∩’, ‘∧’, ‘=’, ‘∃’, ‘∝’, ‘∀’, or ‘At’), the theory still provides a principled answer to the otherwise worrisome question: ‘Where does this power end?’

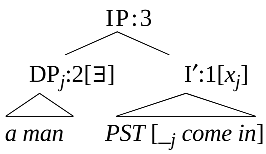
3.2 *Logical constants as default semantic links*

The power is useful because substantive type lifting can be seen as the general source of constructional meaning. On this view, elements of constructional meaning are predictable: they are logical constants filled in by type lifting operations to resolve various kinds of mismatch. In XLS this view is formalized by embedding the type lifting system of $^{\Uparrow}$ME in a strictly type-driven framework (an extension of Rooth & Partee 1982). The resulting theory of constructional meaning generalizes and unifies ideas from seemingly unrelated proposals.

As already discussed, Dowty’s (1979) idea that the causal relation in English resultatives is introduced by a compositional semantic rule emerges as a special case. So does the idea, articulated in various ways in Kamp 1981, Heim 1982, Partee 1986, and van Geenhoven 1996, that other semantic operations—termed ‘existential closure’ by Heim, or ‘semantic incorporation’ by van Geenhoven—contribute the existential force of indefinites in certain environments. In the present theory both elements of constructional meaning are introduced by the same basic operation—the type lifting rule T. To this extent they instantiate the same semantic phenomenon. The differences are due to the particular type lifting operators involved—causative (as in (8–9)) or existential (as in (10–11)):

(10) a. [$_{IP}$ A man [$_{I'}$ came in]].

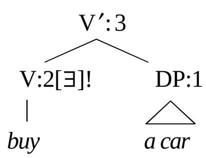
b.[2]



1	$\mathbf{cm}(x_j)$	$\{x_j\}$
	$\lambda x_j\ \mathbf{cm}(x_j)$	Ø
2	$\lambda y\ \mathbf{mn}(y)$	Ø
	$\lambda Q_{et}\ \exists y(\mathbf{mn}(y) \wedge Q(y))$	Ø
3	$\exists y(\mathbf{mn}(y) \wedge \mathbf{cm}(y))$	Ø

(11) a. John [$_{V'}$ bought [$_{DP}$ a car]].

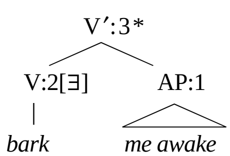
b.



1	$\lambda y\ \mathbf{cr}(y)$	Ø
2	$\lambda y\ \lambda x\ \mathbf{buy}(x, y)$	Ø
	$\lambda Q_{et}\ \lambda x\ \exists y(Q(y) \wedge \mathbf{buy}(x, y))$	Ø
3	$\lambda x\ \exists y(\mathbf{cr}(y) \wedge \mathbf{buy}(x, y))$	Ø

As far as rule T is concerned, the choice of the type lifting operator is free. All that this local rule requires is initial type mismatch (as in Rooth & Partee 1982). So in addition to the desired translations we also get, *e.g.*:

(12)



1	$\mathbf{awk}(i)$	Ø
2	$\lambda y\ \mathbf{brk}(y)$	Ø
	$\lambda Q_{et}\ \exists y(\mathbf{brk}(y) \wedge Q(y))$	Ø
3	??? **Initial Filter*	

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[2] Sorted individual variables are henceforth abbreviated as: x, y, z (object sort), t, t' (time sort, see Appendix 1). In LFs node annotations indicate how the final translation is related to the initial one. If there is no annotation, the two are identical, by the copying rule K′. Otherwise, the final translation is derived by the variable binding rule B if the annotation is or begins with a variable, or by the type lifting rule T if the annotation is or begins with an operator (see Bittner 1998).

(13) IP:3*

DP$_j$:2[∝] I′:1

a man *PST* [$\_{j}$ *come in*]

1	$\mathbf{cm}(x_j)$	$\{x_j\}$
2	$\lambda y\ \mathbf{mn}(y)$	Ø
	$\lambda q_t\, \lambda y(.\mathbf{mn}(y) \wedge \Delta q.\cap it_1 \propto it_0)$	Ø
3	$\lambda y(.\mathbf{mn}(y) \wedge \Delta\mathbf{cm}(x_j).\cap it_1 \propto it_0)\,\{x_j\}$	**Type Filter*, **Store Filter*

These *improper translations* are ruled out by semantic filters (D6 in Appendix 2), which check the interpreted LF as a whole. Constituents such as (12)—meaningless in spite of meaningful parts, due to unresolved type mismatch—violate the Initial Filter. The interpreted LF (13) fails to pass the Type Filter (which requires a translation of the propositional type *t* for the root) as well as the Store Filter (which demands an empty final store). [3] Type lifting, then, is free up to the filtering component—a yet another parallel to syntactic movement.

Departing from tradition, this theory does not directly correlate any element of constructional meaning with any particular structural element—*e.g.*, the causal relation with a resultative complement (as in Dowty 1979), or the existential quantifier with an indefinite (as in Kamp 1981, Heim 1982, Partee 1986, 1987, van Geenhoven 1996). Instead, structural elements channel the interpretation in indirect ways—by giving rise to a type mismatch that can be resolved by certain type lifting operators in the right sort of semantic environment for the output to survive the semantic filters. If other structural means can guide the interpretation into the same channel, then the same type lifting operation is predicted to take place, introducing the same element of constructional meaning.

Bearing out this general prediction, concealed existential quantifiers are also attested in absence of indefinites. A case in point is the verb *consider* in sentences like (14). In Bittner 1998 I proposed that this verb basically denotes a triadic relation to a structured proposition and that it combines with its small clause complement as follows: [4]

(14) John [$_{V'}$ *considers*$_i$ [$_{AP}$ [Bill *Op*$_i$] smart]]

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[3] These semantic filters obviate the need for certain syntactic filters—such as the Theta Criterion, which is a special case of the Type Filter, and Full Interpretation, whose intuitive content is subsumed under the Initial and Final Filters. The Store Filter is standard in all storage systems (e.g. Cooper 1985).

[4] In step 2, the initial translation of *consider* relates this verb to *believe* (compared below), which translates into **bel**. In the final translation the temporal relation 'At' (cf. Dowty 1979, Kamp & Reyle 1993), introduced by [∀]!, is ignored at this point pending detailed discussion in section 5. Also, the variable store is henceforth omitted—it can be recovered as the set of free variables with compositionally visible indices (meta-language variables *i*, *j*, *k*, or *n*, as on x_j in (13)).

(14′) $\tau = e$

$\mathrm{V}'{:}3$

$\mathrm{V}_i{:}2\langle[\forall]!_\tau, [\exists]!_{(\tau t)\tau}\rangle$ $\quad$ $\mathrm{AP}{:}1[h_{i,(\tau t)\tau}]$

consider $\quad$ [*Bill Op*$_i$] *smart*

1 $h_{i,(\tau t)\tau}(\mathbf{sm}) = b$

$\lambda h_i[h_i(\mathbf{sm}) = b]$

2 $\lambda P_{\tau t}\, \lambda y_\tau\, \lambda x\, \mathbf{bel}(x, P(y))$

$[\exists]!_{(\tau t)\tau}([\forall]!_\tau(\lambda P\, \lambda y\, \lambda x\, \mathbf{bel}(x, P(y))))$

$\equiv\ \lambda H_{((\tau t)\tau)t}\, \lambda x\, \exists h_{(\tau t)\tau}(H(h) \wedge \forall Q_{\tau t}[Q \in \mathrm{Dom}\ h \rightarrow \mathbf{bel}(x, Q(h(Q)))])$

3 $\lambda x\, \exists h(h(\mathbf{sm}) = b \wedge \forall Q[Q \in \mathrm{Dom}\ h \rightarrow \mathbf{bel}(x, Q(h(Q)))])$

$\equiv\ \lambda x\, \mathbf{bel}(x, \mathbf{sm}(b))$

The small clause initially denotes a proposition—as required by the Type Filter—but not the proposition that Bill is smart. Instead, its subject-predicate structure is made compositionally visible to the verb *consider* by means of a variable over functions from properties to objects that can instantiate them. This variable, $h_{i,(et)e}$, is introduced by a gap—Op_i, licensed by the verb and interpreted by rules E and B(c)—and it is bound in the final translation. The result is a higher order property which determines a class of event concepts and so can be intuitively thought of as such (Kim 1973, 1976). Since type lifting is cross-categorial—all τt-meanings are treated as a class—the small clause complement of (14′) is now on a par with the indefinite *a car* of (11), which denotes a property to begin with.

Initially, the verb *consider* is of the wrong type to combine with its small clause complement because it denotes a relation to a structured proposition (type schema $(\tau t)\tau et$; cf. Cresswell & von Stechow 1982). The type mismatch is resolved, in part by interpreting the small clause as above, and in part by type lifting *consider* in two cycles. In the first cycle the meaning of this verb is transformed into a diadic relation (type $((\tau t)\tau)et$). This renders the underlyingly triadic verb *consider* typewise parallel to the diadic verb *buy*, reducing the type mismatch in (14′) to a variant of (11). Both mismatches are resolved by the high existential operator with a suitable type index—$[\exists]!_e$ applied directly in (11), or $[\exists]!_{(et)e}$ applied on the second cycle in (14′). The final reduction in (14′) follows from the semantics of the translation language, ELA, given in Appendix 1 (see Bittner 1998 for a sketch of a proof).

This analysis immediately generalizes to small clauses with propositional logical subjects. Once again, the type-driven nature of semantic operations—$[\forall]!$, $[\exists]!$, and the rules that introduce and bind variables—enables them to recognize semantic parallels across syntactic differences that are not relevant to compositionality.

(15) John [$_{V'}$ considers$_i$ [$_{AP}$ it$_i$ obvious [Op_i that Bill is smart]]

(15′) $\tau = t$

V′:3

V$_i$:2$\langle[\forall]!_\tau, [\exists]!_{(\tau t)\tau}\rangle$ AP:1[$h_{i,(\tau t)\tau}$]

consider *it$_i$ obvious* [*Op$_i$ that* …]

1 $h_{i,(\tau t)\tau}(\mathbf{obv}) = \mathbf{sm}(b)$

$\lambda h_i[h_i(\mathbf{obv}) = \mathbf{sm}(b)]$

2 $\lambda P_{\tau t}\, \lambda q_\tau\, \lambda x\, \mathbf{bel}(x, P(q))$

$[\exists]!_{(\tau t)\tau}([\forall]!_\tau(\lambda P\, \lambda q\, \lambda x\, \mathbf{bel}(x, P(q)))$

$\equiv\ \lambda H_{((\tau t)\tau)t}\, \lambda x\, \exists h_{(\tau t)\tau}(H(h) \wedge \forall Q_{\tau t}[Q \in \mathrm{Dom}\ h \rightarrow \mathbf{bel}(x, Q(h(Q)))])$

3 $\lambda x\, \exists h(h(\mathbf{obv}) = \mathbf{sm}(b) \wedge \forall Q[Q \in \mathrm{Dom}\ h \rightarrow \mathbf{bel}(x, Q(h(Q)))])$

$\equiv\ \lambda x\, \mathbf{bel}(x, \mathbf{obv}(\mathbf{sm}(b)))$

So far the verb *consider* behaves just like *believe*, a classical propositional attitude. Both verbs take a clausal complement that must initially denote a proposition, to satisfy the Type Filter. Also, both require this or a related proposition to hold in the possible worlds that conform to the beliefs of the individual referred to by the subject (Hintikka 1969). Nevertheless, the two verbs diverge in ways that follow from the proposed difference in logical type, and the type-driven operations of the XLS theory—crucially including existential type lifting. The verb *believe* is of type *tet*, relating an individual to a proposition as a whole. In contrast, *consider* is of type $(\tau t)\tau et$ where τ is either *e* (as in (14′)) or *t* (as in (15′)). As a consequence, the logical subject-predicate structure of the propositional complement is also compositionally relevant.

For example, if the propositional complement is a disjunction, the connective can be exported over *consider* but not over *believe*. The valid argument (16) instantiates the equivalence (16′) (valid in ELA as defined in Appendix 1):

(16) John considers [[Bill smart] *or* [Anne brilliant]].

$\vDash$ [John [considers Bill smart]] *or* [John [considers Anne brilliant]].

(16′) $\exists h_{(et)e}(.h(\mathbf{sm}) = b \vee h(\mathbf{br}) = a. \wedge \forall Q_{et}[Q \in \mathrm{Dom}\ h \rightarrow \mathbf{bel}(j, Q(h(Q)))])$

$\equiv\ \mathbf{bel}(j, \mathbf{sm}(b)) \vee \mathbf{bel}(j, \mathbf{br}(a))$

In contrast, (17) is invalidated by a scenario in which John has made up his mind that one of the disjuncts holds but not which one—this, of course, follows from the classical semantics for propositional attitudes (Hintikka 1969).

(17) John believes [[that Bill is smart] *or* [that Anne is brilliant]].

$\not\models$ [John [believes that Bill is smart] *or* [John [believes that Anne is brilliant]].

(17′) $\mathbf{bel}(j, \mathbf{sm}(b) \vee \mathbf{br}(a))$

$\not\models$ $\mathbf{bel}(j, \mathbf{sm}(b)) \vee \mathbf{bel}(j, \mathbf{br}(a))$

Furthermore, clausal coordination which mixes logical subjects of different types is disallowed in the complement of *consider* but is acceptable in the complement of *believe*.

(18) a.* John considers [[*Bill* smart] and [(it) obvious *that Anne is brilliant*]]

b. John believes [[that *Bill* is smart] and [that it is obvious *that Anne is brilliant*]]

This, too, is expected since only *consider*—an attitude to a structured proposition—is sensitive to the logical subject-predicate structure of its complement. To be precise, the type-driven analysis in (14′) and (15′) predicts unresolvable type mismatch—and hence exclusion by the Initial Filter—if subjects of different types are mixed.

Finally, substitution of a coextensive subject in the complement is truth-preserving for *consider* but not necessarily for *believe*. Thus, (19) is a valid argument, but (20) is not—as predicted by the proposed formalizations:

(19) John considers [*Bill* smart]. Bill is Anne’s husband.

$\models$ John considers [*Anne’s husband* smart].

(19′) $\exists h_{(et)e}(.h(\mathbf{sm}) = b \wedge \forall Q_{et}[Q \in \text{Dom } h \rightarrow \mathbf{bel}(j, Q(h(Q)))])$, $[b = \iota x\, \mathbf{hsb}(x, a)]$

$\models$ $\exists h_{(et)e}(.h(\mathbf{sm}) = \iota x\, \mathbf{hsb}(x, a) \wedge \forall Q_{et}[Q \in \text{Dom } h \rightarrow \mathbf{bel}(j, Q(h(Q)))])$

(20) John believes [that *Bill* is smart]. Bill is Anne’s husband.

$\not\models$ John believes [that *Anne’s husband* is smart].

(20′) $\mathbf{bel}(j, \mathbf{sm}(b))$, $[b = \iota x\, \mathbf{hsb}(x, a)]$

$\not\models$ $\mathbf{bel}(j, \mathbf{sm}(\iota x\, \mathbf{hsb}(x, a)))$

Thus recasting ‘existential closure’ and ‘semantic incorporation’ as type lifting yields a more general theory of concealed existential generalization. The resulting semantic theory is autonomous enough to draw its own parallels and distinctions, independently of the syntax. Existential type lifting unifies a syntactically varied class because the key type mismatch may arise due to different syntactic elements—including, to be sure, indefinites (as in (10–11)), but also verbs with small clause complements (as in (14–15)). Conversely, classes of similar syntactic elements—such as the verbs *consider* and *believe*—are split by differences in logical type.

In Bittner 1998, 1997a, b, I present evidence that other type lifting operations of this system also extrapolate from prior proposals. Thus, the intersective family ($[\cap]_\tau$, $[\cap]!_\tau$) subsumes Montague’s (1973) intersective semantics for relative clauses, Abusch’s (1997) intersective semantics for temporal frame adverbials, as well as assorted maximization operations posited to explain various instances of concealed summation (Dayal 1996) or definiteness (Partee 1986, Rullman 1995). The identity family ($[=]_\tau$, $[=]!_\tau$) generalizes a type lifting operation from Partee’s (1986) analysis of pseudo-clefts. Karttunen’s (1977) semantics for proto-questions then emerges as another instance of the same type lifting operation. So do further instances of concealed identity in quite different syntactic environments—including, for example, structured small clauses (14–15) as well as possessed nominals. The universal family ($[\forall]_\tau$, $[\forall]!_\tau$) factors out concealed universal generalization from Engdahl’s (1986) semantics for functional *wh*-phrases. As expected by now, this move reveals new instances of this constructional meaning—for example, in small clause complements of *consider*. Finally, the functional family ($[()]_\tau$, $[()]!_\tau$), which does not introduce any constructional meaning apart from the temporal relation ‘At’, represents meaning-preserving type lifting, the kind that all theories allow (Rooth & Partee 1982, van Benthem 1984, Hendriks 1993, etc).

The XLS framework thus provides a general theory of constructional meaning without positing any essentially new semantic operations. Instead, a seemingly mixed bag of operations which have been posited under various headings is recast as instances of type lifting. The resulting type lifting system, $^{\Uparrow}$ME, is parallel to the system of movement operations in the syntax—an isomorphism which constrains both systems, as already discussed. Also, only two basic kinds of semantic adjustment are allowed—type lifting and variable binding—parallel to movement and deletion in the syntax. Integrated into a single system, different type lifting operations interact freely up to the filtering component—a freedom which radically expands the empirical coverage (see Bittner 1998, 1997a, b). Further empirical results follow from the general principles that govern the interaction of type lifting with other type-driven operations (such as variable binding and the semantics of gaps; see Appendix 2).

The detailed empirical analyses in sections 5 and 6 below show that this theory of constructional meaning provides a systematic account of concealed causatives parallel to the account of concealed existential quantification (illustrated in (11–20)). The only difference is in the type mismatch involved (generalization (T)) and hence in the choice of the type lifting family suited to resolve it (causative, $[\propto]_\tau$ or $[\propto]!_\tau$, instead of existential, $[\exists]_\tau$ or $[\exists]!_\tau$).

Some of these empirical results depend only on considerations of logical type. Type-wise, of course, the causative family fits into the type lifting system of $^{\Uparrow}$ME like hand in glove (section 3.1). Still, it appears to break one theoretically important pattern. The element of constructional meaning introduced by this family—the direct causal relation, $\propto$—appears to be a non-logical constant. If this were actually the case, then causative type lifting would be unlike any other type lifting operation ever proposed—raising serious doubts whether it is, in fact, an instance of type lifting. Before turning to detailed empirical analyses, I argue that these appearances are deceptive. Once pragmatic coarse-graining is taken into account, direct causation emerges as a strict partial order between events—the causal counterpart of familiar logical relations between points in time and space (denoted by *immediately before*, *immediately after*, etc). In each domain the context determines a discrete order so that immediate precedence is also well-defined. It is this logical relation—that is, immediate precedence in the pragmatically determined causal order—which causative type lifting contributes.

4. Logical Parallelism between Time, Space, and Causation

4.1 *Variable pragmatic coarse-graining*

The indexicals *here* and *now* generally behave as if they referred to indivisible point-like locations in space and time. These point-like locations, however, cannot be equated with points in the continuous space and time of classical physics. Unlike physicist's points, they can cover extended spatial regions or periods of time:

(21) a. We don't do such things *here*.

b. Nothing much is happening (*right*) *now*.

The extent depends on the context. Thus, the size of the region denoted by *here* varies widely depending on whether (21a) is said by an Alien to a visitor from Earth, an Israeli to an American, a teacher to a new student, etc. Likewise, the extent of (*right*) *now* in (21b) depends on whether the speaker is an astrophysicist debating the history of the Universe with a colleague, or a new-baked father discussing the development of the baby with his wife.

Similar observations hold for the adverb *immediately*. Again, the context determines how long, and how far, before counts as *immediately* before, and how far in the causal hierarchy one should look for the *immediate* cause.

(22) a. This happened [*immediately* before that].

b. This is located [*immediately* before that].

c. This was [the *immediate* cause of that].

The following dialogues illustrate this point for time (23) and causation (24). In (24) it is the 21st century and banks have surveillance cameras that film events at the molecular level (to facilitate DNA identification of any robbers).

(23) **Q**: When did Mary leave the party?

A: She left immediately before John.

• *Better informed observer*

B: No, she didn't. I saw her leave before Bill, and Bill left before John.

• *Pragmatically challenged observer*

C: No, she didn't. I watched the door the entire second before John left, and she didn't leave during that time.

(24) **Q**: What happened here?

A: A woman tried to rob a bank, and John shot her dead.

• *Better informed observer*

B: No, he didn't. His bullet just grazed her ear. But this frightened her so much that she had a heart attack, and that was the immediate cause of her death.

• *Pragmatically challenged observer* (watching replay on film)

C: No, he didn't. His bullet just started a long chain reaction. For when this molecule in his bullet got close to that molecule in her heart then their electrons repelled, and that made the heart molecule go that-a-way, which in turn caused …., and that (*last mentioned molecular event*) was the immediate cause of her death.

Intuitively, the objections of the better informed observer, B, are relevant, whereas those of the pragmatically challenged observer, C, are not. Even if what C says is absolutely true, his objections carry no force because they are too fine-grained for the discourse initiated by the topical question, Q, and A's pragmatically competent answer. The temporal and causal relations may be, in fact, just as C claims—after all, he watched the door in (23) and a replay on film in (24)—but events at this fine level of detail are simply not under discussion in this context.

In general, pragmatic coarse-graining pervades natural language discourse, affecting the interpretation of most temporal and spatial expressions (*instant*, *point*, *next to*, *and then*, *and there*, *adjacent*, etc) as well as expressions that treat time, space, and causation on a par (e.g., *throughout*, *from*, *almost*, *overlap*). These generalizations receive a natural account within the theory developed in the following subsections, which extends the event-based theory of coarse-grained time presented in Kamp 1979. The ideas informally discussed in the text are formalized in Appendix 1.

4.2 *From events to coarse-grained time*

In classical physics time and space are taken as primitives jointly forming a four-dimensional continuum. Events—such as particle motion—are defined in relation to that continuum. In contrast, Kamp (1979) argued that in order to understand the use of temporal expressions in natural language (his examples included temporal anaphora in narrative discourse, as well as the interpretation of *and then*, and *become*) it is better to reverse this sequence—a set of events, E, together with some basic temporal relations are taken as primitives, and this relational event structure is used to generate a temporal structure with the right grain for talking about these particular events.

The primitive temporal relations in Kamp's theory are overlap, $\bigcirc_E$, and precedence, $<_E$. The overlap relation is symmetric ($\boldsymbol{e} \bigcirc_E \boldsymbol{e}' \rightarrow \boldsymbol{e}' \bigcirc_E \boldsymbol{e}$) and reflexive ($\boldsymbol{e} \bigcirc_E \boldsymbol{e}$ for all $\boldsymbol{e} \in E$), while precedence is a strict partial order (irreflexive, $\neg \boldsymbol{e} <_E \boldsymbol{e}$ for all $\boldsymbol{e} \in E$, and transitive, $\boldsymbol{e} <_E \boldsymbol{e}' \;\&\; \boldsymbol{e}' <_E \boldsymbol{e}'' \rightarrow \boldsymbol{e} <_E \boldsymbol{e}''$). Additional postulates ensure that precedence, in one direction or the other, holds just in case there is no overlap, and that overlapping events count as a unit for the transitivity of precedence—that is, if $\boldsymbol{e}$ precedes $\boldsymbol{e}'$, $\boldsymbol{e}'$ overlaps with $\boldsymbol{e}''$, and $\boldsymbol{e}''$ precedes $\boldsymbol{e}'''$, then $\boldsymbol{e}$ must also precede $\boldsymbol{e}'''$ (strengthening the above transitivity requirement).

For example, these postulates admit the relational event structure $\mathscr{E} = \langle E, \bigcirc_E, <_E \rangle$ diagrammed in Fig. 1. The set $E = \{\boldsymbol{e}_1, \ldots, \boldsymbol{e}_7\}$ is the domain of events, the relation $\bigcirc_E$ is indicated by overlapping circles, and $<_E$, by precedence in the left-to-right order.

Fig. 1. *From events to granular time* (Kamp 1979)

	$\boldsymbol{e}_2$				$\boldsymbol{e}_6$			*Events*
$\boldsymbol{e}_1$		$\boldsymbol{e}_3$	$\boldsymbol{e}_4$	$\boldsymbol{e}_5$			$\boldsymbol{e}_7$	
ι_1		ι_2		ι_3	ι_4			*Instants*
$\{\iota_1\}$		$\{\iota_2\}$		$\{\iota_3\}$	$\{\iota_4\}$			*Periods*
ι_1		ι_2		ι_3	ι_4			
ι_1		ι_2		ι_3	ι_4			
ι_1		ι_2		ι_3	ι_4			

This event structure $\mathscr{E}$ generates an instant structure, $\langle I, <_I\rangle$. (The following construction goes back to Russell (1956) and Wiener (1914)). An $\mathscr{E}$-instant is a maximal set of pairwise overlapping events. To form such a set, start with any event—say, $\boldsymbol{e}_1$. If there is an overlapping event—e.g., $\boldsymbol{e}_2$—add it to the set. If there is a third event which overlaps with both of the above—here, $\boldsymbol{e}_3$—add that one too. Continue until you reach a point when adding another event would lead to failure of overlap with some event already in the set. In this case, the point has already been reached so $\iota_1 = \{\boldsymbol{e}_1, \boldsymbol{e}_2, \boldsymbol{e}_3\}$ is an $\mathscr{E}$-instant. So are $\iota_2 = \{\boldsymbol{e}_3, \boldsymbol{e}_4\}$, $\iota_3 = \{\boldsymbol{e}_5, \boldsymbol{e}_6\}$, and $\iota_4 = \{\boldsymbol{e}_6, \boldsymbol{e}_7\}$. This construction immediately explains why in a discourse about long-lasting events (such as those that make up the history of the Universe) the extent of the generated instants (e.g., the one denoted by *now*) is correspondingly long. In general, an instant generated by an event structure will be of the same order of magnitude as the events it consists of.

The order of precedence between events, $<_E$, determines the order of precedence between instants, $<_I$, as follows: an instant ι *I*-precedes an instant ι' just in case some event in ι *E*-precedes some event in ι'. For example, ι_1 *I*-precedes ι_2 in virtue of the fact that $\boldsymbol{e}_1 \in \iota_1$ *E*-precedes $\boldsymbol{e}_4 \in \iota_2$. It follows that *I*-precedence is not only a strict order (like $<_E$) but must also be total (which $<_E$ need not be, see Fig. 1). Of any two instants, one must *I*-precede the other—in contrast to events and periods, which may overlap. This is the sense in which instants are point-like. Even if they consist of many or long-lasting events, they are conceptualized as indivisible points along a time line.

The $\mathscr{E}$-instant structure, $\langle I, <_I\rangle$, in turn generates an *I*-period structure, $\langle T, <_T, \cup_T, [\ ]_T\rangle$. [5] This consists of a set of time periods, T, with a precedence relation $<_T$, temporal sum operation $\cup_T$, and a mapping $[\ ]_T$ from events to

[5] With an eye to the intended applications, I generate a slightly richer period structure than Kamp (1979).

temporal coordinates. A period is a convex set of instants—that is, a non-empty set of instants such that whenever two instants are in the set then so is any intervening instant (Fig. 1). The *I*-precedence relation between instants induces *T*-precedence between periods—a period θ *T*-precedes a period θ' iff every instant in θ *I*-precedes every instant in θ' (*e.g.*, $\{\iota_1, \iota_2\} <_T \{\iota_3, \iota_4\}$). The temporal sum $\theta \cup_T \theta'$ is the smallest period that includes both θ and θ'. Finally, the temporal coordinate $[\boldsymbol{e}]_T$ of an event $\boldsymbol{e}$ is the period just big enough to cover $\boldsymbol{e}$ (*e.g.*, $[\boldsymbol{e}_3]_T = \{\iota_1, \iota_2\}$).

So far, nothing guarantees that the generated time structure, $Tm(\mathscr{E}) = \langle\langle I, <_I\rangle, \langle T, <_T, \cup_T, [\ ]_T\rangle\rangle$, will be discrete. For suppose that the underlying event structure was infinite, containing one event for each non-empty set of real numbers, with precedence and overlap defined in the obvious way. This would generate a continuous time structure—to wit, the structure of real numbers, returning us to classical physics. The theory of Universal Grammar should exclude this possibility since no language has temporal expressions that require continuous temporal order, whereas expressions that crucially rely on discreteness are abundant (*immediately before*, *throughout*, *next*, *become*, etc).

I propose that linguistic time structures are discrete because the underlying event structures are necessarily finite. This constraint, in turn, can be understood if event structures are viewed as representations of chunks of reality under discussion in a particular context and of the level of precision appropriate for that discussion. In other words, linguistic events are not part of the continuous reality that surrounds us. They are part of a discrete conceptual structure that we may impose on this reality in order to talk about it. The issue is not what is out there, but rather how we choose to conceptualize it given our interests in a particular context. On this view, the domain of the event structure is the set of events and states that the discourse is about. In any context this set must be finite in view of the finite capacity of the human brain. Depending on the number and size of these topical events, the grain of the generated time structure will vary—from coarse-grained, if the topical events are few or long-lasting, to fine-grained, if they are short-lived and many. But even though the grain in principle can be refined to an arbitrary level of precision, the time structure generated by any finite event structure will be discrete—the desired result.

These ideas can be formalized—in a way compatible with the XLS theory of compositionality—as a typed logic with events and anaphora by extending the predicate logic with anaphora, *PLA*, presented in Dekker 1994 (see *ELA* in Appendix 1). The classical theory of context dependence (Kaplan 1979) is combined with a dynamic theory of context change (Stalnaker 1975, Kamp 1981, Heim 1982, Groenendijk & Stokhof 1991, etc). That is, a sentence is interpreted relative to an input state of information, and the output is an updated state. An information state is a set of cases, each of which consists of a world and a sequence of entities of various sorts—ordinary objects, events, periods, or regions (cf. Lewis 1975). Intuitively, these entities are salient in the world of the case and thus available for anaphoric reference by sorted donkey pronouns (he_i for objects, it_i for events, dn_i for periods, dr_i for regions). In addition, there are the classical parameters of evaluation: a model (M), a variable assignment (g), and a context (k):

(25) *Context coordinates* (1st guess)

$k = \langle \mathscr{E}_k, s_k, c_k \rangle$,

where $\mathscr{E}_k = \langle E, \bigcirc_E, <_E \rangle$ is a finite event structure

s_k is a non-empty information state

$c_k = \langle w_k, \langle o_k, o'_k, \{\iota_{k-}\}, \{\iota_k\}, \{\iota_{k+}\}\rangle\rangle$ is a case such that (i) $o_k, o'_k \in O$ (*objects*), and (ii) $\iota_{k-} <_I \iota_k <_I \iota_{k+}$

The context includes a finite event structure, $\mathscr{E}_k$, which represents the events under the discussion and vagueness resolution concerning their temporal boundaries. In addition, there is a non-empty information state, s_k, representing the presupposed background (Stalnaker 1975), and a case, c_k, specifying other features of the speech situation required to interpret indexical expressions (indicative mood, *I*, *you*, *PST*, *now*, *FUT*, etc). These features include the world of the utterance, w_k, the speaker o_k, the addressee o'_k (Kaplan 1979), a past reference point $\{\iota_{k-}\}$, current time $\{\iota_k\}$, and another reference point located in the future $\{\iota_{k+}\}$ (Reichenbach 1947, Partee 1973, 1984, Abusch 1997, etc).

In this formal language the key aspects of the meaning of (22a) can be represented as in (26a). The anaphoric demonstratives *this* and *that* translate into donkey pronouns, it_0 and it_1. These will be interpretable only if the initial information state, s, makes salient two discourse referents of the event sort—a requirement made explicit in (26b). Updating $s := \{\langle w, \ldots, \boldsymbol{e}, \boldsymbol{e}'\rangle| \ldots\}$ with the content of (22a) yields (26c) as the output state: [6]

(26) This happened *immediately before* that.

a. $s[\![{}^{\mathrm{T}}it_0 < {}^{\mathrm{T}}it_1 \wedge \forall t(t \neq {}^{\mathrm{T}}it_0 \wedge t < {}^{\mathrm{T}}it_1 \rightarrow t < {}^{\mathrm{T}}it_0)]\!]^{M, k, g}$

b. $\{\langle w, \ldots, \boldsymbol{e}, \boldsymbol{e}'\rangle| \ldots\}[\![{}^{\mathrm{T}}it_0 < {}^{\mathrm{T}}it_1 \wedge \forall t(t \neq {}^{\mathrm{T}}it_0 \wedge t < {}^{\mathrm{T}}it_1 \rightarrow t < {}^{\mathrm{T}}it_0)]\!]^{M, k, g}$

c. $\{\langle w, \ldots, \boldsymbol{e}, \boldsymbol{e}'\rangle| \ldots \;\&\; [\boldsymbol{e}']_T <_T [\boldsymbol{e}]_T \;\&\; \forall \theta \in T{:}\ \theta \neq [\boldsymbol{e}']_T \;\&\; \theta <_T [\boldsymbol{e}]_T \rightarrow \theta <_T [\boldsymbol{e}']_T\}$

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[6] The analysis in (26b–c) is simplified in ways that do not affect the point under the discussion (see Appendix 1, and section 4.4). Also, the semantic contribution of tense is ignored until section 5. For simplicity, I also ignore the fact that $\exists t$—like other quantifiers—may quantify over a contextually restricted domain, as in the following coherent discourse (Fred Landman, p.c.): *John left, and then the clock struck 12, and right afterwards Mary left. So she left immediately after John.*

That is, (22a) adds the information that the last mentioned event (***e*ʹ**) temporally precedes the one mentioned just before (***e***), and that the two are not separated by any period under the discussion ($\theta \in T$). This amounts to a ban on the intervention of any other topical event (see Fig. 1). ‘Dead time’ is ignored—which explains why anything from microseconds to aeons might elapse depending on whether the topic is nuclear fusion or history of the Universe.

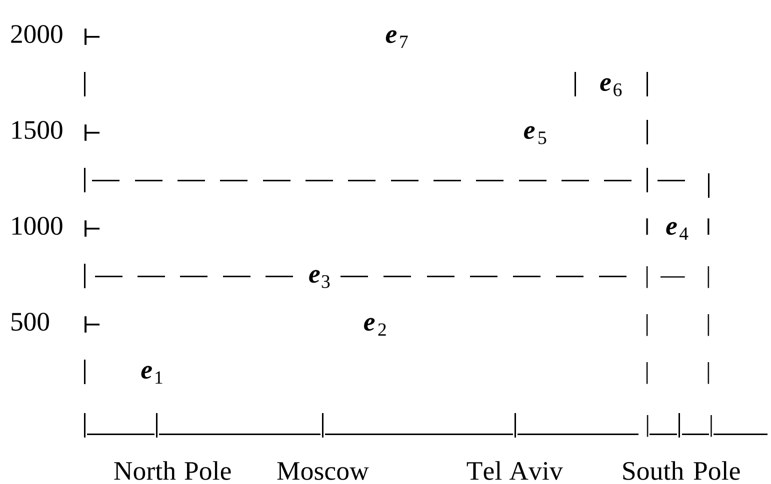
This analysis also explains the intuition that the objection of the better informed observer, B in (22), is valid. What he notes is that there is, in fact, an intervening event and hence at least one intervening instant. In contrast, the objection of the pragmatically challenged observer violates the maxim of relevance (Grice 1975). The topical question, Q, and A’s pragmatically competent answer indicate that the discourse is about ordinary human events such as departures. Since these events last more than a second, C’s remark that there are no such events in the second immediately prior to John’s leaving fails to add any new information in this context. That is, no cases are eliminated from the current state of information, which is why C’s remark is felt to be pragmatically deviant (Stalnaker 1978).

4.3 *Generalization to space*

In regard to pragmatic coarse-graining, temporal and spatial expressions behave alike. Indeed, the same lexical item often allows both uses, as (*immediately*) *before* in (22a–b). Also, the grain in the temporal and spatial domain tends to be similar—coarse if the discourse is about large-scale events, fine if the topical events are small. These patterns will follow if we assume that the same pragmatic event structure which imposes discrete structure on time in discourse also imposes similar structure on space in a closely analogous manner.

For example, suppose that the events from Fig. 1 are distributed in time and space as follows:

Fig. 2



This graph could be a report of interesting events along a line from the North Pole to the South Pole, via Moscow and Tel Aviv, between year 0 and a little over 2000. If these events are projected onto the temporal axis, we obtain the temporal diagram in Fig. 1. Projection onto the spatial axis yields the spatial diagram in Fig. 3, where overlapping circles now indicate spatial overlap ($\bullet_E$), while tangential circles represent spatial adjacency (∞_E): [7]

Fig. 3 *From events to granular space*

$\boldsymbol{e}_2$ *Events* (in space)

$\boldsymbol{e}_1$ $\boldsymbol{e}_3$ $\boldsymbol{e}_7$ $\boldsymbol{e}_5$ $\boldsymbol{e}_6$ $\boldsymbol{e}_4$

ι'_1 ι'_2 ι'_3 ι'_4 ι'_5 *Points*

ι'_1 ι'_2 ι'_3 ι'_4 ι'_5 *Directed paths*

— ———>
<— — — —
— — — >
<— — —
— — — — — >
<— — — — —

$\{\iota'_1\}$ $\{\iota'_2\}$ $\{\iota'_3\}$ $\{\iota'_4\}$ $\{\iota'_5\}$ *Regions*

ι'_3 ι'_4 ι'_5

ι'_3 ι'_4 ι'_5

ι'_1 ι'_2 ι'_3 ι'_4 ι'_5

Extended with these two spatial relations, the event structure generates a granular point structure, $\langle P, \infty_P, \langle P \rangle \rangle$. An $\mathscr{E}$-point is a maximal set of events that pairwise overlap in space. That is, points are generated like instants, except that the relevant overlap relation is spatial ($\bullet_E$) rather than temporal ($\bigcirc_E$). Since the two relations are independent, a set of events that qualifies as a point need not constitute an instant, nor vice versa (in Fig. 1–2, I and P are disjoint). Thus, points and instants are not conflated even though both are maximal sets of pairwise overlapping events. Adjacency between points (∞_P) is determined by event adjacency (∞_E) in the obvious way—two points are P-adjacent if they contain E-adjacent events—another similarity to the temporal domain (cf. the relation between $<_I$ and $<_E$). Parallel temporal and spatial uses of indexicals like (*immediately*) *before* reveal an underlying

[7] For ease of drawing, the space in the graph of Fig. 2 is one-dimensional. However, the key relations of spatial overlap and adjacency can hold between three-dimensional events as well, so the construction about to be discussed is fully general.

intuitive conception of space with a structure similar to the arrow of time. This is captured by the notion of a *directed path*—a sequence of points such that each non-final point is P-adjacent to the next point in the sequence (as in $\langle \iota'_5, \iota'_4, \iota'_3 \rangle$) unless there is only one point in the path (as in ι'_3).

We can now generate a spatial region structure, $\langle L, <_L, \cup_L, [\ ]_L \rangle$, similar to the temporal period structure, $\langle T, <_T, \cup_T, [\ ]_T \rangle$. A P-region is either the entire set of points, P, or else a path-connected subset—that is, a non-empty subset of P such that for any two points in that set there is a directed path from one point to the other (cf. periods, convex sets of instants). Spatial precedence is relative to a directed path. For example, $\{\iota'_5\}$ L-precedes $\{\iota'_3\}$ along the path $\pi_{11} := \langle \iota'_5, \iota'_4, \iota'_3 \rangle$—in symbols, $\{\iota'_5\} <_{L,\,\pi 11} \{\iota'_3\}$—because ι'_5 precedes ι'_3 in the sequence of points that constitutes π_{11}. The spatial sum $\theta \cup_L \theta'$ is the smallest region that includes both θ and θ' (cf. $\cup_T$). The spatial coordinate $[\boldsymbol{e}]_L$ of an event $\boldsymbol{e}$ is the region just big enough to cover $\boldsymbol{e}$ (e.g., $[\boldsymbol{e}_3]_L = \{\iota'_2\}$; cf. $[\boldsymbol{e}_3]_T = \{\iota_1, \iota_2\}$).

The enriched event structure underlying this construction requires a correspondingly richer view of the context:

(28) *Context coordinates* (2nd guess)

$k = \langle \mathscr{E}_k, s_k, c_k, \approx_k \rangle$,

where $\mathscr{E}_k = \langle E, \langle \bigcirc_E, <_E \rangle, \langle \bullet_E, \infty_E \rangle \rangle$ is a finite event structure

s_k is a non-empty information state

$c_k = \langle w_k, \langle o_k, o'_k, \{\iota_{k-}\}, \{\iota_k\}, \{\iota_{k+}\}, \{\iota'_k\}, \{\iota'_{k1}\}, \ldots, \{\iota'_{kn}\} \rangle \rangle$ is a case such that:

(i) $o_k, o'_k \in O$, (ii) $\iota_{k-} <_I \iota_k <_I \iota_{k+}$, and (iii) $\pi_k := \langle \iota'_k, \iota'_{k1}, \ldots, \iota'_{kn} \rangle \in \langle P \rangle$

$\approx_k$ assigns to each world w a relation $\approx_{k,\,w}$ from events in E to objects in O (of M) such that …

The context case is extended to represent the salient path from the point referred to by *here*—usually the spatial coordinate of the speaker—to the point denoted by *there*, $\pi_k := \langle \iota'_k, \iota'_{k1}, \ldots, \iota'_{kn} \rangle \in \langle P \rangle$ (cf. Kaplan 1979). This, of course, need not be the straight path. All that is required is point-to-point adjacency within the resolution determined by ∞_E. Depending on the context, the salient path could be the sequence of people in a winding line for check-in; or the sequence of stops along a particular bus route from Austin to Boston; or the sequence of planets circling around the sun, etc. The physical size of the points denoted by *here* and *there* will vary accordingly.

In this theory spatio-temporal locations are directly assigned—by the coordinate functions $[\ ]_L$ and $[\ ]_T$—only to events (more precisely, eventualities; Bach 1986). People and other entities of the object sort (determined by the model M) can be located only in virtue of a suitable relation, $\approx_{k,\,w}$, to entities of the event sort. I take this to be the stage relation of Carlson 1977—that is, $\boldsymbol{e} \approx_{k,\,w} o$, just in case the eventuality $\boldsymbol{e}$ is a stage of the object o in w and k.

The resulting theory factors out the contribution of *immediately before* shared by its temporal and spatial uses:

(26) This happened *immediately before* that.

$$\{\langle w, \ldots, \boldsymbol{e}, \boldsymbol{e}'\rangle | \ldots\}[\![{}^{\mathrm{T}}it_0 < {}^{\mathrm{T}}it_1 \wedge \forall t(t \neq {}^{\mathrm{T}}it_0 \wedge t < {}^{\mathrm{T}}it_1 \rightarrow t < {}^{\mathrm{T}}it_0)]\!]^{M,\,k,\,g}$$

$$= \{\langle w, \ldots, \boldsymbol{e}, \boldsymbol{e}'\rangle | \ldots \;\&\; [\boldsymbol{e}']_T <_T [\boldsymbol{e}]_T \;\&\; \forall\theta \in T\text{: } \theta \neq [\boldsymbol{e}']_T \;\&\; \theta <_T [\boldsymbol{e}]_T \rightarrow \theta <_T [\boldsymbol{e}']_T\}$$

(29) This is located *immediately before* that.

$$\{\langle w, \ldots o, o'\rangle | \ldots\}[\![\neg\neg\exists e\exists e'(e \approx he_1 \wedge e' \approx he_0 \wedge {}^{\mathrm{L}}e' < {}^{\mathrm{L}}e \wedge \forall l(l \neq {}^{\mathrm{L}}e' \wedge l < {}^{\mathrm{L}}e \rightarrow l < {}^{\mathrm{L}}e'))]\!]^{M,\,k,\,g}$$

$$= \{\langle w, \ldots o, o'\rangle | \ldots \;\&\; \exists \boldsymbol{e}, \boldsymbol{e}'(\boldsymbol{e} \approx_{k,\,w} o \;\&\; \boldsymbol{e}' \approx_{k,\,w} o' \;\&\; [\boldsymbol{e}']_L <_{L,\,\pi k} [\boldsymbol{e}]_L$$

$$\&\; \forall\theta' \in L\text{: } \theta' \neq [\boldsymbol{e}']_L \;\&\; \theta' <_{L,\,\pi k} [\boldsymbol{e}]_L \rightarrow \theta' <_{L,\,\pi k} [\boldsymbol{e}']_L)\}$$

It is the relation of immediate precedence in a discrete order determined by the contextual event structure. Which order depends on the arguments of this relation. If the arguments are of the period sort, then the order is temporal ($<_T$, as in (26)). But if they are of the region sort, then it is the spatial order along the salient path ($<_{L,\,\pi k}$, as in (29)).

4.4 *Generalization to causal hierarchy*

In pretheoretical terms, an event $\boldsymbol{e}$ is *a cause* of an event $\boldsymbol{e}'$ in a world w just in case $\boldsymbol{e}$ occurred in w no later than $\boldsymbol{e}'$, and what happened in $\boldsymbol{e}'$ is determined by $\boldsymbol{e}$ in the sense that none of it would have taken place if it had not been for some fact about $\boldsymbol{e}$ (cf. Lewis 1973, Bennett 1988). Assuming event-based pragmatics, this causal relation can be seen as one more discrete order determined by the contextual event structure. That is, for each world w the event structure generates a *causal hierarchy* with a discrete structure similar to that generated for time and space. The cause relation is precedence between events in the causal hierarchy, parallel to precedence between instants, or points. Direct causation, on this view, is immediate precedence in the pragmatically determined causal order.

To make these ideas formally precise we need to extend our pragmatic event structures to include contextually relevant information about various possible worlds. Each of these worlds represents an alternative states of affairs—that is, what might have been and not just what is—considered a live possibility by the participants in the discourse:

($\mathscr{E}$) An *M-event structure* (for a model $M = \langle W, O, \subseteq_O, F\rangle$) is a structure $\mathscr{E} = \langle\langle E_0, W_0, |\,|\rangle, \langle \bigcirc_E, <_E\rangle, \langle \bullet_E, \infty_E\rangle\rangle$

where E_0 (*basic events under discussion*) is a non-empty finite set disjoint from $W \cup O$ (*worlds* and *objects*)

W_0 (*worlds under discussion*) is a non-empty finite subset of W

$|\,|$ assigns to each event $\boldsymbol{e} \in E_0$ a *factual description*, $\varnothing \subset |\boldsymbol{e}|_w \subseteq \{p \in \mathscr{P}(W_0)\colon w \in p\}$, for each $w \in W_0$

The alternative ways our world might have been are endless. But since only so many of them can be discussed in any given context, the relevant coordinates of the event structure—the domain of worlds, W_0, and the assignment of a factual description to each minimal event $\boldsymbol{e} \in E_0$ in each world $w \in W_0$—are finite just like the other coordinates. The causal hierarchy generated by this event structure will therefore be granular, like time and space—indeed, the grain in all three domains tends to be similar, being determined by (different aspects of) the same finite set of events.

Parallel to the instant structure $\langle I, <_I\rangle$ in the temporal domain, and the point structure $\langle P, \infty_P, \langle P\rangle\rangle$ in the spatial domain, this intensional event structure generates a world-dependent causal link structure, $\langle K_w, <_w, \propto_w\rangle$:

(K1) *Causal link structure* $\langle K_w, <_w, \propto_w\rangle$ generated for any world $w \in W_0$ by $\mathscr{E}$:

- ι is an $\mathscr{E}$*-description of* $[\boldsymbol{e}\backslash p]$*-alternatives* to w, $\iota \in K_w[\boldsymbol{e}\backslash p]$, iff ι is a maximal consistent set of propositions $(\{W_0 - p\} \cup \kappa \cup \kappa')$ such that $\kappa \subseteq |\boldsymbol{e}|_w - \{p\}$ and $\kappa' \subseteq \{|\boldsymbol{e}'|_w\colon [\boldsymbol{e}']_T \subseteq [\boldsymbol{e}]_T \;\&\; [\boldsymbol{e}']_L \subseteq [\boldsymbol{e}]_L\}$
- $\boldsymbol{e}$ *K-precedes* $\boldsymbol{e}'$ in w, $\boldsymbol{e} <_w \boldsymbol{e}'$, iff $[\boldsymbol{e}]_T \leqq_T [\boldsymbol{e}']_T \;\&\; |\boldsymbol{e}'|_w \neq \varnothing \;\&\; \forall q \in |\boldsymbol{e}'|_w\, \exists p \in |\boldsymbol{e}|_w\colon \cap K_w[\boldsymbol{e}\backslash p] \subset \cap K_w[\boldsymbol{e}'\backslash q]$
- $\boldsymbol{e}$ is *the immediate K-predecessor* of $\boldsymbol{e}'$ in w, $\boldsymbol{e} \propto_w \boldsymbol{e}'$, iff $\boldsymbol{e} <_w \boldsymbol{e}' \;\&\; \forall \boldsymbol{e}''\colon \boldsymbol{e}'' \neq \boldsymbol{e} \;\&\; \boldsymbol{e}'' <_w \boldsymbol{e}' \rightarrow \boldsymbol{e}'' <_w \boldsymbol{e}$

K_w assigns, to each event $\boldsymbol{e} \in E_0$ and descriptive fact $p \in |\boldsymbol{e}|_w$, the set of descriptions of the closest worlds where p fails to hold. Each description is a maximal consistent set of propositions formed in the following manner. Start with the negation of p, $(W_0 - p)$. If there are other descriptive facts of $\boldsymbol{e}$ in w—*i.e*, facts from $|\boldsymbol{e}|_w$ other than p—that are consistent with the negation of p, add as many of them as you can while maintaining consistency. (There may be several ways to do this). Continue with facts about other events that occurred in w within the same spatio-temporal location until you reach a point when adding another fact would render the set inconsistent. This construction, adapted from premise semantics for counterfactuals (Kratzer 1979, 1981, Lewis 1981), bears an obvious family resemblance to the construction of instants, and points, as maximal sets of pairwise overlapping events.

Corresponding to the strict temporal order between instants, $<_I$, we have a strict causal order between events, $<_w$. The latter order—intuitively, the relation ‘a cause of’—is only partial since not all events are causally related. An event $\boldsymbol{e}$ causally precedes $\boldsymbol{e}'$ in w, $\boldsymbol{e} <_w \boldsymbol{e}'$, just in case two conditions are met. One, $\boldsymbol{e}$ occurred in w either before or simultaneously with $\boldsymbol{e}'$. Secondly, nothing that happened in $\boldsymbol{e}'$ in w would have happened if it had not been for some fact about $\boldsymbol{e}$. That is, for each aspect of the effect $\boldsymbol{e}'$, the closest worlds where the relevant fact of the cause $\boldsymbol{e}$ is eliminated are among the closest worlds where this aspect of $\boldsymbol{e}'$ likewise vanishes. But not vice versa—departing from w just enough to eliminate some aspect of the effect $\boldsymbol{e}'$ is not enough to change any fact about the cause $\boldsymbol{e}$.

It is easy to show that $<_w$ is a strict order—transitive and irreflexive—like the intuitive relation '*a* cause of.' *The direct* cause of an event $\boldsymbol{e}'$ is its $<_w$-greatest cause—an event that caused $\boldsymbol{e}'$ in w and was caused by all the other causes. Thus the direct cause, if there is one, is unique. This relation, denoted by $\propto_w$, is irreflexive and asymmetric (like $<_w$) as well as intransitive (unlike $<_w$). It also follows that if $\boldsymbol{e}$ is the direct cause of $\boldsymbol{e}'$ and $\boldsymbol{e}'$ is the direct cause of $\boldsymbol{e}''$ then $\boldsymbol{e}$ is *a* cause of $\boldsymbol{e}''$ (by the transitivity of $<_w$) but not *the direct* cause of $\boldsymbol{e}''$ (by the intransitivity of $\propto_w$).

This analysis of event causation is similar, but not identical, to Lewis's (1973) counterfactual theory. Consider, for example, preemption. There are two kinds of bullets, red and blue. Both are deadly in isolation but if a red bullet encounters a blue one it turns it into popcorn. Aiming for the heart, John and Bill simultaneously shoot at Mary with a red bullet and a blue bullet, respectively. The two bullets meet as they are about to enter Mary's body. As expected, John's red bullet annihilates Bill's blue bullet so only the red bullet actually enters and does its grizzly work. In this scenario the resultative *John shot Mary dead* is clearly true so this should be an instance of direct causation. But how can John's shooting count as a cause, let alone the direct cause? After all, if he hadn't shot Mary with his red bullet then Bill's blue bullet would have succeeded in entering her heart and so she still would have died.

Lewis's solution is to appeal to a causal chain. John's shooting causes the red bullet to penetrate Mary's heart, which in turn causes her death. That is, John's shooting is a cause of Mary's death, but not the direct cause. This is incompatible with generalization (C), which predicts that *John shot Mary dead* should require direct causation.

The solution available in the present theory is that the shooting event—call it $\boldsymbol{e}_1$—is naturally individuated by three salient facts: that John shot off the red bullet (p_1), that the red bullet met and destroyed Bill's blue bullet (p_2), and that the red bullet forcefully entered a vital organ in Mary's body (p_3). Extending the boundary of the shooting event until the bullet enters Mary's heart, with its lethal qualities still intact, is justified since it is only at that point that John could be charged with having shot Mary (as opposed to having shot off his gun, for which p_1 would suffice). To identify the death event—call it $\boldsymbol{e}_2$—one fact, that Mary died (p_4), will do. Thus, $|\boldsymbol{e}_1|_w = \{p_1, p_2, p_3\}$ and

$|\boldsymbol{e}_2|_w = \{p_4\}$. Since p_4 counterfactually depends on p_3, $\boldsymbol{e}_1$ causally precedes $\boldsymbol{e}_2$ ($<_w$). Indeed, in this scenario it is the immediate predecessor ($\propto_w$), the desired result. In intuitive terms, the fine-grained individuation of the shooting induces a correspondingly fine-grained proximity order amongst possible worlds. Crucially, it identifies a class of closest worlds in which both John and Bill still shoot, the red bullet still destroys the blue bullet, but the red bullet somehow—by divine intervention perhaps—fails to enter Mary's body. In these worlds, of course, Mary lives.

The intuitions about the heart attack scenario also fall into place. The robber's heart attack—unlike a bullet penetrating her heart—is conceptualized as a separate event, not a fact that individuates John's shooting. This may be due, in part, to differences in predictability. It is known what kind of shooting leads to a bullet hole through the heart, but not what kind of shooting brings on a heart attack. Be it as it may, John's shooting, the robber's heart attack, and her death, are thought of as three separate events forming a causal chain. The shooting is a cause of the death ($<_w$), but not the direct cause (not $\propto_w$). The resultative *John shot the robber dead*, therefore, is false.[8]

If several causes compete, then none may qualify as the direct cause—*i.e.*, the one caused by all the others. Suppose Mary is shot by a firing squad consisting of John, Bill, and Charles. All three are expert marksmen so she dies with three bullets in her heart. In this scenario the resultative *John shot Mary dead* seems false—as expected since not only John's shooting, but also Bill's and Charles's qualify as causes of Mary's death, and none of these shootings caused the other two. In contrast, *The firing squad shot Mary dead* is clearly true. What happened is now presented as a single shooting event, with the three component shots either ignored or viewed as individuating facts.

Finally, we generate a causal chain structure, $\langle E_w, <_{w+}, \cup_w, [\ ]_w\rangle$—completing the parallelism with the temporal period structure, $\langle T, <_T, \cup_T, [\ ]_T\rangle$, and the spatial region structure, $\langle L, <_L, \cup_L, [\ ]_L\rangle$:

(K2) *Causal chain structure* $\langle E_w, <_{w+}, \cup_w, [\ ]_w\rangle$ generated for w by $\mathscr{E}$:

$\varepsilon = \langle \boldsymbol{e}_1, \ldots, \boldsymbol{e}_n\rangle \in E_0{}^n$ ($n \geq 1$) is a *w-event*, $\varepsilon \in E_w$, iff ($\boldsymbol{e}_1 \neq \boldsymbol{e}_n \rightarrow \boldsymbol{e}_1 \propto_w \boldsymbol{e}_2$ & $\ldots$ $\boldsymbol{e}_{n-1} \propto_w \boldsymbol{e}_n$)

ε *Cs-precedes* ε' in w, $\varepsilon <_{w+} \varepsilon'$, iff $\exists\langle \boldsymbol{e}_1, \ldots \boldsymbol{e}_n, \ldots, \boldsymbol{e}'_1 \ldots \boldsymbol{e}'_m\rangle \in E_w$: $\varepsilon = \langle \boldsymbol{e}_1, \ldots \boldsymbol{e}_n\rangle$ & $\varepsilon' = \langle \boldsymbol{e}'_1 \ldots \boldsymbol{e}'_m\rangle$

$\varepsilon \cup_w \varepsilon' := \langle \boldsymbol{e}_1, \ldots \boldsymbol{e}_n, \boldsymbol{e}'_1, \ldots \boldsymbol{e}'_m\rangle$ is the *w-sum* of any $\varepsilon = \langle \boldsymbol{e}_1, \ldots \boldsymbol{e}_n\rangle$ and $\varepsilon' = \langle \boldsymbol{e}'_1, \ldots \boldsymbol{e}'_m\rangle \in E_w$ s.t. $\boldsymbol{e}_n \propto_w \boldsymbol{e}'_1$

$[\varepsilon]_w := \cup\{|\boldsymbol{e}_i|_w : 1 \leq i \leq n\}$ is the *factual description* in w of $\varepsilon = \langle \boldsymbol{e}_1, \ldots \boldsymbol{e}_n\rangle \in E_w$

[8] The heart attack is naturally thought of as a fact about the death. But that amounts to conceptualizing the death as an event of dying, not a state of being dead—in conflict with the aspectual restrictions on resultative type lifting (see sec. 5).

Causal chains—the domain of entities of the event sort—are similar to directed paths, with events replacing points, and immediate causal precedence replacing spatial adjacency. That is, in any world w a causal chain is a sequence of events such that every non-final event is the immediate cause, in w, of the next event, unless the chain is trivial, consisting of one event only. Precedence amongst causal chains is similar to spatial precedence along a directed path. A causal chain ε precedes another chain ε′ in w, $\varepsilon <_{w+} \varepsilon'$, if there is a causal chain whose initial segment coincides with ε while the final segment coincides with ε′. The sum operation, on the other hand, is more like summation in the temporal domain—unlike spatial regions, both causal chains and time periods are associated with a natural direction of flow. Reflecting this, the sum of two causal chains $\varepsilon \cup_w \varepsilon'$ is obtained by extending ε with ε′ if this results in a causal chain—that is, if the last event in ε is the immediate cause in w of the first event in ε′; otherwise the sum is undefined. Finally, the causal coordinate $[\varepsilon]_w$ is the the union of the factual descriptions in w of all the events in the causal chain ε. Similarly for the temporal and spatial coordinates:

(T) $[\varepsilon]_T := \cup_T\{[\boldsymbol{e}_i]_T: 1 \leq i \leq n\}$ is the *Tm-coordinate* of $\varepsilon = \langle \boldsymbol{e}_1, \ldots \boldsymbol{e}_n\rangle \in E_w$

(L) $[\varepsilon]_L := \cup_L\{[\boldsymbol{e}_i]_L: 1 \leq i \leq n\}$ is the *Sp-coordinate* of $\varepsilon = \langle \boldsymbol{e}_1, \ldots \boldsymbol{e}_n\rangle \in E_w$

Extended in this way, our formal language captures the full parallelism between time, space, and causation:

(30) This happened *immediately before* that.

$$\{\langle w, \ldots, \varepsilon, \varepsilon'\rangle | \ldots\}[\![{}^{\mathrm{T}}it_0 < {}^{\mathrm{T}}it_1 \wedge \forall t(t \neq {}^{\mathrm{T}}it_0 \wedge t < {}^{\mathrm{T}}it_1 \rightarrow t < {}^{\mathrm{T}}it_0)]\!]^{M, k, g}$$

$$= \{\langle w, \ldots, \varepsilon, \varepsilon'\rangle | \ldots \;\&\; [\varepsilon']_T <_T [\varepsilon]_T \;\&\; \forall \theta \in T: \theta \neq [\varepsilon']_T \;\&\; \theta <_T [\varepsilon]_T \rightarrow \theta <_T [\varepsilon']_T\}$$

(31) This is located *immediately before* that.

$$\{\langle w, \ldots o, o'\rangle | \ldots\}[\![\neg\neg\exists e\exists e'(e \approx he_1 \wedge e' \approx he_0 \wedge {}^{\mathrm{L}}e' < {}^{\mathrm{L}}e \wedge \forall l(l \neq {}^{\mathrm{L}}e' \wedge l < {}^{\mathrm{L}}e \rightarrow l < {}^{\mathrm{L}}e'))]\!]^{M, k, g}$$

$$= \{\langle w, \ldots o, o'\rangle | \ldots \;\&\; \exists \boldsymbol{e}, \boldsymbol{e}'(\boldsymbol{e} \approx_{k, w} o \;\&\; \boldsymbol{e}' \approx_{k, w} o' \;\&\; [\boldsymbol{e}']_L <_{L, \pi k} [\boldsymbol{e}]_L$$

$$\&\; \forall \theta' \in L: \theta' \neq [\boldsymbol{e}']_L \;\&\; \theta' <_{L, \pi k} [\boldsymbol{e}]_L \rightarrow \theta' <_{L, \pi k} [\boldsymbol{e}']_L)\}$$

(32) This was the *immediate* cause of that.

$$\{\langle w, \ldots, \varepsilon, \varepsilon'\rangle | \ldots\}[\![it_0 < it_1 \wedge \forall e(e \neq it_0 \wedge e < it_1 \rightarrow e < it_0)]\!]^{M, k, g}$$

$$= \{\langle w, \ldots, \varepsilon, \varepsilon'\rangle | \ldots \;\&\; \varepsilon' <_{w+} \varepsilon \;\&\; \forall \varepsilon'' \in E_w: \varepsilon'' \neq \varepsilon' \;\&\; \varepsilon'' <_{w+} \varepsilon \rightarrow \varepsilon'' <_{w+} \varepsilon'\}$$

As already noted, the common denominator is the relation of immediate precedence in a pragmatically determined discrete order. This is the temporal order, $<_T$, for arguments of the period sort, the spatial order, $<_{L,\,\pi k}$, for arguments of the region sort, and the causal order, $<_{w+}$, for arguments of the event sort (i.e., trivial or extended causal chains).

This completes the development of a general theory of concealed causation as an instance of constructional meaning introduced by type lifting operators. More precisely, the hypothesis is that operators from the causative family introduce the direct causal relation, $\propto_w$, as the default semantic link that enables a property to take on an extra propositional argument (as in intransitive resultatives), or a relation to take on an extra property argument (as in transitive resultatives). I now turn to show in detail how this universal hypothesis explains the semantic behavior of resultative complements in English (section 5) as well as causative subjects in Miskitu (section 6).

5. Resultative Complements in English

5.1 *Aspectual restrictions*

It has long been recognized that in a resultative construction the verb and its complement are aspectually restricted. The verb must describe a dynamic event and the complement, a change of state (Dowty 1979, Hoekstra 1988). The distinction between events and states is also known to play a role in temporal anaphora (Kamp 1979, Partee 1984, Kamp & Reyle 1993). In the present theory these two phenomena are related—causative type lifting introduces two donkey pronouns which can only be interpreted if the verb and the resultative complement each provide an antecedent of the appropriate sort. This is enforced by dynamic intersection, $\cap$, which is like dynamic conjunction, $\wedge$, except that any donkey pronoun in the second conjunct must get its antecedent locally, from the first conjunct.

- $[\propto]_\tau$ τt $t\tau t$ $\lambda P_{\tau t}\,\lambda q_t\,\lambda v_\tau\,(.P(v) \wedge \Delta q.\cap it_1 \propto it_0)$

  $[\propto]!_\tau$ τet $(\tau t)\tau et$ $\lambda A_{\tau et}\,\lambda Q_{\tau t}\,\lambda v_\tau\,\lambda u_e\,(.A(u, v) \wedge \Delta Q(v).\cap it_1 \propto it_0)$

Based on evidence from temporal anaphora, I propose that an eventive sentence gives prominence to an event:

(33) John *shot* Mary.

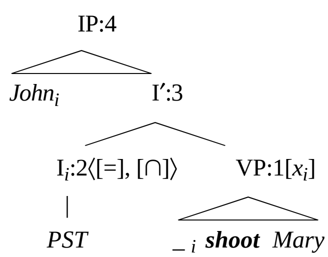
$s[\![\mathbf{sht}(j, m) \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n]]\!]^{M, k, g}$

$= \{c \cdot \boldsymbol{e} |\ c \in s\ \&\ \cap|\boldsymbol{e}|_{wc} \subseteq F(\mathbf{sht})(F(j), F(m))\ \&\ [\boldsymbol{e}]_T \subseteq \{\iota_{k-}\} \cup_T \{\iota_k\}\}$

On this view, for example, the update of an input information state s with the eventive sentence *John shot Mary* (evaluated relative to a model M, context k, and assignment g) would be represented in *ELA* as in (33). This denotes the set of extensions of cases c from s with an event $\boldsymbol{e}$ which meets the following conditions: the factual description of $\boldsymbol{e}$ in the world of c entails that John shot Mary, $\cap|\boldsymbol{e}|_{wc} \subseteq F(\mathbf{sht})(F(j), F(m))$; and $\boldsymbol{e}$ is temporally located within the contextually relevant past, $[\boldsymbol{e}]_T \subseteq \{\iota_{k-}\} \cup_T \{\iota_k\}$.

Compositionally, this representation can be derived as in (33′). The eventive verb contributes an implicit event argument (cf. Dekker 1993). The tense inflection denotes the contextually relevant past—that is, the period from the past reference point up to the present (cf. Abusch 1997). Sortal mismatch between the inflection (period sort) and the object-level property derived from the VP is resolved by type lifting with the intersective operator [∩]. This introduces an anaphoric link which in effect locates the implicit event argument of the verb within the time period denoted by the tense inflection (cf. Reichenbach 1947, Partee 1973, 1984, Kamp & Reyle 1993).

(33′)



1 $\lambda x_i\, \mathbf{sht}(x_i, m)$

2 $[-, n]$

$\lambda P_{et}(P \cap \lambda t'.\ t' = [-, n].)$

3 $(\lambda x_i\, \mathbf{sht}(x_i, m) \cap \lambda t'.\ t' = [-, n].)$

$\equiv \lambda x\, (\mathbf{sht}(x, m) \cap (he_0 = [-, n] \vee dn_0 \bigcirc \iota t'.\ t' = [-, n].\ \vee {}^{\mathrm{T}}it_0 \subseteq \iota t'.\ t' = [-, n].))$

$\equiv \lambda x\, (\mathbf{sht}(x, m) \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n])$

4 $\mathbf{sht}(j, m) \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n]$

Mutatis mutandis this analysis generalizes to stative stage-level predicates. These, too, have an implicit argument which interacts with temporal anaphora as the most prominent discourse referent. For stage-level statives, however, this argument is not the eventuality itself but rather its temporal location (cf. Kamp 1979, Partee 1984):

(34) Mary was *dead.*

$s[\![\mathbf{dd}(m) \wedge dn_0 \bigcirc [-, n]]\!]^{M, k, g}$

$= \{c \cdot [\boldsymbol{e}]_T |\ c \in s\ \&\ \cap|\boldsymbol{e}|_{wc} \subseteq F(\mathbf{dd})(F(m))\ \&\ [\boldsymbol{e}]_T \bigcirc_T \{\iota_{k-}\} \cup_T \{\iota_k\}\}$

This sortal shift, from eventualities to time periods, has implications for temporal anaphora. First of all, it is reflected in the output of the intersective type lifting operator [∩], which establishes the anaphoric link via a sorted donkey pronoun—it_0 for eventive predicates (as in (33′)), or dn_0 for stage-level statives (as in (34′)):

(34′)

IP:4

$Mary_i$ I′:3

I_i:2⟨[=], [∩]⟩   VP:1[x_i]

PRS   *be* [_ $_i$ ***dead***]

1	$\lambda x_i\, \mathbf{dd}(x_i)$
2	$\lambda P_{et}(P \cap \lambda t'.\ t' = [–, n])$
3	$(\lambda x_i\, \mathbf{dd}(x_i) \cap \lambda t'.\ t' = [–, n])$
	$\equiv \lambda x\, (\mathbf{dd}(x) \cap (he_0 = [–, n] \vee dn_0 \bigcirc \iota t'.\ t' = [–, n].\ \vee\ {}^{\mathrm{T}}it_0 \subseteq \iota t'.\ t' = [–, n].))$
	$\equiv \lambda x\, (\mathbf{dd}(x) \wedge dn_0 \bigcirc [–, n])$
4	$\mathbf{dd}(m) \wedge dn_0 \bigcirc [–, n]$

Moreover, the change-of-state operator, Δ, yields a non-empty information state only if its scope is stative:

(35) … [Mary *die*]$_{\mathrm{VP}}$

$$s[\![\Delta\mathbf{dd}(m)]\!]^{M,\,k,\,g}$$

$$= \{c \cdot \boldsymbol{e} \mid c \in s\ \&\ \cap|\boldsymbol{e}|_{wc} \subseteq F(\mathbf{dd})(F(m))$$

$$\&\ \exists\iota, \iota'\ ([\boldsymbol{e}]_T = \{\iota\}\ \&\ \iota' \propto_I \iota\ \&\ \neg\exists\boldsymbol{e}'([\boldsymbol{e}']_T = \{\iota'\}\ \&\ \cap|\boldsymbol{e}'|_{wc} \subseteq F(\mathbf{dd})(F(m))))\}$$

The times made salient by the cases in the scope of this operator (each a time throughout which the state holds) are scanned for the instants of transition—that is, for the first instant at which the state holds immediately after a period when it did not hold. The output information state is eventive. It consists of the extensions of cases from the input state of information with events representing the transition—formally, the temporal location of such an event coincides with the instant of transition and its factual description in the world of the case entails that the state holds.

In an aspectually acceptable resultative construction the head verb is an eventive predicate while the resultative complement is headed by a stage-level stative predicate (see below on individual-level statives):

(36) John [*shot* [Mary *dead*]].

$$s[\![\mathbf{sht}(j, m) \wedge \Delta\mathbf{dd}(m) \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]]\!]^{M,\,k,\,g}$$

$$= \{c \cdot \boldsymbol{e} \cdot \boldsymbol{e}' \cdot \langle \boldsymbol{e}, \boldsymbol{e}'\rangle \mid c \in s$$

$$\&\ \cap|\boldsymbol{e}|_{wc} \subseteq F(\mathbf{sht})(F(j), F(m))$$

$$\&\ \cap|\boldsymbol{e}'|_{wc} \subseteq F(\mathbf{dd})(F(m))$$

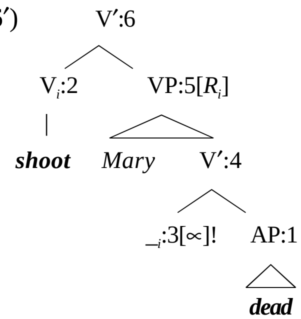
$$\&\ \exists\iota\ ([\boldsymbol{e}']_T = \{\iota\}\ \&\ \neg\exists\boldsymbol{e}'', \iota'\ (\iota' \propto_I \iota\ \&\ [\boldsymbol{e}'']_T = \{\iota'\}\ \&\ \cap|\boldsymbol{e}''|_{wc} \subseteq F(\mathbf{dd})(F(m))))$$

$$\&\ \boldsymbol{e} \propto_{wc} \boldsymbol{e}'$$

$$\&\ [\boldsymbol{e}]_T \cup_T [\boldsymbol{e}']_T \subseteq \{\iota_{k-}\} \cup_T \{\iota_k\}\}$$

Causative type lifting introduces the change-of-state operator, Δ, which turns this stative input into an eventive proposition:

(36′)



1 $\lambda y\ \mathbf{dd}(y)$

2 $\lambda y\ \lambda x\ \mathbf{sht}(x, y)$

3 $R_{i,\ eet}$

$\lambda P_{et}\ \lambda y\ \lambda x\ (.R_i(x, y) \wedge \Delta P(y).\cap it_1 \propto it_0)$

4 $\lambda y\ \lambda x\ (.R_i(x, y) \wedge \Delta\mathbf{dd}(y).\cap it_1 \propto it_0)$

5 $\lambda R_i\ \lambda x\ (.R_i(x, m) \wedge \Delta\mathbf{dd}(m).\cap it_1 \propto it_0)$

6 $\lambda x\ (.\mathbf{sht}(x, m) \wedge \Delta\mathbf{dd}(m).\cap it_1 \propto it_0)$

$\equiv \lambda x\ (\mathbf{sht}(x, m) \wedge \Delta\mathbf{dd}(m) \wedge it_1 \propto it_0)$

Thus, both of the donkey pronouns introduced by causative type lifting have local antecedents of the appropriate sort—it_1 refers to the implicit event argument of the verb (***e*** in (36)), and it_0, to the change-of-state event (***e′***). The former event is identified as the direct cause of the latter, and the causal chain of the two (⟨***e***, ***e′***⟩) is made salient. It is the entire chain, therefore, which the past tense inflection locates in the contextually relevant past (as in (33′)).

Other aspectual combinations fail because one or both of the donkey pronouns introduced by causative type lifting are uninterpretable: [9]

(37) a. John [shot/*resembled* [Bill dead]]. (* resultative reading with *resemble*)

b. John [shot [Mary dead/to death/**die*]]

c. John [hammered [the metal flat/thin/**beautiful*]].

d. John [pounded [the dough *(into) *a pancake*]].

For example, a stative head verb (such as *resemble* in (37a)) sets up a time as the most prominent discourse referent. This is of the wrong sort for the pronoun it_1, which requires an antecedent of the event sort. An eventive complement (e.g., *Mary die* in (37b)) leads to an aspectual clash with the change-of-state operator, which demands stative scope. This conflict, in turn, implies that there is no antecedent for it_0. The change-of-state operator also clashes with stative complements headed by individual-level predicates (such as the individual-level adjective

9 Formally, they refer to †, which leads to a violation of the Initial Filter within the minimal containing small clause.

beautiful in (37c), or the nominal predicate *a pancake* if the stage-level preposition *into* is omitted in (37d)). These predicates do not introduce any discourse referents that are relevant for temporal anaphora—either times or events.

5.2 *Negation*

Updating an information state *s* with the negation of φ yields the set of those cases in *s* that cannot be extended to any case in the update of *s* with φ:

(38) John did*n't* shoot Mary.

$s[\![\neg(\mathbf{sht}(j, m) \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n])]\!]^{M, k, g}$

$= \{c \in s | \neg\exists c': c \leqslant c' \;\&\; c' \in s[\![\mathbf{sht}(j, m) \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n]]\!]^{M, k, g}\}$

$= \{c \in s | \neg\exists \boldsymbol{e}: \cap|\boldsymbol{e}|_{wc} \subseteq F(\mathbf{sht})(F(j), F(m)) \;\&\; [\boldsymbol{e}]_T \subseteq \{\iota_{k-}\} \cup_T \{\iota_k\}\}$

In update semantics this explains the well-known fact that negation creates an anaphoric island. A discourse referent introduced in the scope of negation, as in (39a), is inaccessible to any external donkey pronoun (Karttunen 1976):

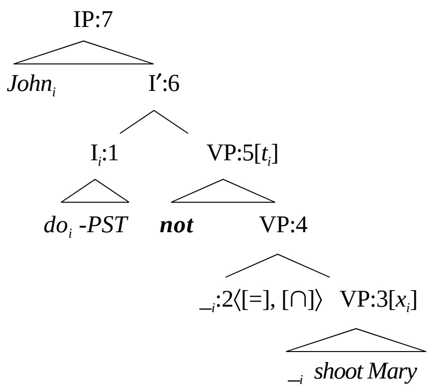
(39) a. [Bill does***n't*** [have *a car*]]. #*It* is black.

b. * John *shot* [Mary ***not*** [*alive*]].

The present theory extends this explanation to unacceptable resultatives with negated complements, such as (39b). These are excluded because negation makes the temporal discourse referent introduced by the stative predicate in its scope inaccessible to the change-of-state operator contributed by causative type lifting (cf. (35) and (36′)).

The parallel problem does not arise with sentential negation. Here the auxiliary verb incorporates into the tense inflection, as in (40). Its trace, in the scope of negation, is semantically identified with the inflected auxiliary, which I take to be equivalent to pure tense inflection (step 2, by rule E(b) motivated in Bittner 1994a, b, 1998). The key anaphoric relation can therefore be established, in the scope of negation, in the usual manner (steps 2–4):

(40)



1 $[-, n]$

2 t_i

$\lambda P_{et}(P \cap \lambda t'.\ t' = t_i.)$

3 $\lambda x_i\ \mathbf{sht}(x_i, m)$

4 $(\lambda x_i\ \mathbf{sht}(x_i, m) \cap \lambda t'.\ t' = t_i.)$

$\equiv\ \lambda x\ (\mathbf{sht}(x, m) \wedge {}^{\mathrm{T}}it_0 \subseteq t_i)$

5 $\lambda x\ \neg(\mathbf{sht}(x, m) \wedge {}^{\mathrm{T}}it_0 \subseteq t_i)$

$\lambda t_i\ \lambda x\ \neg(\mathbf{sht}(x, m) \wedge {}^{\mathrm{T}}it_0 \subseteq t_i)$

6 $\lambda x\ \neg(\mathbf{sht}(x, m) \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n])$

7 $\neg(\mathbf{sht}(j, m) \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n])$

5.3 *Export and import of connectives*

With regard to the export and import of connectives, resultative complements pattern like the complement of *consider*. That is, both laws are valid for disjunction and conjunction, provided that the scope of the export, and import, is restricted to the matrix V′ (crucially not including the matrix subject when that is quantified):

(41) a. John considers [[Bill smart] *or* [Anne brilliant]].

≡ [John [considers Bill smart]] *or* [John [considers Anne brilliant]].

b. John wiped [[the table clean] *or* [the glasses dry]].

≡ [John wiped [the table clean]] *or* [John wiped [the glasses dry]].

This parallel follows because the two constructions have similar logical forms:

(41′) a. $\exists h_{(et)e}(.h(\mathbf{sm}) = b \vee h(\mathbf{br}) = a.\ \wedge\ \forall Q_{et}[Q \in \mathrm{Dom}\ h \longrightarrow \mathrm{At}(n, \mathbf{bel}(j, Q(h(Q))))])$

b. $\exists h_{(et)e}(.h(\mathbf{cln}) = tb \vee h(\mathbf{dr}) = gl.\ \wedge\ \forall Q_{et}[Q \in \mathrm{Dom}\ h \longrightarrow \mathrm{At}([-, n], .\mathbf{wp}(j, h(Q)) \wedge \Delta Q(h(Q)).\ \cap\ it_1 \propto it_0)])$

Both equivalences in (41), with *or*, can therefore be derived as instances of the valid inference schema for the export and import of disjunction ($h.\vee$) (valid in *ELA* as defined in Appendix 1). Analogous equivalences with *and* follow from ($h.\wedge$) (provable by similar reasoning, sketched in Bittner 1998):

($h.\vee$) $\exists h_{(\tau t)\tau}(.h(\beta'_{1,\tau t}) = \beta_{1,\tau} \vee \ldots h(\beta'_{n,\tau t}) = \beta_{n,\tau}.\ \wedge\ \forall Q_{\tau t}[Q \in \mathrm{Dom}\ h \longrightarrow \mathrm{At}(\theta, \gamma_{(\tau t)\tau et}(\alpha_e, h(Q), Q))])$

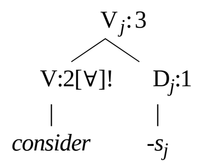
$\equiv\ \mathrm{At}(\theta, \gamma(\alpha, \beta_1, \beta'_1)) \vee \ldots \mathrm{At}(\theta, \gamma(\alpha, \beta_n, \beta'_n))$

(*h*.∧) $\exists h_{(\tau t)\tau}(.h(\beta'_{1,\tau t}) = \beta_{1,\tau} \wedge \ldots h(\beta'_{n,\tau t}) = \beta_{n,\tau}. \wedge \forall Q_{\tau t}[Q \in \text{Dom } h \rightarrow \text{At}(\theta, \gamma_{(\tau t)\tau et}(\alpha_e, h(Q), Q))])$

$\equiv \text{At}(\theta, \gamma(\alpha, \beta_1, \beta'_1)) \wedge \ldots \text{At}(\theta, \gamma(\alpha, \beta_n, \beta'_n))$

For the construction with *consider* the tenseless version of (41′a) (with one disjunct) was derived in section 3.2. The full derivation is spelled out in (42). It crucially relies on the configuration-driven theory of Case and agreement developed in Bittner & Hale 1996a, b, according to which accusative Case is assigned by V with an adjoined D: [10]

(42) a.



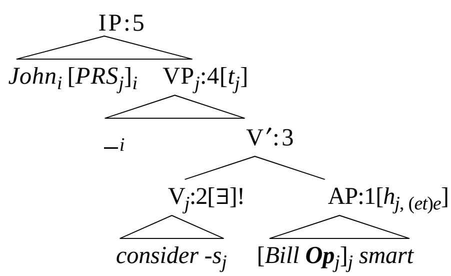
1 t_j

2 $[\forall]!(\lambda Q_{et}\, \lambda y\, \lambda x\, \mathbf{bel}(x, Q(y)))$

$\equiv \lambda t\, \lambda h_{(et)e}\, \lambda x\, \forall Q_{et}[Q \in \text{Dom } h \rightarrow \text{At}(t, \mathbf{bel}(x, Q(h(Q))))]$

3 $\lambda h\, \lambda x\, \forall Q[Q \in \text{Dom } h \rightarrow \text{At}(t_j, \mathbf{bel}(x, Q(h(Q))))]$

b.



1 $\lambda h_{j,(et)e}\, [h_j(\mathbf{sm}) = b]$

2 $\lambda H_{((et)e)t}\, \lambda x\, \exists h_{(et)e}(H(h) \wedge \forall Q_{et}[Q \in \text{Dom } h \rightarrow \text{At}(t_j, \mathbf{bel}(x, Q(h(Q))))])$

3 $\lambda x\, \exists h(h(\mathbf{sm}) = b \wedge \forall Q[Q \in \text{Dom } h \rightarrow \text{At}(t_j, \mathbf{bel}(x, Q(h(Q))))])$

4 $\lambda t_j\, \exists h(h(\mathbf{sm}) = b \wedge \forall Q[Q \in \text{Dom } h \rightarrow \text{At}(t_j, \mathbf{bel}(x_i, Q(h(Q))))])$

5 $\exists h(h(\mathbf{sm}) = b \wedge \forall Q[Q \in \text{Dom } h \rightarrow \text{At}(n, \mathbf{bel}(j, Q(h(Q))))])$

In English this D element is realized as an aspectual affix (-*s*, -*ed*, -*ing*, or -Ø), which can be interpreted as temporal agreement—an element which introduces a temporal variable (t_j) that gets bound by tense (PRS_j). In this way the tense inflection can be related to the verb even though type lifting with [∀]! traps the verb inside an anaphoric island.

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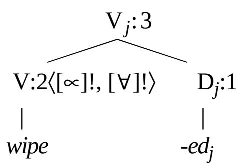
[10] Historically, the [$_V$ V, D] complex may arise, e.g., through reanalysis of an incorporated pronoun or of an antipassive affixal noun. Also, if the accusative object triggers agreement, this will be realized in the V-adjoined D (as in Miskitu (4)).

This analysis generalizes to transitive resultatives because causative type lifting transforms a meaning of type *eet* (the basic type of *wipe*) into a causative meaning of type (*et*)*eet* (the basic type of *consider*):

(43) a.



1 t_j

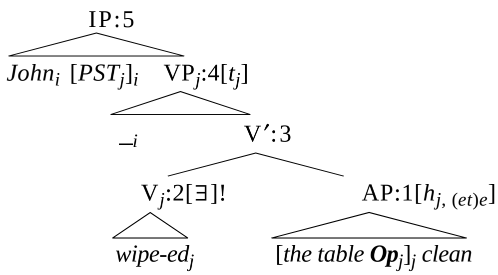
2 $[\forall]!([\propto]!(\lambda y\lambda x\ \mathbf{wp}(x, y)))$

$\equiv\ [\forall]!(\lambda Q_{et}\lambda y\lambda x\ [.\mathbf{wp}(x, y) \wedge \Delta Q(y).\cap it_1 \propto it_0])$

$\equiv\ \lambda t\lambda h_{(et)e}\lambda x\ \forall Q_{et}[Q \in \text{Dom } h \rightarrow \text{At}(t, .\mathbf{wp}(x, h(Q)) \wedge \Delta Q(h(Q)).\cap it_1 \propto it_0)]$

3 $\lambda h\lambda x\ \forall Q[Q \in \text{Dom } h \rightarrow \text{At}(t_j, .\mathbf{wp}(x, h(Q)) \wedge \Delta Q(h(Q)).\cap it_1 \propto it_0)]$

b.



1 $\lambda h_{j,(et)e}\ [h_j(\mathbf{cln}) = tb]$

2 $\lambda H_{((et)e)t}\ \lambda x\ \exists h_{(et)e}(H(h) \wedge \forall Q_{et}[Q \in \text{Dom } h \rightarrow \text{At}(t_j, .\mathbf{wp}(x, h(Q)) \wedge \Delta Q(h(Q)).\cap it_1 \propto it_0)])$

3 $\lambda x\ \exists h(h(\mathbf{cln}) = tb \wedge \forall Q[Q \in \text{Dom } h \rightarrow \text{At}(t_j, .\mathbf{wp}(x, h(Q)) \wedge \Delta Q(h(Q)).\cap it_1 \propto it_0)])$

4 $\lambda t_j\ \exists h(h(\mathbf{cln}) = tb \wedge \forall Q[Q \in \text{Dom } h \rightarrow \text{At}(t_j, .\mathbf{wp}(x_i, h(Q)) \wedge \Delta Q(h(Q)).\cap it_1 \propto it_0)])$

5 $\exists h(h(\mathbf{cln}) = tb \wedge \forall Q[Q \in \text{Dom } h \rightarrow \text{At}([-, n], .\mathbf{wp}(j, h(Q)) \wedge \Delta Q(h(Q)).\cap it_1 \propto it_0)])$

From that point onwards the two constructions become compositionally indistinguishable. Hence parallel semantic operations—crucially including type lifting with [∀]! and [∃]!—derive parallel logical forms and thus license the export and import of connectives in constructions of either kind.

5.4 *Export and import of quantifiers*

This theory correctly generalizes to the export and import of quantifiers. For example, assuming the logical forms in (44′) for sentences with imported quantifers, the equivalences in (44) instantiate the valid inference schema ($h.\wedge$). These are single case second order instances—that is, $n = 1$ and $\tau = et$.

(44) a. John [considers [*no theory* useful]].

$\equiv$ *no theory* is such that John [considers it useful].

b. John [wiped [*few tables* clean]].

$\equiv$ *few tables* are such that John [wiped them clean]

(44′) $\tau = et$

a. $\exists h_{(\tau t)\tau}(h(\lambda P_\tau \neg\exists y.\mathbf{thr}(y) \wedge P(y).) = \mathbf{usf}$

$\wedge\ \forall\mathfrak{Q}_{\tau t}[\mathfrak{Q} \in \text{Dom } h \longrightarrow \text{At}(n, \mathfrak{Q}(\lambda y\ \text{At}(n, \mathbf{bel}(j, h(\mathfrak{Q})(y))))))])$

b. $\exists h_{(\tau t)\tau}(h(\ \mathbf{few}(\mathbf{tbl})) = \mathbf{cln}$

$\wedge\ \forall\mathfrak{Q}_{\tau t}[\mathfrak{Q} \in \text{Dom } h \longrightarrow \text{At}([-, n], \mathfrak{Q}(\lambda y\ \text{At}([-, n], .\mathbf{wp}(j, y) \wedge \Delta h(\mathfrak{Q})(y). \cap it_1 \propto it_0)))])$

For example, the logical form (44′b)—with an imported quantifer—is equivalent to (45a), being related to it by valid λ-conversion. This, in turn, is equivalent to (45b), by a transparent instance of ($h.\wedge$). Finally, (45c)—with the exported quantifier—follows by valid λ-conversion, and the semantics of ‘At’ and ‘∩’:

(45) a. $\exists h_{(\tau t)\tau}(h(\ \mathbf{few}(\mathbf{tbl})) = \mathbf{cln}$

$\wedge\ \forall\mathfrak{Q}_{\tau t}[\mathfrak{Q} \in \text{Dom } h \longrightarrow \text{At}([-, n], \lambda\mathcal{P}_{\tau t}\lambda P_\tau\lambda x_e[\mathcal{P}(\lambda y\ \text{At}([-, n], .\mathbf{wp}(x, y) \wedge \Delta P(y). \cap it_1 \propto it_0))](j, h(\mathfrak{Q}), \mathfrak{Q}))])$

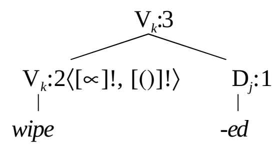
b. $\text{At}([-, n], \lambda\mathcal{P}_{\tau t}\lambda P_\tau\lambda x_e[\mathcal{P}(\lambda y\ \text{At}([-, n], .\mathbf{wp}(x, y) \wedge \Delta P(y). \cap it_1 \propto it_0))](j, \mathbf{cln}, \mathbf{few}(\mathbf{tbl})))$

c. $\mathbf{few}(\mathbf{tbl})(\lambda y.\mathbf{wp}(j, y) \wedge \Delta\mathbf{cln}(y) \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n].)$

The compositional interpretation of LFs with quantifiers is similar to that of LFs with referring terms:

(46) $\tau = et$

a.



1 t_j

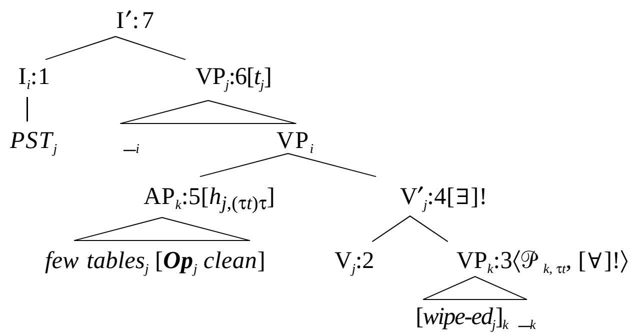
2 $[()]!([\propto]!(\lambda y\, \lambda x\, \mathbf{wp}(x, y))$

$\equiv [()]!(\lambda P_\tau\, \lambda y\, \lambda x\, [.\mathbf{wp}(x, y) \wedge \Delta P(y). \cap it_1 \propto it_0])$

$\equiv \lambda t\, \lambda \mathcal{P}_{\tau t}\, \lambda P\, \lambda x\, \mathcal{P}(\lambda y\, \mathrm{At}(t, .\mathbf{wp}(x, y) \wedge \Delta P(y). \cap it_1 \propto it_0))$

3 $\lambda \mathcal{P}\, \lambda P\, \lambda x\, \mathcal{P}(\lambda y\, \mathrm{At}(t_j, .\mathbf{wp}(x, y) \wedge \Delta P(y). \cap it_1 \propto it_0))$

b.



1 $[–, n]$

2 t_j

3 $\lambda t\, \lambda h_{(\tau t)\tau}\, \lambda x\, \forall \mathfrak{Q}_{(\tau t)t}[\mathfrak{Q} \in \mathrm{Dom}\, h \rightarrow \mathrm{At}(t, \mathfrak{Q}(\lambda y\, \mathrm{At}(t_j, .\mathbf{wp}(x, y) \wedge \Delta h(\mathfrak{Q})(y). \cap it_1 \propto it_0)))]$

4 $\lambda H_{((\tau t)\tau)t}\, \lambda x\, \exists h(H(h) \wedge \forall \mathfrak{Q}[\mathfrak{Q} \in \mathrm{Dom}\, h \rightarrow \mathrm{At}(t_j, \mathfrak{Q}(\lambda y\, \mathrm{At}(t_j, .\mathbf{wp}(x, y) \wedge \Delta h(\mathfrak{Q})(y). \cap it_1 \propto it_0)))])$

5 $\lambda h_{j,(\tau t)\tau}\, .h_j(\mathbf{few}(\mathbf{tbl})) = \mathbf{cln}.$

6 $\lambda t_j\, \exists h(h(\mathbf{few}(\mathbf{tbl})) = \mathbf{cln} \wedge \forall \mathfrak{Q}[\mathfrak{Q} \in \mathrm{Dom}\, h \rightarrow \mathrm{At}(t_j, \mathfrak{Q}(\lambda y\, \mathrm{At}(t_j, .\mathbf{wp}(x_i, y) \wedge \Delta h(\mathfrak{Q})(y). \cap it_1 \propto it_0)))])$

7 $\exists h(h(\mathbf{few}(\mathbf{tbl})) = \mathbf{cln} \wedge \forall \mathfrak{Q}[\mathfrak{Q} \in \mathrm{Dom}\, h \rightarrow \mathrm{At}([–, n], \mathfrak{Q}(\lambda y\, \mathrm{At}([–, n], .\mathbf{wp}(x_i, y) \wedge \Delta h(\mathfrak{Q})(y). \cap it_1 \propto it_0)))])$

The internal structure of the agreeing verb is the same, but the VP is syntactically a little more complex. To be precise, it has a shell structure (Larson 1988), with the agreeing verb generated in the lower shell, while the head of the higher shell is left empty (V_j). This gap is syntactically licensed by the tense inflection, and it is semantically identified with it (by rule E(b) in step 3). In effect, therefore, there are two place-holders for the tense inflection—temporal verb agreement (*-ed$_j$*) and the empty verb heading the higher shell (V_j). This makes it possible to type lift the agreeing verb with an extra operator, [()]!, which in turn makes the final verb meaning (step 4) compositionally compatible with the final meaning of the small clause (step 5). Note that the null operator which makes the subject-predicate structure of this small clause compositionally visible to the verb is adjoined to the adjectival predicate (*i.e.*, the logical subject of second order predication) not to the syntactic subject (the second order predicate). Also, the small clause must be raised to the matrix [SPEC, VP] at LF, to avoid unresolvable type mismatch.

For simple examples like (44) this analysis competes with a standard QR account, in which only the quantifier would raise (May 1977). But standard QR fails to generalize to equivalences with multiple quantifiers:

(47)a. John considers [[*few ideas* interesting] and [*no theory* useful]].

≡ [*few ideas* are s.t. John [considers them interesting]] and [*no theory* is s.t. John [considers it useful]].

b. John wiped [[*few tables* clean] and [*no glasses* completely dry]].

≡ [*few tables* are s.t. John [wiped them clean]] and [*no glass* is s.t. John [wiped it completely dry]].

Under the present analysis these equivalences follow without any new stipulations. They are multiple case ($n > 1$) second order ($\tau = et$) instances of ($h.\wedge$) if the connective is *and* (as in (47)), or of ($h.\vee$) if the connective is *or*.

5.5 *Simplification*

Though transitive resultatives have similar logic to constructions with *consider*—and other verbs of that logical type, such as *order*, *urge*, *ask*, *beckon*, *send*, *let*, etc—the extra step of causative type lifting implies a difference in relation to simplification. A transitive resultative with a referring term in the postverbal position entails both the inchoative of its small clause result (48), and the simple transitive sentence without the resultative predicate (49).

(48) Sam [*helped* [John out of the car]]. $\textbf{hlp}(s, j) \wedge \Delta\textbf{out-of}(j, c) \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n]$

$\models$ John *got* out of the car. $\models \quad \Delta\textbf{out-of}(j, c) \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n]$

(49) Sam [*helped* [John out of the car]]. $\textbf{hlp}(s, j) \wedge \Delta\textbf{out-of}(j, c) \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n]$

$\models$ Sam [*helped* John]. $\models \quad \textbf{hlp}(s, j) \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n]$

Both of these inferences follow from the semantics of dynamic conjunction, $\wedge$, intersection, $\cap$, and temporal donkey anaphora (see Appendix 1).

In contrast, neither inference is valid for *consider* and other verbs of that logical type (e.g., *order* in (50–51)): [11]

(50) Sam [*ordered* [John out of the car]]. $\mathbf{ord}(s, \Delta\mathbf{out\text{-}of}(j, c)) \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

$\not\models$ John *got* out of the car. $\not\models\ \Delta\mathbf{out\text{-}of}(j, c) \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

(51) Sam [*ordered* [John out of the car]]. $\mathbf{ord}(s, \Delta\mathbf{out\text{-}of}(j, c)) \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

$\not\models$ * Sam [*ordered* John]. (wrong meaning) $\not\models\ \mathbf{ord}(s, ???(j)) \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

This, too, is accounted for by this theory. The inference in (50) fails because, under the standard analysis, it is only in those worlds where John complies with the order that he gets out of the car, and those worlds, of course, need not include the one in which the sentence is uttered. Also, the verb *order*—like *consider*—relates an entity to a structured proposition, so the reduction in (51) leaves this triadic (*et*)*eet*-predicate unsaturated, in violation of the Type Filter.

5.6 *Selectional restrictions*

This theory further explains why a transitive verb imposes the same selectional restrictions on the postverbal nominal in simple transitives as it does in related resultatives.

(52) a. The bear scared *the campers*. $\mathbf{scr}(b, c) \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

b. The bear scared [*the campers* up into trees]. $\mathbf{scr}(b, c) \wedge \Delta\mathbf{up\text{-}in\text{-}tr}(c) \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

(53) a.# The bear scared *the campground*. # $\mathbf{scr}(b, cg) \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

b.# The bear scared [*the campground* empty] # $\mathbf{scr}(b, cg) \wedge \Delta\mathbf{emp}(cg) \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

In both constructions the postverbal nominal is interpreted as the innermost argument of the verb. Compositionally, this is accomplished by function application in simple transitives, and by causative type lifting in resultatives. But regardless of the compositional tools, the same selectional restrictions are expected if the relation denoted by the verb is partial (e.g., the innermost argument of the verb *scare* must denote an entity that is capable of experiencing fear), so that certain entities (such as the one referred to by *the campground*) fall outside of its domain.

[11] Goldberg (1995) cites both sentence types as instances of her 'caused motion construction,' although she notes that actual motion—in my terms, the inchoative of the directional PP small clause—is entailed only for verbs in the *help*-class (*assist*, *guide*, *walk* (tr.), *escort*, etc), not for the *consider*-class (*order*, *ask*, *beckon*, *urge*, *send*, *let*, etc).

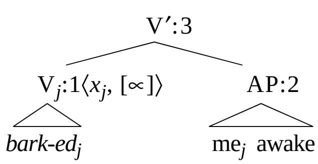
This solves a much debated problem in the syntactic literature on resultatives. Viewed in purely syntactic terms, resultatives give rise to a paradox. On the one hand, θ-Theory attributes selectional restrictions to θ-role assignment under sisterhood (Chomsky 1981). Hence the patterns of selection in (52–53) would imply that the post-verbal nominal is sister to the verb, ruling out the binary branching analysis of resultatives. On the other hand, ternary branching structures (Rothstein 1983, Simpson 1983, Carrier & Randall 1992, etc) make wrong predictions for coordination and incorporation. If both the post-verbal nominal and the resultative predicate are sisters to the verb, then the coordination facts are mysterious. So is the fact that cross-linguistically only the resultative predicate ever incorporates (as in (9)), never the post-verbal nominal. If both are sisters to the verb, why the asymmetry? The present theory resolves the paradox by maintaining binary branching in the syntax and shifting the task of explaining semantic selection to compositional semantics. Indeed, θ-Theory turns out to be entirely redundant. To the extent that it is correct, its predictions follow from the XLS theory of compositional semantics (recall ftn. 3).

5.7 *Intransitive resultatives*

Resultatives based on intransitive verbs can be derived by the low causative operator, [∝], if the agreement element in the verb (-*ed*$_j$ in (54′)) introduces a variable of the object sort (x_j) instead of the temporal sort (t_j in (42–43)):

(54) The dog *barked* me awake

(54′)



1 $[\propto](\lambda x_j\ \mathbf{brk}(x_j))$

$\equiv\ \lambda q_t\ \lambda y(.\mathbf{brk}(y) \wedge \Delta q.\cap it_1 \propto it_0)$

2 $\mathbf{awk}(i)$

3 $\lambda y(.\mathbf{brk}(y) \wedge \Delta\mathbf{awk}(i).\cap it_1 \propto it_0)$

$\equiv\ \lambda y(\mathbf{brk}(y) \wedge \Delta\mathbf{awk}(i) \wedge it_1 \propto it_0)$

This compositional analysis correctly aligns these constructions with transitive resultatives in relation to phenomena for which the type difference between the two variants of the causative operator is irrelevant—such as the aspectual restrictions (55), negation (56), and simplification (57–58) (compare (37), (39), and (48–49), respectively):

(55) a. The disabled $ship_j$ [drifted/**was adrift* [$\__j$ into the bay]].

b. The dog [barked [me awake/**wake up*]].

c. John [worked [himself sick/into a nervous breakdown/**mentally ill*]].

d. The $milk_j$ [froze [$\__j$ solid/*(into) *a block of ice*]].

(56) * The dog *barked* [me ***not*** [*asleep*]].

(57) The dog [*barked* [me awake]] — $\mathbf{brk}(d) \wedge \Delta\mathbf{awk}(i) \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

⊨ I woke up — $\models \Delta\mathbf{awk}(i) \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

(58) The dog [*barked* [me awake]] — $\mathbf{brk}(d) \wedge \Delta\mathbf{awk}(i) \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

⊨ The dog *barked*. — $\models \mathbf{brk}(d) \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

In contrast, results which crucially rely on the high variant of the causative operator, [∝]!, do not extend to intransitive resultatives. Thus, for example, we correctly predict that an intransitive verb will not impose any selectional restrictions on the post-verbal nominal since, semantically, this nominal is not an argument of the verb:

(59) The dog [*barked* [me awake]] — $\mathbf{brk}_{et}(d_e) \wedge \Delta\mathbf{awk}(i) \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [–, n]$

|≠ * The dog *barked* me. — $\not\models \mathbf{brk}_{et}(d_e)(i)$???… (ill-formed in *ELA*)

6. CAUSATIVE SUBJECTS IN MISKITU

The Misumalpan language Miskitu spoken in Nicaragua has a classical system of subject obviation (see, e.g., Hale 1965, Jacobsen 1967, Haiman & Munro 1983, and Finer 1985, on obviation, and Hale 1989, 1991, on Miskitu):

(60) *tuktan ba* dim-***i*** _ kik-an

[*child the* come.in-***PRX***$]_{CP}$ [*pro* laugh-PST.3$]_{IP}$

'The $child_j$ came in, and it_j laughed.'

(61) *tuktan ba* dim-***an*** *yang* kik-ri

[*child the* come.in-***OBV***.3$]_{CP}$ [*I* laugh-PST.1$]_{IP}$

'The child came in, and I laughed.'

The inflection in a subordinate clause takes one form (*proximate*, glossed ‘PRX’) if its subject is anaphorically linked to the matrix subject, and a different form (*obviative*, glossed ‘OBV’) otherwise. The subordinate clause is adjoined to the matrix, so a shared argument can be overtly realized in either clause of the chain.

(62) a. yang *sula kum* (*ra*) kaik-**ri** _ plap-an

[I *deer one* (*ACC*) 3.see-**OBV**.1]$_{CP}$ *pro* run-PST.3

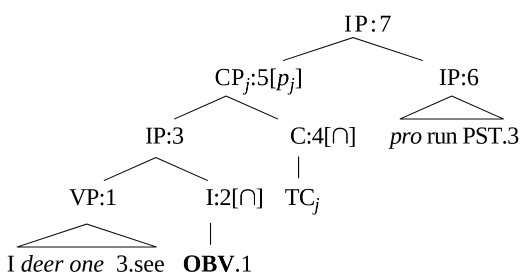
b. yang _ kaik-**ri** *sula kum* plap-an

[I *pro* 3.see-**OBV**.1]$_{CP}$ *deer one* run-PST.3

BOTH: ‘I saw a deer$_j$, and it$_j$ ran.’

Semantically, the two clauses form a temporal chain (TC). Transposing the theory of temporal anaphora developed in Partee 1973, 1984, and Kamp 1979, we can interpret such a chain as in (63). The operator [–/dn_0] (defined in Appendix 1) sets the past reference point, for the proposition in its scope, to the time referred to by dn_0:

(63)



1 $\exists y(\mathbf{dr}(y) \wedge \mathbf{see}(i, y))$

2 $\lambda q_t .q \cap \exists t(- < {}^{T}it_0 \propto t < n).$

3 $\exists y(\mathbf{dr}(y) \wedge \mathbf{see}(i, y)) \cap \exists t(- < {}^{T}it_0 \propto t < n)$

4 $\lambda q_t .q \cap [-/dn_0]p_{j,t}.$

5 $\lambda p_j .(\exists y(\mathbf{dr}(y) \wedge \mathbf{see}(i, y)) \cap \exists t(- < {}^{T}it_0 \propto t < n)) \cap [-/dn_0]p_j.$

6 $\mathbf{rn}(he_0) \cap {}^{T}it_0 \subseteq -$

7 $(\exists y(\mathbf{dr}(y) \wedge \mathbf{see}(i, y)) \cap \exists t(- < {}^{T}it_0 \propto t < n)) \cap [-/dn_0](\mathbf{rn}(he_0) \cap {}^{T}it_0 \subseteq -)$

$\equiv \exists t \exists y(\mathbf{dr}(y) \wedge \mathbf{see}(i, y) \wedge - < {}^{T}it_0 \propto t < n \wedge \mathbf{rn}(y) \wedge {}^{T}it_0 = t)$

In Miskitu this canonical use of obviative morphology is extended to a typologically unusual construction in which the obviative clause expresses a cause, and the matrix clause, its immediate effect (Hale 1991). Simple causative chains look just like temporal chains. In a causative chain, though, the obviative cause verb must be transitive (see section 6.7 below), and either the object or its possessor must be shared with the matrix (section 6.6):

(64) a. man *yang* *ra* ai=pruk-**ram** _ kauh-ri

[you *me* *ACC* 1=hit-**OBV**.2] *pro* fall-PST.1

'You knocked me down.'

b. witin _ mun-**ka** *yul* *ba* (yang ra) ai=sam-bia

[he *pro* 3.*R*-**FUT.OBV**.3] *dog* *the* (me ACC) 1=bite-FUT.3

'He will *R* the dog into biting me.'

The cause verb may also be semantically 'bleached'—as the verb *mun-* glossed '*R*' in (64b), whose bleached semantics is manifest in (65).

(65) Muih-ki _ ai=*mun*-an

brother-1 pro$_j$ 1$_j$=*R*-PST.3

'My brother *R*-ed me.' (*R* = hit, push, cut, etc, depending on the context)

Superficial similarities notwithstanding, causative chaining is syntactically distinguished from temporal chaining by the interaction with control. When embedded under a control verb, the subject of the obviative clause in a temporal chain cannot be controlled (66), as expected for the subject of an adjunct (compare (67) in English).

(66) * *yang* _ sula kum (ra) kaik-rika _ plap-aia ***want*** sna

I [[*PRO* deer one (ACC) 3.see-FUT.OBV.1]$_{CP}$ [pro run-INF]$_{IP}$]$_{IP}$ ***want*** PRS.1

(67) * *I* ***want*** [[as soon as *PRO* see a deer]$_{CP}$ [it to run]$_{IP}$]$_{IP}$

In contrast, control is possible for the subject of the obviative clause in a causative chain (68a–b) (Hale 1992). This suggests that the obviative clause itself is a subject (like XP$_j$ in (69); see Chomsky 1981 on binding into subjects):

(68) a. *man* _ yang ra ai=pruk-rika _ kauhw-aia ***want*** sma

you [[*PRO* me ACC 1=hit-FUT.OBV.2]$_{CPn}$ [pro fall]$_{VPn}$]$_{VP}$-INF ***want*** PRS.2

b. *man* _ _ ai=pruk-rika yang kauhw-aia ***want*** sma

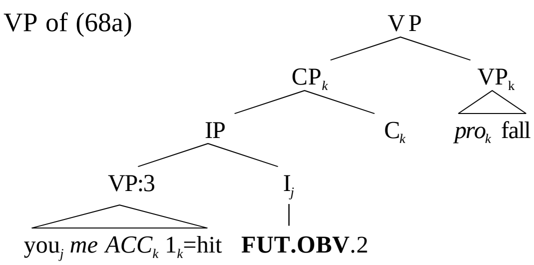
you [[*PRO* pro 1=hit-FUT.OBV.2]$_{CPn}$ [I fall]$_{VPn}$]$_{VP}$-INF ***want*** PRS.2

BOTH: ‘You want to knock me down.’

(69) *You* seem to ***consider*** [[*PRO* hitting me]$_{XPj}$ [very amusing]$_{APj}$]$_{AP}$

According to the theory of Bittner & Hale 1996a, b, the internal subject is a special case of an adjunct—it is a functional category adjoined to a lexical predicate phrase and coindexed with it by syntactic predication (recall ftn. 1):

(70) VP of (68a)



The well-known differences in regard to the A/A′-distinction, control, and so forth, are consequences of this special relation of subjects to syntactic predication. In this theory, the [SPEC, VP] position of the matrix verb (*pro*$_k$ in (70)) is still available since it is not the position of the internal subject—here CP$_k$, the obviative clause minus the ‘TC’ operator. It is, therefore, not surprising that the shared argument can be overtly realized in this position, as in (64b) and (68b). Given the structure in (70), the Case and agreement relations—in Miskitu, as well as the closely related Ulwa, which has agreeing infinitives—also follow from the universal principles of this configuration-driven theory:

(71) *Ulwa* (Misumalpan: Nicaragua)

yang _ _ mâ=ting _ wauhda-*nama* walta-yang

I$_j$ [[*PRO*$_j$ pro$_k$ 2$_k$=*R*-OBV.1$_j$]$_{CPk}$ [pro$_k$ fall]$_{VPk}$]$_{VP}$-*INF*.2$_k$ want-PRS.1$_j$

‘I want to *R* you into falling.’

Thus, the structural analysis in (70) makes it possible to bring the seemingly exotic syntactic behaviour of Miskitu causatives in line with the syntactic component of the Universal Grammar. Interpreting this structure by the universal principles of XLS, we can further explain its semantics. The semantic facts of this concealed causative construction are, if anything, even more exotic. The puzzles include the interaction with aspect (sec. 6.1), negation (sec. 6.2), other VP operators (sec. 6.3), backwards donkey anaphora (sec. 6.4), *wh*-questions (sec. 6.5), an exotic version of the direct object restriction (sec. 6.6) and, finally, the transitivity restriction on the cause verb (sec. 6.7).

6.1 *Eventive effect clause*

In contrast to English resultatives, the effect clause in Miskitu is eventive, not stative—e.g., in (68a) the Miskitu causative has the eventive verb *kauhw*- 'fall' where English has the stative particle *down*. At first sight, this seems to pose a problem for the universal hypothesis that causative type lifting introduces the change-of-state operator, Δ, which requires stative input (section 5.1). Closer inspection, however, reveals that the aspectual pattern of Miskitu (no exceptions in 45 pages of Hale's field notes) in fact provides further empirical support. Crucially, the Miskitu causative includes the obviative inflection. As we saw in the context of temporal chaining (63), this inflection requires eventive input (because the donkey pronoun it_0 must refer to an event) and returns stative output (by giving prominence to an immediately following time). In causative chaining the obviative inflection semantically operates on the matrix VP—the eventive effect—so the aspectual requirements of the change-of-state operator are in fact met.

Compositionally, object agreement in the obviative verb contributes a temporal donkey pronoun, dn_0. (A stored variable, t_k, would fail to get bound in this structure). The resulting sortal mismatch triggers causative type lifting—as in English (46a). But because of its different structure, the obviative VP in Miskitu is then interpreted as follows:

(72) a. VP:5
you$_j$ VP$_j$
$\__j$:4 V′:3
KP$_k$:2⟨[=], [∃]⟩ V:1
me ACC 1$_k$=hit:⟨[∝]!, [()]!⟩

1 $\lambda\mathcal{P}_{(et)t}\,\lambda P_{et}\,\lambda x\,\mathcal{P}(\lambda y\ \mathrm{At}(dn_0, .\mathbf{ht}(x, y) \wedge \Delta P(y). \cap it_1 \propto it_0))$

2 $\lambda Q_{et}\ \exists y(y = i \wedge Q(y))$

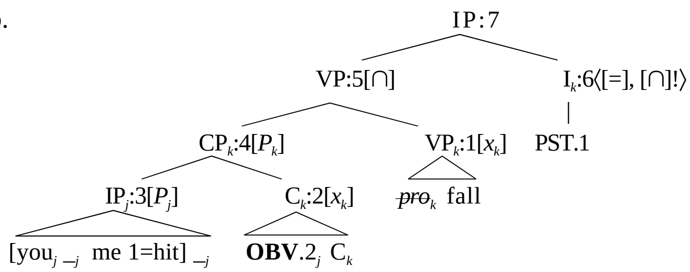
3 $\lambda P \lambda x\ \exists y(y = i \wedge \mathrm{At}(dn_0, .\mathbf{ht}(x, y) \wedge \Delta P(y). \cap it_1 \propto it_0))$

4 $P_{j,et}$

5 $\exists y(y = i \wedge \mathrm{At}(dn_0, .\mathbf{ht}(u, y) \wedge \Delta P_j(y). \cap it_1 \propto it_0))$

The result is an open causative proposition with a stored property variable (P_j, contributed by a trace in [SPEC, VP]). At the level of the IP, still in the obviative clause, this variable is traded for an aspectually more articulated property, obtained by combining the obviative inflection with the empty complementizer.[12] This is the point at which the key aspectual shift takes place (steps 2–4 in (72b)):

(72) b.



1 $\mathbf{fll}(x_k)$

2 $\lambda x_k\, [P_k(x_k) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)]$

3 $\lambda P_j\, \exists y(y = i \wedge \mathrm{At}(dn_0, .\mathbf{ht}(u, y) \wedge \Delta P_j(y). \cap it_1 \propto it_0))$

4 $\lambda P_k\, \exists y(y = i \wedge \mathrm{At}(dn_0, .\mathbf{ht}(u, y) \wedge \Delta[P_k(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

1′ $\lambda x_k\, \mathbf{fll}(x_k)$

5 $\exists y(y = i \wedge \mathrm{At}(dn_0, .\mathbf{ht}(u, y) \wedge \Delta[\mathbf{fll}(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

$\lambda q_t.q_t \cap \exists y(y = i \wedge \mathrm{At}(dn_0, .\mathbf{ht}(u, y) \wedge \Delta[\mathbf{fll}(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

6 $\lambda W_{tt} W_{tt}(\cap\lambda t'.t' = [-, n].)$

7 $(\cap\lambda t'.t' = [-, n].) \cap \exists y(y = i \wedge \mathrm{At}(dn_0, .\mathbf{ht}(u, y) \wedge \Delta[\mathbf{fll}(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

$\equiv\ \exists t'(t' = [-, n]) \wedge \exists y(y = i \wedge \mathrm{At}(t', \mathbf{ht}(u, y) \wedge \Delta[\mathbf{fll}(y) \wedge \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)] \wedge it_1 \propto it_0))$

$\cong\ \mathbf{ht}(u, i) \wedge \Delta[\mathbf{fll}(i) \wedge \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)] \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n]$

The new property still contains a stored property variable (P_k, see ftn. 12). This variable requires an eventive antecedent, and it is this antecedent which the matrix VP predicate (VP_k) provides (steps 4–5). This is possible, in part, because the anaphoric pronoun (or rather its trace ~~pro~~$_k$) in the matrix VP can be interpreted as a bound variable (x_k, not he_0 as in (63)) since it is c-commanded by a coindexed A-position (CP_k, the internal subject).[13] In effect, therefore, the input to the change-of-state operator, Δ, is not the eventive proposition that the speaker fall. Instead, it is the proposition that the speaker has just fallen, which is stative as required (cf. Kamp & Reyle 1993 on perfective

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[12] The empty C_k initially introduces the variable $p_{k,t}$, by rule E(b), which can then be structured into the complex $P_{k,et}(x_k)$, by rule B(c). The trace of 'OBV.2_j' is vacuous, being interpreted as the identity operator $\lambda p_{j,t}\, p_j$, by rules E(b) and B(a).

[13] Formally, I assume as in Bittner 1998 that an A-bound pronoun is optionally deleted at LF (cf. Kratzer 1991). The resulting gap (~~pro~~$_k$ in (72b)) is interpreted by rule E, which introduces a stored variable—the desired result. This accounts for the well-known generalization that only A-bound pronouns allow bound variable readings.

aspect). Finally, the causative chain as a whole is related to the matrix tense, via the temporal object agreement in the obviative clause (dn_0). Semantically, this temporal agreement relates to the matrix tense inflection (I_k) like a resumptive pronoun to a dislocated constituent (steps 5–7 á la Bittner 1997a). [14]

As expected on this analysis, the obviative inflection depends on the embedding matrix. For instance, the second person inflection is *-rika* in future contexts (under future tense or future-oriented verb like 'want') and *-ri*, otherwise:

(73) man *yul* ra mun-**rika** _ (yang ra) ai=sam-**bia**

[[you *dog* *ACC* 3.*R*-**FUT.OBV**.2]$_{\mathrm{CP}k}$ [*pro* (me ACC) 1=bite]$_{\mathrm{VP}k}$]-**FUT**.3

'You will *R* the dog into biting me.'

(73′) $\exists t'(t' = [n, +]) \wedge \exists y(y = d \wedge \mathrm{At}(dn_0, R(u, y) \wedge \Delta[\mathbf{bt}(y, i) \wedge \exists t(n < {}^{\mathrm{T}}it_0 \propto t < +)] \wedge it_1 \propto it_0))$

$\cong R(u, d) \wedge \Delta[\mathbf{bt}(d, i) \wedge \exists t(n < {}^{\mathrm{T}}it_0 \propto t < +)] \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [n, +]$

This dependency ensures that the temporal constraints imposed by the obviative inflection (such as '${}^{\mathrm{T}}it_0 < n$' in (72) and '$n < {}^{\mathrm{T}}it_0$' in (73′)) are reinforced—not countermanded—by the matrix ('${}^{\mathrm{T}}it_0 \subseteq [-, n]$' versus '${}^{\mathrm{T}}it_0 \subseteq [n, +]$').[15]

6.2 *Negation*

Obviative clauses in Miskitu cannot be negated (Hale p.c.). For matrix negation, the scope in temporal chaining is different from causative chaining (Hale 1991). In a temporal chain matrix negation takes scope over the matrix VP only (74a), failing to license any negative polarity items (NPI) in the initial obviative clause (74b):

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14 The final reduction in step 7 preserves the truth conditions but not the potential for later anaphora—hence '≅', not '≡'.

15 The modal-free semantic representation in (73′) incorporates Hans Kamp's dictum: 'To know whether a sentence in the future tense is true all you have to do is wait'.

(74) a. yang sula kum kaik-ri _ _ plap-*ras* kan

[I deer one 3.see-OBV.1]$_{CP}$ pro ***PAS*** run-*NE* PST.3

'I saw a deer and it didn't run.'

b.* *upla kumi sin* sula kum kaik-an _ _ plap-*ras* kan

[*person one NPI* deer one 3.see-OBV.3]$_{CP}$ [pro ***PAS*** run-*NE* PST.3

(*'Anybody saw a deer and it didn't run.')

In contrast, in causative chaining negation takes scope over the entire chain (75a) so negative polarity items are licensed (75b):

(75) a. _ yang sula kumi *sin* mun-ri _ plap-*ras* kan

PAS [[I deer one *NPI* 3.*R*-OBV.1] pro run]-*NE* PST.3

'I didn't *R* any deer into running away.'

b. _ upla kumi *sin* yul ra mun-ka _ (man ra) mai=sam-bia=*apia*

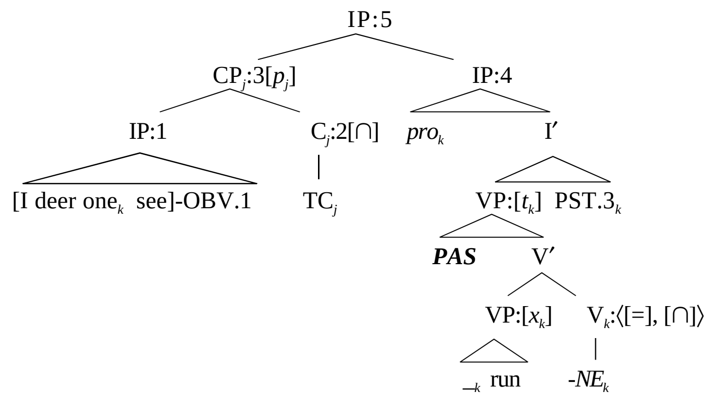
PAS [[person one *NPI* dog ACC 3.*R*-FUT.OBV.3] pro (you ACC) 2=bite]-FUT.3=*NE*

'Nobody will *R* the dog into biting you.'

These patterns can be understood if we assume that negation in Miskitu actually consists of two elements—like AUX…*not* in English, and *ne…pas* in French. What is overt in Miskitu is just the auxiliary (glossed '*NE*'), which is selected by tense and in the future tense incorporates (as in (75b)). I assume that this auxiliary—like the trace of *do* in English (40)—contributes a stored temporal variable which is bound by the tense inflection. The actual negation operator in Miskitu is expressed by a covert element (glossed '***PAS***') in [SPEC, VP] of the negative auxiliary.

Under these assumptions, the temporal chain (74a) can be interpreted as in (76). In the compositionally relevant respects, the matrix IP in Miskitu is isomorphic to English (40) and so amenable to the same semantic analysis:

(76)



1 $\exists y(\mathbf{dr}(y) \wedge \mathbf{see}(i, y)) \cap \exists t(– < {}^{\mathrm{T}}it_0 \propto t < n)$

2 $\lambda q_t .q \cap [–/dn_0]p_{j,t}.$

3 $\lambda p_j .(\exists y(\mathbf{dr}(y) \wedge \mathbf{see}(i, y)) \cap \exists t(– < {}^{\mathrm{T}}it_0 \propto t < n)) \cap [–/dn_0]p_j.$

4 $\neg(\mathbf{rn}(he_0) \cap {}^{\mathrm{T}}it_0 \subseteq –)$

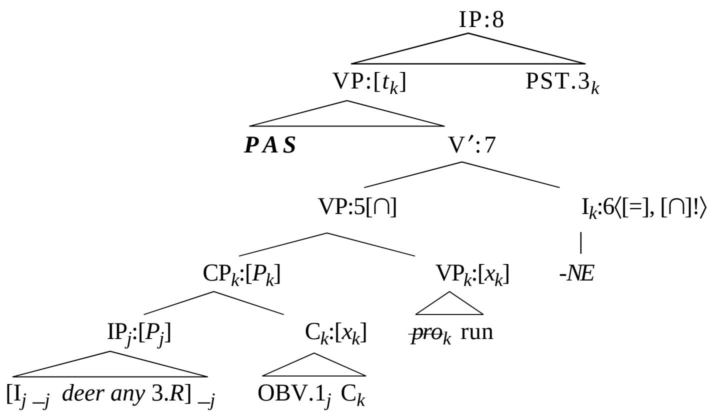
5 $(\exists y(\mathbf{dr}(y) \wedge \mathbf{see}(i, y)) \cap \exists t(– < {}^{\mathrm{T}}it_0 \propto t < n)) \cap [–/dn_0]\neg(\mathbf{rn}(he_0) \cap {}^{\mathrm{T}}it_0 \subseteq –)$

$\equiv \exists t\exists y(\mathbf{dr}(y) \wedge \mathbf{see}(i, y) \wedge – < {}^{\mathrm{T}}it_0 \propto t < n \wedge \neg(\mathbf{rn}(y) \wedge {}^{\mathrm{T}}it_0 = t))$

This compositional derivation yields the right truth conditions: the contextually relevant past contains an event of the speaker seeing a deer which is not immediately followed by any event of the deer running. To give the negation (***PAS***) scope over the entire temporal chain, we would have to adjoin the obviative clause lower, to the complement of the negative auxiliary (*NE*). But that would render the temporal chaining operator (TC$_j$) vacuous since it would no longer c-command the tense inflection and so would lack any occurrence of the past reference point, –, in its scope. Since natural languages prohibit vacuous operators, this scope configuration is ruled out.

The temporal chaining operator is omitted in forming a causative chain, so here negation can take wide scope. To facilitate comparison with the affirmative (72b), node numbering in the following LF of (75a) is analogous:

(77)



5 $\lambda q_t.q_t \cap \exists y(\mathbf{dr}(y) \wedge \mathrm{At}(dn_0, .R(i, y) \wedge \Delta[\mathbf{rn}(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

6 $\lambda W_{tt} W_{tt}(\cap\lambda t'.t' = t_k.)$

7 $(\cap\lambda t'.t' = t_k.) \cap \exists y(\mathbf{dr}(y) \wedge \mathrm{At}(dn_0, .R(i, y) \wedge \Delta[\mathbf{rn}(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

$\equiv \exists t' \exists y(t' = t_k \wedge \mathbf{dr}(y) \wedge R(i, y) \wedge \Delta[\mathbf{rn}(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)] \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq t')$

8 $\lambda t_k[\neg\exists t' \exists y(t' = t_k \wedge \mathbf{dr}(y) \wedge R(i, y) \wedge \Delta[\mathbf{rn}(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)] \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq t')]([-, n])$

$\equiv \neg\exists y(\mathbf{dr}(y) \wedge R(i, y) \wedge \Delta[\mathbf{rn}(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)] \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq [-, n])$

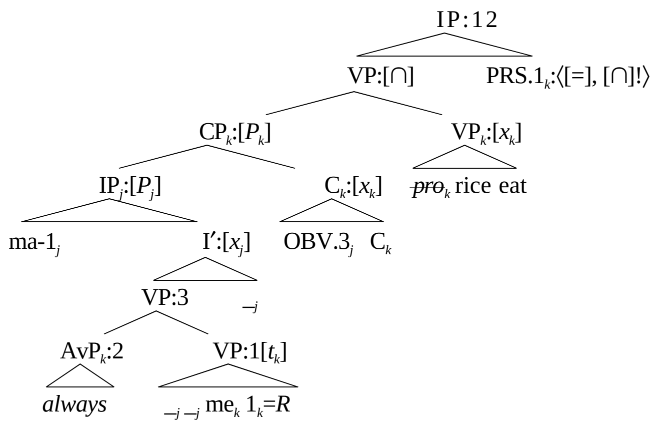
In a causative chain it is the narrow scope reading which is blocked, for the same reason that it is for the English resultative (39b) (**John shot Mary* ***not*** *alive*)—to wit, interference with temporal anaphora.

Finally, we explain why negation cannot occur in the obviative clause. In a temporal chain this, too, leads to a clash with the temporal chaining operator—this time, because the temporal donkey pronoun dn_0 is uninterpretable, its antecedent trapped inside an anaphoric island. The problem in a causative chain is that the temporal variable (t_k in (77)) contributed by the negative auxiliary cannot be bound by the obviative inflection, since this is of a different type (step 2 in (72b)). The derivation is therefore filtered out because of unresolvable type mismatch (*Initial Filter).

6.3 *Other VP operators*

According to this theory, the meaning of a causative chain is almost entirely determined within the obviative VP. The other constituents—the obviative inflection, matrix VP and tense—just fix the values of some parameters left open in the obviative VP. This makes the dramatic prediction that an operator which c-commands just the obviative VP—such as the adverb *always* in (78′)—will semantically take scope over the entire causative chain.

(78′)



1 $\lambda t_k\, \exists y(y = i \wedge \mathrm{At}(t_k, .R_{eet}(x_j, y) \wedge \Delta P_{j,et}(y).\cap it_1 \propto it_0))$

2 $\lambda U_{et}\, \forall t(t \subseteq dn_0 \wedge T_{et}(t) \rightarrow U(t))$

3 $\forall t(t \subseteq dn_0 \wedge T(t) \rightarrow \exists y(y = i \wedge \mathrm{At}(t, .R(x_j, y) \wedge \Delta P_j(y).\cap it_1 \propto it_0)))$

$\equiv \forall t(t \subseteq t_k \wedge T(t) \rightarrow \mathrm{At}(t, .R(x_j, i) \wedge \Delta P_j(i).\cap it_1 \propto it_0))$

⋮ ⋮

12 $\forall t(t \subseteq [-, +] \wedge T(t) \rightarrow \mathrm{At}(t, .R(\iota x\, \mathbf{ma}(x, i), i) \wedge \Delta[\exists y(\mathbf{rc}(y) \wedge \mathbf{eat}(i, y)) \cap \exists t'(- < {}^{\mathrm{T}}it_0 \propto t' < +)].\cap it_1 \propto it_0))$

$\equiv \forall t(t \subseteq [-, +] \wedge T(t) \rightarrow R(\iota x\, \mathbf{ma}(x, i), i) \wedge \Delta\exists t'\exists y(\mathbf{rc}(y) \wedge \mathbf{eat}(i, y) \wedge - < {}^{\mathrm{T}}it_0 \propto t' < +) \wedge it_1 \propto it_0 \wedge {}^{\mathrm{T}}it_0 \subseteq t)$

This general prediction is borne out by the facts, as the following sentences attest:

(78)	yapti-ki	***taim***	***bani***	yang	ra	ai=mun-an	_	rais	pi	sna
	[[ma-1	***time***	***all***	me	ACC	1=*R*-OBV.3]	[pro	rice	3.eat]]	PRS.1

‘My mother always *R*s me into eating rice.’

(79)	_	tuktan	ba	ra	mun-***s***	_	kauhw-bia	
	[[pro	child	the	ACC	3.*R*-***IMPER***.2]	[pro	fall]]-FUT.3	

‘*R* the child into falling!’

6.4 *Backwards donkey anaphora*

Though the order antecedent-pronoun is preferred, backwards anaphora is also possible as in (64b) and (80):

(80)	upla	bani	(raks	ni)	_	sab-an	*sula*	*kum*	pru-an
	[[person	all	(gun	INS)	***pro***	3.shoot-OBV.3]	[*deer*	*one*	die]]-PST.3

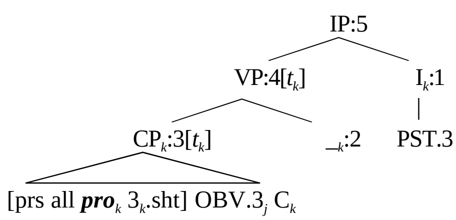
‘Everybody shot one deer dead.’ (one collectively)

In these structures the anaphoric pronoun cannot be interpreted as a bound variable since it is not c-commanded by any coindexed A-position (recall ftn. 13). Instead it must be a donkey pronoun, like its English counterpart in (81):

(81) With everybody shooting at ***it***, ?*one*/**no*/**every deer* died.

Compositionally, the backwards anaphoric link can be established by effectively reordering the donkey pronoun and its antecedent at LF. The matrix VP predicate is topicalized, leaving a trace which is semantically identified with the tense inflection (by rule E(b), step 2 in (82a)). Temporal agreement in the obviative verb can then be interpreted as a stored variable (t_k) instead of a donkey pronoun (dn_0). The object itself, therefore, can be interpreted as a donkey pronoun (he_0) within the locality constraints imposed on donkey anaphora by the dynamic intersection operator, ∩ (see Appendix 1). Semantically, the antecedent is close enough because the IP containing the pronoun is quantified into a null operator which immediately follows the antecedent in the topicalized VP predicate (as in (82b); cf. null operators in other constructions (14′), (15′), etc):

(82) a.



1 $[-, n]$

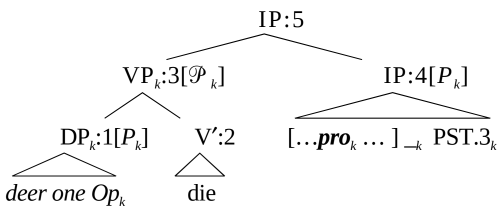
2 t_k

3 $\lambda t_k\, \exists y'(y' = he_0 \wedge \mathrm{At}(t_k, .\mathbf{sht}(\iota z\, {*}\mathbf{prs}(z), y') \wedge \Delta[P_k(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

4 $\lambda t_k\, \exists y'(y' = he_0 \wedge \mathrm{At}(t_k, .\mathbf{sht}(\iota z\, {*}\mathbf{prs}(z), y') \wedge \Delta[P_k(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

5 $\exists y'(y' = he_0 \wedge \mathrm{At}([-, n], .\mathbf{sht}(\iota z\, {*}\mathbf{prs}(z), y') \wedge \Delta[P_k(y) \cap \exists t(- < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

(82) b.



1 $\exists y\ \mathbf{dr}(y) \cap \mathcal{P}_{k,(et)t}(P_{k,et})$

$\lambda P_k\ (\exists y\ \mathbf{dr}(y) \cap \mathcal{P}_k(P_k))$

2 $\mathbf{die}$

3 $\lambda \mathcal{P}_k(\exists y\ \mathbf{dr}(y) \cap \mathcal{P}_k(\mathbf{die}))$

4 $\lambda P_k\ \exists y'(y' = he_0 \wedge \mathrm{At}([–, n], .\mathbf{sht}(\iota z\ {}^*\mathbf{prs}(z), y') \wedge \Delta[P_k(y) \cap \exists t(– < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

5 $\exists y\ \mathbf{dr}(y) \cap \exists y'(y' = he_0 \wedge \mathrm{At}([–, n], .\mathbf{sht}(\iota z\ {}^*\mathbf{prs}(z), y') \wedge \Delta[\mathbf{die}(y) \cap \exists t(– < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))$

$\equiv \exists y[\mathbf{dr}(y) \wedge \mathrm{At}([–, n], \mathbf{sht}(\iota z\ {}^*\mathbf{prs}(z), y) \wedge \Delta[\mathbf{die}(y) \wedge \exists t(– < {}^{\mathrm{T}}it_0 \propto t < n)] \wedge it_1 \propto it_0\ )]$

This compositional analysis correctly predicts that backwards donkey anaphora will force an indefinite antecedent to take wide scope relative to any operator contained in the clause hosting the donkey pronoun. In (80) this amounts to a collective construal since a particular event—here, one death—cannot have more than one direct cause (section 4.4). If it were not for backwards donkey anaphora, then the Miskitu determiner *bani* ‘all’—like its English counterpart—would normally require distributive construal, as in (83). Here the anaphoric pronoun is interpreted as a bound variable, and its indefinite antecedent is correctly predicted to take narrow scope (see (72b)): [16]

(83)	upla	bani	(raks	ni)	*sula*	*kum*	(*ra*)	sab-an	_	pru-an
	[[person	all	(gun	INS)	*deer*	*one*	(*ACC*)$_k$	3.shoot-OBV.3]	[~~*pro*~~$_k$	die]]-PST.3

‘Everybody shot one deer dead.’ (one each)

(83′) ${}^{\mathrm{D}}\lambda x[\exists y(\mathbf{dr}(y) \wedge \mathrm{At}([–, n], .\mathbf{sht}(x, y) \wedge \Delta[\mathbf{die}(y) \cap \exists t(– < {}^{\mathrm{T}}it_0 \propto t < n)]. \cap it_1 \propto it_0))](\iota z\ {}^*\mathbf{prs}(z))$

$\equiv \forall x(\mathbf{prs}(x) \rightarrow \exists y[\mathbf{dr}(y) \wedge \mathrm{At}([–, n], \mathbf{sht}(x, y) \wedge \Delta[\mathbf{die}(y) \wedge \exists t(– < {}^{\mathrm{T}}it_0 \propto t < n)] \wedge it_1 \propto it_0)])$

[16] I am indebted to Ken Hale for testing these scope predictions for several sentences with several Miskitu consultants. The judgements systematically patterned as in (80) and (83). The distributive operator in (83′) is defined as in Link 1987.

6.5 *Constituent questions*

Further evidence comes from *wh*-questions. These are formed by replacing focal constituents with *wh*-operators and optionally inserting the complementizer *ki*. The following examples illustrate the interaction with causative chains:

(84) Q: man _ mun-ram *yâ* kauhw-an (***ki***)

[[you$_j$ *pro*$_k$ 3.*R*-OBV.2] [*who*$_k$ fall]]-PST.3 (**?**)

Lit. 'With you *R*-ing him, who fell?'

A: *yang bîbi-ki* kauhw-an

[*my child*-1$_k$ fall]-PST.3

'My child fell.'

(85) Q: man *yâ*-ura mun-ram _ kauhw-an (***ki***)

[[you$_j$ *who*-ACC$_k$ 3.*R*-OBV.2] [~~*pro*~~$_k$ fall]]-PST.3 (**?**)

'Who did you *R* into falling?'

A: yang *bîbi-ki* mun-ri _ kauhw-an

[[I$_j$ *child*-1$_k$ 3.*R*-OBV.1] [~~*pro*~~$_k$ fall]]-PST.3

'I *R*-ed my child into falling.'

(86) Q: yaptik-am (man ra) mai=mun-an _ *dia* lulk-ram (***ki***)

[[ma-2$_j$ (you ACC$_k$) 2=*R*-OBV.3] [~~pro~~$_k$ *what*$_n$ 3.throw]]-PST.2 (**?**)

Lit. 'With your mother *R*-ing you, what did you throw?'

A: _ *skiru* lulk-ri

[pro$_k$ *knife*$_n$ 3.throw]-PST.1

'I threw a knife.'

(87) Q: *dia* (man ra) mai=sam-an _ in-ram (***ki***)

[[*what*$_j$ (you ACC$_k$) 2=*R*-OBV.3] [~~pro~~$_k$ cry]]-PST.2 (**?**)

‘What bit you into crying?’

A: *ulu* _ ai=sam-an _ in-ri

[[*wasp*$_j$ pro$_k$ 1=bite-OBV.3] [~~pro~~$_k$ cry]]-PST.1

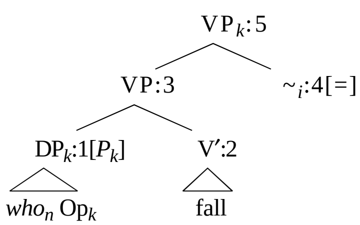
‘A wasp bit me into crying.’

That is, it is possible to question both the shared argument (as in (84–85)) and any other major constituent (as in (86–87)). *Wh*-operators are preferred in the obviative clause but are also allowed in the matrix VP. In that case, speakers normally give a short answer, consisting of the matrix clause only (as in (84) and (86)).

I propose that *wh*-operators in Miskitu are focused and symmetrically licensed by focus in the answer. The answer thus indicates the scope of the focal contrast operator, $\sim_i$, an empty category licensed by the interrogative complementizer, ?, and interpreted by rule E (cf. Rooth 1992). The *wh*-operators behave both like bound variable pronouns (cf. Baker 1970) and like indefinites (cf. Karttunen 1977), because they both introduce a stored variable with a restricted range (e.g., $x_{n,\mathbf{prs}}$, cf. Abusch 1994) and give prominence to the entity assigned to this variable:

(84′) *Wh-operator in matrix* VP (cf. (82))

a.



1 $\lambda P_k(\exists y.y = x_{n,\mathbf{prs}}. \cap \mathcal{P}_k(P_k))$

2 $\mathbf{fll}$

3 $\exists y.y = x_{n,\mathbf{prs}}. \cap \mathcal{P}_k(\mathbf{fll})$

4 $p_{i,t}$

$\lambda q_t\,[p_i = q]$

5 $p_i = (\exists y.y = x_{n,\mathbf{prs}}. \cap \mathcal{P}_k(\mathbf{fll}))$

b. CP$_i$:5[p_i]

IP:3[$x_{n,\mathbf{prs}}$]   C$_n$:4[∃]

VP$_k$:1[$\mathcal{P}_k$]   IP:2[P_k]   **?**$_i$

[who_n Op$_k$ fall] ~$_i$ […]$_{\text{CP}k}$ $\_{k}$ PST.3$_k$

1 $\lambda \mathcal{P}_k[p_i = (\exists y.y = x_{n,\mathbf{prs}}. \cap \mathcal{P}_k(\mathbf{fll}))]$

2 $\lambda P_k\ \exists y'(y' = he_0 \wedge \text{At}([-, n], .R(u, y') \wedge \Delta[P_k(y) \cap \exists t(- <^{\text{T}} it_0 \propto t < n)]. \cap it_1 \propto it_0))$

3 $\lambda x_{n,\mathbf{prs}}\ [p_i = (\exists y.y = x_{n,\mathbf{prs}}. \cap \exists y'(y' = he_0 \wedge \text{At}([-, n], .R(u, y') \wedge \Delta[\mathbf{fll}(y) \cap \exists t(- <^{\text{T}} it_0 \propto t < n)].\cap it_1 \propto it_0)))]$

$\equiv\ \lambda x_{n,\mathbf{prs}}\ [p_i = \text{At}([-, n], R(u, x_{n,\mathbf{prs}}) \wedge \Delta[\mathbf{fll}(x_{n,\mathbf{prs}}) \wedge \exists t(- <^{\text{T}} it_0 \propto t < n)] \wedge it_1 \propto it_0)]$

4 $\lambda y.y = y.$

$\lambda Q_{et}\ \exists y(y = y \wedge Q(y))$

5 $\lambda p_i\ \exists y_{\mathbf{prs}}\ (y_{\mathbf{prs}} = y_{\mathbf{prs}} \wedge p_i = \text{At}([-, n], R(u, y_{\mathbf{prs}}) \wedge \Delta[\mathbf{fll}(y_{\mathbf{prs}}) \wedge \exists t(- <^{\text{T}} it_0 \propto t < n)] \wedge it_1 \propto it_0))$

$\equiv \lambda p\ \exists y_{\mathbf{prs}}\ (p = \text{At}([-, n], R(u, y_{\mathbf{prs}}) \wedge \Delta[\mathbf{fll}(y_{\mathbf{prs}}) \wedge \exists t(- <^{\text{T}} it_0 \propto t < n)] \wedge it_1 \propto it_0))$

(85′) *Wh-operator in adjoined subject* CP (cf. (72))

CP$_i$:3[p_i]

IP:2[$x_{n,\mathbf{prs}}$]   [**?**$_i$]$_n$:[∃]

IP:1   ~$_i$:[=]

VP:[∩]   I$_k$:⟨[=], [∩]!⟩

CP$_k$:[P_k]   VP$_k$:[x_k]   PST.1

IP$_j$:[P_j]   C$_k$:[x_k]   ~~pro~~$_k$ fall

[you$_j$…[wh_n]$_k$ 3$_k$.R] $\_{j}$ OBV.2$_j$ C$_k$

1 $(\cap\lambda t'.t' = [-, n].) \cap \exists y(y = x_{n,\mathbf{prs}} \wedge \text{At}(dn_0, .R(u, y) \wedge \Delta[\mathbf{fll}(y) \cap \exists t(- <^{\text{T}} it_0 \propto t < n)]. \cap it_1 \propto it_0))$

$\equiv \exists y \exists t'(t' = [-, n] \wedge y = x_{n,\mathbf{prs}} \wedge \text{At}(t', R(u, y) \wedge \Delta[\mathbf{fll}(y) \wedge \exists t(- <^{\text{T}} it_0 \propto t < n)] \wedge it_1 \propto it_0)$

2 $\lambda x_{n,\mathbf{prs}}\ [p_i = \exists y \exists t'(t' = [-, n] \wedge y = x_{n,\mathbf{prs}} \wedge \text{At}(t', R(u, y) \wedge \Delta[\mathbf{fll}(y) \wedge \exists t(- <^{\text{T}} it_0 \propto t < n)] \wedge it_1 \propto it_0)]$

$\equiv \lambda x_{n,\mathbf{prs}}\ [p_i = \text{At}([-, n], R(u, x_{n,\mathbf{prs}}) \wedge \Delta[\mathbf{fll}(x_{n,\mathbf{prs}}) \wedge \exists t(- <^{\text{T}} it_0 \propto t < n)] \wedge it_1 \propto it_0)]$

3 $\lambda p_i\ \exists y_{\mathbf{prs}}\ (y_{\mathbf{prs}} = y_{\mathbf{prs}} \wedge p_i = \text{At}([-, n], R(u, y_{\mathbf{prs}}) \wedge \Delta[\mathbf{fll}(y_{\mathbf{prs}}) \wedge \exists t(- <^{\text{T}} it_0 \propto t < n)] \wedge it_1 \propto it_0))$

$\equiv \lambda p\ \exists y_{\mathbf{prs}}\ (p = \text{At}([-, n], R(u, y_{\mathbf{prs}}) \wedge \Delta[\mathbf{fll}(y_{\mathbf{prs}}) \wedge \exists t(- <^{\text{T}} it_0 \propto t < n)] \wedge it_1 \propto it_0))$

In monadic questions the *wh*-operator is bound by the interrogative complementizer, ? (steps 3–4 in (84′b), step 2 in (85′)). Additional *wh*-operators, in multiple *wh*-questions, may be bound in the same manner by arbitrary *PRO*s. As bound variable anaphora, this semantic relation is syntactically unbounded and is not subject to blocking by elements which create islands for donkey anaphora (e.g., negation, propositional identity, =, or dynamic intersection,

∩). At the same time, because of their indefinite-like context change potential *wh*-operators may serve as antecedents for donkey pronouns, like true indefinites (hence parallel reductions in step 3 of (84′b), and step 5 of (82b)).

6.6 *Direct object restriction with a twist*

Because of high causative type lifting the obviative clause must share an argument with the matrix VP. As expected, this argument is normally the object of the obviative cause verb (cf. Simpson 1983). The grammatical relation to the matrix effect verb is unrestricted since the property contributed by the matrix VP is derived by λ-abstraction:

(88)	_	upla	kumi	sin	*man ra*	mai=mun-an	yul	_	mai=sam-ras	kan
	PAS	[[person	one	NPI	*you ACC*$_k$	2=*R*-OBV.3]	[dog	~~*pro*~~$_k$	2=bite]]-NE	PST.3

‘Nobody *R*-ed you into getting bitten by the dog.’

(Lit. ‘Nobody *R*-ed you into the dog biting you.’)

Indeed, the matrix VP can even be an idiom (such as (89)), in which case the shared argument can fill any open argument slot (here the possessor of the subject) as long as *pro* can be licensed by agreement (as in (90)). That these are still *bona fide* causative chains is shown by the characteristic interaction with negation (88) and control (90b):

(89)	du-ki	nani	_	aiya	tiw-an
	things-1	PL	*pro*	liver.1	get.lost-PST.3

‘I forgot my things.’

(Lit. ‘My liver got lost in relation to my things.’)

(90) a.	naha	saika	ba	_	ai=mun-an	diara	nani	sut	_	aiya	tiw-an
	[this	medicine	DEF	*pro*$_k$	1=*R*-OBV.3]	[thing	PL	all	~~*pro*~~$_k$	liver.1	get.lost]]-PST.3

‘This medicine *R*s me into forgetting everything.’

b.	witin	want-sa	_	altaim	_	ai=mun-ka	du-ki	nani	_	aiya	tiw-aia
	he$_i$	want-PRS.3	[[PRO$_i$	always	*pro*$_k$	1=*R*-OBV.3]	[thing-1	PL	~~*pro*~~$_k$	liver.1	get.lost]]-INF

‘He wants to *R* me into forgetting my things all the time.’

Surprisingly, at first sight, the shared argument is not always the object of the obviative clause. It can also be the possessor of this argument:

(91) a. witin (*yang*) yul-i (ra) pruk-an _ law-ri

[he [*my*$_n$ dog-1 ACC] hit-OBV.3] [~~*pro*~~$_n$ get.angry]]-PST.1

'His hitting *my* dog angered *me*.'

b. witin _ (*yang*) yul-i (ra) pruk-ka _ law-aia want sa

he$_i$ [[PRO$_i$ [*my*$_n$ dog-1 ACC] hit-FUT.OBV.3] [~~*pro*~~$_n$ get.angry]]-INF want PRS.3

'He wants to anger *me* by hitting *my* dog.'

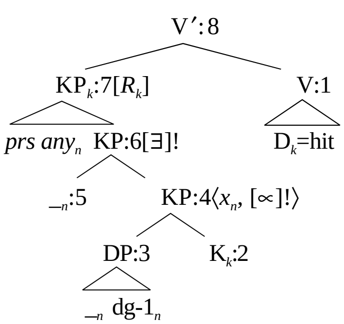
c. _ witin *upla* *kumi sin* yul-a (ra) pruk-an _ law-ras kan

PAS [he [*person one NPI*$_n$ dog-3 ACC] hit-OBV.3] [~~*pro*~~$_n$ get.angry]]-NE PST.3

'He didn't anger *anybody*$_n$ by hitting *his*$_n$ dog.'

In fact, there are no grounds for surprise. This pattern, too, falls within the theoretically predicted range of possibilities—given that both the accusative K and the licensing V-adjoined D may be empty (Bittner & Hale 1996a) and the possessor may move locally, yielding the following representation for the obviative V′ of (91c) at LF:

(92)



1 **h t**

2 $R_{k,eet}$

3 $\iota z\ \mathbf{dg\text{-}of}(z, x_n)$

4 $R_k(\iota z\ \mathbf{dg\text{-}of}(z, x_n))$

5 $P_{n,et}$

4′ $\lambda Q_{et}\, \lambda x_n\, \lambda x\ (.R_k(x, \iota z\ \mathbf{dg\text{-}of}(z, x_n)) \wedge \Delta Q(x_n).\ \cap\ it_1 \propto\ it_0)$

6 $\lambda Q_{et}\, \lambda x\ \exists y(Q(y) \wedge (.R_k(x, \iota z\ \mathbf{dg\text{-}of}(z, y)) \wedge \Delta P_n(y).\ \cap\ it_1 \propto\ it_0))$

7 $\lambda R_k\, \lambda x\ \exists y(\mathbf{prs}(y) \wedge (.R_k(x, \iota z\ \mathbf{dg\text{-}of}(z, y)) \wedge \Delta P_n(y).\ \cap\ it_1 \propto\ it_0))$

8 $\lambda x\ \exists y(\mathbf{prs}(y) \wedge (.\mathbf{ht}(x, \iota z\ \mathbf{dg\text{-}of}(z, y)) \wedge \Delta P_n(y).\ \cap\ it_1 \propto\ it_0))$

As empty heads, both D and K are interpreted by rule E(b), which renders D vacuous and identifies K with V (steps 1–2). At the level of the lowest segment of KP, an intermediate trace of the raised possessor is again interpreted by rule E(b), which results in a type mismatch of the right kind to be resolved by causative type lifting (steps 4–5–4′). In effect, the trace is identified with the result predicate (P_n), while the DP complement of K is interpreted as part of a derived cause predicate whose inner argument is the possessor. From then on the compositional interpretation of (91c) is straightforward, proceeding as in English (36′) up to V′ (steps 6–8) and then switching to Miskitu (77).

6.7 *Transitivity restriction*

Finally, we explain why the obviative cause verb must be transitive. Intransitive verbs form only temporal chains, as shown by the interaction with negation (93b) and control as well as case assignment and word order (93a):

(93) a. _ sûs-ki (**ra*) ***plap***-ri _ aisaw-an

[pro shoes-1 (**OBL*) (3.)***run***-OBV.1]$_{CP}$ [pro wear.out-PST.3]$_{IP}$

'I ran (*in) my shoes and they wore out.' (NOT: 'I ran my shoes to shreds.')

b. _ ***plap***-ri sûs-ki _ aisaw-*ras* kan

[pro ***run***-OBV.1]$_{CP}$ [shoes-1 *PAS* wear.out-*NE* PST.3]$_{IP}$

'I ran and my shoes didn't wear out.'

The explanation is simple. All of the above compositional analyses crucially require that the cause verb be of the relational type *eet*. Any attempt to substitute an intransitive verb, type *et*, and apply low causative type lifting is ruled out by semantic filters—as the following short-lived attempt to interpret (93a) as a causative chain illustrates:

(94)

```
          V:3*
        /      \
   D_k:1…     V:2[∝]
     |          |
     3         run
```

1 dn_0

2 $\lambda x\ \mathbf{rn}(x)$

2′ $\lambda q_t\ \lambda x[.\mathbf{rn}(x) \wedge \Delta q. \cap it_1 \propto it_0]$

1′ …

3 ??? **Initial Filter*

7. Conclusion

I have argued for a theory of concealed causatives which takes their characteristic morphosyntax at face value. That is, the fact that the understood causal relation has no overt reflex—only its arguments are overtly expressed—is taken to mean that this element of meaning is not contributed by any terminal node. Instead, it is due to a mismatch, in logical type or sort, between the basic meanings of two sister nodes in the syntactic representation at LF. Mismatched constituents in general license type lifting operations, and it is one of these semantic operations which, given an appropriate type configuration, will introduce the direct causal relation as the default semantic link. In addition to the absence of any morphosyntactic reflex, this theory explains how concealed causation can arise in typologically unrelated languages and syntactically quite different structures and yet maintain its distinctive semantic profile—that of a direct causal relation, which does not tolerate any intermediate or even competing causes.

In other words, this is a what-you-see-is-what-you-get theory of concealed causation. Pedestrian though it may sound, a formally explicit version of this view turns out to have some far reaching theoretical implications. A few of them were explored in this work.

For example, because of the syntactic heterogeneity of concealed causatives it is difficult to explicate the what-you-see-is-what-you-get theory in the rule-by-rule framework, which requires a homomorphic mapping from syntactic operations that build LF constituents to semantic operations that interpret them. To bring out the fundamental semantic unity of concealed causatives, and still leave room for the observed syntactic spectrum, it is necessary to adopt a more flexible type-driven approach, where the mapping from syntax to semantics is independent of the derivational history of LF constituents, being guided by their logical types instead. The classical hypothesis that the syntactic category determines the logical type must also be abandoned. To capture type generalizations that cut across syntactic distinctions, we must assume that logical types are independent of syntactic categories.

The proposed formalization also crucially relies on the conception of type lifting as the semantic counterpart of movement. This, in turn, implies that type lifting may, to a limited extent, introduce substantive elements of meaning as default semantic links—just as movement may, to a limited extent, add certain syntactic elements (such as indices, traces, or additional landing sites) to yield a coherent output structure.

One of the limitations in semantics is that these default semantic links—which correspond to the traditional notion of constructional meaning—be logical relations (e.g., ‘$=$’, ‘At’) or operations (e.g., ‘$\exists$’, ‘$\forall$’, ‘$\cap$’). To bring the direct causal relation (‘∝’) introduced by causative type lifting in line with this general constraint it was necessary to develop a theory of pragmatically determined coarse-grained orders. And this turned out to have profound consequences not only for the theory of causation, but also for the underlying theory of events, space, and time, in natural language discourse.

APPENDIX 1: EVENT LOGIC WITH ANAPHORA (ELA)

Syntax

I. • The set of types, *Type*, is the smallest set X such that (i) $e, t \in X$, and (ii) if $\tau, \upsilon \in X$, then $(\tau\upsilon) \in X$.

(In what follows parentheses may be omitted with the convention that association is to the right.)

• The set of sorts, *Sort* = $\{\mathbf{\sim}, \mathbf{T}, \mathbf{\sim T}, \mathbf{T/\sim}\}$.

II. Primitive symbols:

• Punctuation: (,), [,]

• An infinite set of *basic* τ-*variables*, $var_\tau = \{v_{0,\tau}, v_{1,\tau}, \ldots\}$, for all $\tau \in Type$

An infinite set of *basic* υ-*variables*, $var_\upsilon = \{v_{0,\upsilon}, v_{1,\upsilon}, \ldots\}$, for all $\upsilon \in Sort$

• A set of *sorted* τ-*constants*, $Con_\tau = Con_{\tau:\sim} \cup Con_{\tau:\mathbf{T}} \cup Con_{\tau:\mathbf{\sim T}}$, for all $\tau \in Type$. This set is empty, except for:

• $Con_{e:\sim} = \{m, j, \ldots\}$

$Con_{e:\mathbf{T}} = \{n, -, +, dn_0, dn_1, \ldots\}$

$Con_{e:\mathbf{\sim T}} = \{h, dr_0, dr_1, \ldots, i, u, he_0, he_1, \ldots, it_0, it_1, \ldots\}$

• $Con_{et:\sim} = \{\mathbf{man}, \mathbf{dog}, \ldots, \mathbf{tall}, \ldots\}$

$Con_{et:\mathbf{T}} = \{\mathbf{dead}, \mathbf{awake}, \ldots\}$

$Con_{et:\mathbf{\sim T}} = \{\mathbf{bark}, \mathbf{work}, \ldots\}$

• $Con_{eet:\sim} = \{\mathbf{wife}, \mathbf{dog\text{-}of}, \ldots\}$

$Con_{eet:\mathbf{T}} = \{\mathbf{in}, \mathbf{on}, \ldots, \mathbf{like}, \ldots\}$

$Con_{eet:\mathbf{\sim T}} = \{\mathbf{shoot}, \mathbf{help}, \ldots\}$

• $Con_{tt:\sim} = \{\mathbf{obvious}, \mathbf{likely}, \ldots\}$

$Con_{tt:\mathbf{T}} = \{\mathbf{seem}, \mathbf{continue}, \ldots\}$

$Con_{tt:\mathbf{\sim T}} = \{\mathbf{begin}, \mathbf{cease}, \ldots\}$

• $Con_{tet:\sim} = \{\mathbf{fact}, \mathbf{rumor}, \ldots\}$

$Con_{tet:\mathbf{T}} = \{\mathbf{believe}, \mathbf{want}, \ldots\}$

$Con_{tet:\mathbf{\sim T}} = \{\mathbf{say}, \mathbf{try}, \ldots\}$

• Relational symbols: $\in$ Dom (*proper argument of*), At (*temporally located at*), = (*is*), $\approx$ (*stage of*), $\bigcirc$ (*overlaps*), $\subseteq$ (*part of*), < (*precedes*), $\propto$ (*immediately precedes*)

• Term-forming operators: $^{\mathrm{T}}$ (*time of*), $^{\mathrm{L}}$ (*place of*), , (*period from _ to _*)

• Sentence-forming operators: $\neg$ (*not*), Δ (*change-of-state*), $\wedge$ (*dynamic conjunction*)

• Lattice operators: $\cap$ (*dynamic intersection*), * (*plural*)

• Binders: / (*time setter*), ι, $\exists$, λ

III. For each $\tau \in Type$, the sets Var_τ and ME_τ are the smallest sets that satisfy (**B**)–(λ):

B: If $\upsilon \in Sort$, then $var_\upsilon \subseteq Var_e$. If $\tau \in Type$, then $var_\tau \subseteq Var_\tau \subseteq ME_\tau$ and $Con_\tau \subseteq ME_\tau$.

$\boldsymbol{v}_\alpha$**:** If $\alpha \in ME_{et}$, then $v_{0,\alpha}, v_{1,\alpha}, \ldots \in Var_e$.

(): If $\alpha \in ME_{\tau\upsilon}$ and $\beta \in ME_\tau$, then $\alpha(\beta) \in ME_\upsilon$.

∈: If $\alpha \in ME_{\tau\upsilon}$ and $\beta \in ME_\tau$, then $(\beta \in \mathrm{Dom}\ \alpha) \in ME_t$.

At: If $\alpha \in ME_e$ and $\varphi \in ME_t$, then $\mathrm{At}(\alpha, \varphi) \in ME_t$.

=: If $\alpha, \beta \in ME_\tau$, then $[\alpha = \beta] \in ME_t$.

$\mathbf{R}_e$**:** If $\alpha, \beta \in ME_e$, then $[\alpha \approx \beta], [\alpha \bigcirc \beta], [\alpha \subseteq \beta], [\alpha < \beta], [\alpha \propto \beta] \in ME_t$.

$\mathbf{O}_e$: If $\alpha, \beta \in ME_e$, then ${}^{\mathrm{L}}\alpha, {}^{\mathrm{T}}\alpha, [\alpha, \beta] \in ME_e$.

$\mathbf{O}_t$: If $\varphi, \psi \in ME_t$, then $\neg\varphi, \Delta\varphi, (\varphi \wedge \psi) \in ME_t$.

$\cap_2$: If $\alpha, \beta \in ME_\tau$, $\tau \in \{t, e\}$, then $(\alpha \cap \beta) \in ME_\tau$.

$\cap_1$: If $\alpha \in ME_{\tau t}$, $\tau \in \{t, e\}$, then $[\cap\alpha] \in ME_t$.

*****: If $\alpha \in ME_{et}$, then $[{*}\alpha] \in ME_{et}$.

/: If $\alpha \in ME_e$ and $\varphi \in ME_t$, then $[-/\alpha]\varphi, [+/\alpha]\varphi \in ME_t$.

ι: If $u \in Var_\tau$, $\tau \in \{t, e\}$, and $\varphi \in ME_t$, then $\iota u\varphi \in ME_\tau$.

∃: If $u \in Var_\tau$ and $\varphi \in ME_t$, then $\exists u\varphi \in ME_t$.

λ: If $u \in Var_\tau$ and $\alpha \in ME_\upsilon$, then $\lambda u[\alpha] \in ME_{\tau\upsilon}$.

IV. Abbreviations:

- $x := v_{0,\sim}$, $y := v_{1,\sim}$, $z := v_{2,\sim}$, $\ldots$, $t := v_{0,\mathbf{T}}$, $t' := v_{1,\mathbf{T}}$, $\ldots$, $e := v_{0,\sim\mathbf{T}}$, $e' := v_{1,\sim\mathbf{T}}$, $\ldots$, $l := v_{0,\mathbf{T}/\sim}$, $l' := v_{1,\mathbf{T}/\sim}$, $\ldots$
- $\alpha_{\tau 1\ldots\tau n\upsilon}(\beta_{n,\tau n}, \ldots, \beta_{1,\tau 1}) := \alpha(\beta_1)\ldots(\beta_n)$
- $\forall u_\tau \varphi_t := \neg\exists u \neg\varphi$
- $(\varphi_t \rightarrow \psi_t) := \neg(\varphi \wedge \neg\psi)$
- $(\varphi_t \vee \psi_t) := \neg(\neg\varphi \wedge \neg\psi)$
- $(\alpha_{et} \cap \beta_{et}) := \lambda v_{0,e}\, [\alpha(v_{0,e}) \cap (\beta(he_0) \vee (dn_0 \bigcirc \iota t\, \beta(t) \vee {}^{\mathrm{T}}it_0 \subseteq \iota t\, \beta(t)))]$

<u>Static semantics</u>

I. Let W and O be non-empty disjoint sets. For each $\tau \in Type$, we define $\Delta_{\tau:\sim}$ (set of *static* τ-*denotations*):

- $\Delta_{t:\sim} = \mathcal{P}(W)$
- $\Delta_{e:\sim} = O$
- $\Delta_{\tau\upsilon:\sim} = (\Delta_{\upsilon:\sim})^{\Delta\tau:\sim}$

II. A *model* for ELA is a structure $M = \langle W, O, \subseteq_O, F\rangle$ such that:

- W and O are non-empty disjoint sets (*worlds* and *objects*, respectively).
- $\subseteq_O$ (*part-of*) is a join semilattice order over O.
- F (*static interpretation*) assigns to each non-indexical τ-constant $\alpha \in Con_\tau - (Con_{e:\mathbf{T}} \cup Con_{e:\sim\mathbf{T}})$

  a static τ-denotation $F(\alpha) \in \Delta_{\tau:\sim}$.

<u>Pragmatic event structures, time, space, and causal hierarchy</u>

I. A *pragmatic M-event structure* (for $M = \langle W, O, \subseteq_O, F\rangle$) is a structure $\mathscr{E} = \langle\langle E_0, W_0, |\,|\rangle, \langle\bigcirc_E, <_E\rangle, \langle\bullet_E, \infty_E\rangle\rangle$

such that:

- E_0 (*topical eventualities*) is a non-empty finite set disjoint from $W \cup O$

  W_0 (*topical worlds*) is a non-empty finite subset of W

  $|\,|$ assigns to each $\langle \boldsymbol{e}, w\rangle \in E_0 \times W_0$ a *factual description*, $\varnothing \subset |\boldsymbol{e}|_w \subseteq \{p \in \mathscr{P}(W_0)|\ w \in p\}$.

- $\bigcirc_E$ (*temporal overlap*) is a reflexive and symmetric relation in E_0

  $<_E$ (*temporal precedence*) is a strict partial order in E_0 such that:

  $\boldsymbol{e} \bigcirc_E \boldsymbol{e}' \leftrightarrow \neg\, \boldsymbol{e} <_E \boldsymbol{e}'\ \&\ \neg\, \boldsymbol{e}' <_E \boldsymbol{e}$

  $\boldsymbol{e} <_E \boldsymbol{e}'\ \&\ \boldsymbol{e}' \bigcirc_E \boldsymbol{e}''\ \&\ \boldsymbol{e}'' <_E \boldsymbol{e}''' \rightarrow \boldsymbol{e} <_E \boldsymbol{e}'''$

- $\bullet_E$ (*spatial overlap*) is a reflexive and symmetric relation in E_0

  ∞_E (*spatial adjacency*) is an irreflexive and symmetric relation in E_0 such that:

  $\boldsymbol{e} \bullet_E \boldsymbol{e}' \rightarrow \neg\, \boldsymbol{e} \infty_E \boldsymbol{e}'$

II. The $\mathscr{E}$-*time* is the structure $Tm(\mathscr{E}) = \langle\langle I, <_I, \propto_I\rangle, \langle T, <_T, \cup_T, [\ ]_T\rangle\rangle$ such that:

- ι is an $\mathscr{E}$-*instant*, $\iota \in I$, iff ι is a maximal non-empty subset of E_0 such that $\forall \boldsymbol{e}, \boldsymbol{e}' \in \iota$: $\boldsymbol{e} \bigcirc_E \boldsymbol{e}'$

  ι *I-precedes* ι', $\iota <_I \iota'$, iff $\iota, \iota' \in I\ \&\ \exists \boldsymbol{e} \in \iota\ \exists \boldsymbol{e}' \in \iota'$: $\boldsymbol{e} <_E \boldsymbol{e}'$

  ι is *the immediate I-predecessor* of ι', $\iota \propto_I \iota'$, iff $\iota <_I \iota'\ \&\ \forall \iota''(\iota'' \neq \iota\ \&\ \iota'' <_I \iota' \rightarrow \iota'' <_I \iota)$

- θ is an *I-period*, $\theta \in T$, iff $\varnothing \subset \theta \subseteq I\ \&\ \forall \iota, \iota' \in \theta\ \forall \iota'' \in I$: $\iota <_I \iota'' <_I \iota' \rightarrow \iota'' \in \theta$

  θ *Tm-precedes* θ', $\theta <_T \theta'$, iff $\theta, \theta' \in T\ \&\ \forall \iota \in \theta\ \forall \iota' \in \theta'$: $\iota <_I \iota'$

  $\theta \cup_T \theta' := \min\{\theta'' \in T: \theta \subseteq \theta''\ \&\ \theta' \subseteq \theta''\}$ is the *Tm-sum* of θ and θ', for any $\theta, \theta' \in T$

  $[\boldsymbol{e}]_T := \cup_T\{\{\iota\}: \iota \in I\ \&\ \boldsymbol{e} \in \iota\}$ is the *Tm-coordinate* of $\boldsymbol{e}$, for any $\boldsymbol{e} \in E_0$

III. The $\mathscr{E}$-*space* is the structure $Sp(\mathscr{E}) = \langle\langle P, \infty_P, \langle P\rangle\rangle, \langle L, <_L, \cup_L, [\ ]_L\rangle\rangle$ such that:

- ι is an $\mathscr{E}$-*point*, $\iota \in P$, iff ι is a maximal non-empty subset of E_0 such that $\forall \boldsymbol{e}, \boldsymbol{e}' \in \iota$: $\boldsymbol{e} \bullet_E \boldsymbol{e}'$

  ι is *P-adjacent* to ι', $\iota \infty_P \iota'$, iff $\iota, \iota' \in P$ & $\exists \boldsymbol{e} \in \iota\ \exists \boldsymbol{e}' \in \iota'$: $\boldsymbol{e} \infty_E \boldsymbol{e}'$

  $\pi = \langle\iota_1, \ldots \iota_n\rangle \in P^n$ $(n \geq 1)$ is a *directed P-path*, $\pi \in \langle P\rangle$, iff $(\iota_1 \neq \iota_n \rightarrow \iota_1 \infty_P \iota_2\ \&\ \ldots\ \iota_{n-1} \infty_P \iota_n)$

- θ is a *P-region*, $\theta \in L$, iff $\varnothing \subset \theta \subseteq P$ & $(\theta \neq P \rightarrow \forall\iota, \iota' \in \theta\ \exists\langle\iota_1, \ldots \iota_n\rangle \in \langle P\rangle$: $\iota = \iota_1$ & $\iota' \in \iota_n)$

  θ *Sp-precedes* θ' along $\pi = \langle\iota_1, \ldots\iota_n, \ldots, \iota'_1, \ldots \iota'_m\rangle \in \langle P\rangle$, $\theta <_{L, \pi} \theta'$, iff $\theta = \{\iota_1, \ldots\iota_n\}$ & $\theta' = \{\iota'_1 \ldots \iota'_m\}$

  $\theta \cup_L \theta' := \min\{\theta'' \in L: \theta \subseteq \theta''\ \&\ \theta' \subseteq \theta''\}$ is the *Sp-sum* of θ and θ', for any $\theta, \theta' \in L$

  $[\boldsymbol{e}]_L := \cup_L\{\{\iota\}: \iota \in P\ \&\ \boldsymbol{e} \in \iota\}$ is the *Sp-coordinate* of $\boldsymbol{e}$, for any $\boldsymbol{e} \in E_0$

IV. The *causal* $\mathscr{E}$-*hierarchy* in $w \in W_0$ is the structure $Cs_w(\mathscr{E}) = \langle\langle K_w, <_w, \propto_w\rangle, \langle E_w, <_{w+}, \cup_w, [\ ]_w\rangle\rangle$ such that:

- for any $p \in |\boldsymbol{e}|_w$, ι is an $\mathscr{E}$-*description of* $[\boldsymbol{e}\backslash p]$-*alternatives* to w, $\iota \in K_w[\boldsymbol{e}\backslash p]$, iff ι is a maximal consistent set

  $(\{W_0 - p\} \cup \kappa \cup \kappa')$ such that $\kappa \subseteq (|\boldsymbol{e}|_w - \{p\})$ and $\kappa' \subseteq \{|\boldsymbol{e}'|_w: [\boldsymbol{e}']_T \subseteq [\boldsymbol{e}]_T\ \&\ [\boldsymbol{e}']_L \subseteq [\boldsymbol{e}]_L\}$

  $\boldsymbol{e}$ *K-precedes* $\boldsymbol{e}'$ in w, $\boldsymbol{e} <_w \boldsymbol{e}'$, iff $[\boldsymbol{e}]_T \leqq_T [\boldsymbol{e}']_T$ & $|\boldsymbol{e}'|_w \neq \varnothing$ & $\forall q \in |\boldsymbol{e}'|_w\ \exists p \in |\boldsymbol{e}|_w$: $\cap K_w[\boldsymbol{e}\backslash p] \subset \cap K_w[\boldsymbol{e}'\backslash q]$

  $\boldsymbol{e}$ *is the immediate K-predecessor* of $\boldsymbol{e}'$ in w, $\boldsymbol{e} \propto_w \boldsymbol{e}'$, iff $\boldsymbol{e} <_w \boldsymbol{e}'$ & $\forall \boldsymbol{e}''$: $\boldsymbol{e}'' \neq \boldsymbol{e}$ & $\boldsymbol{e}'' <_w \boldsymbol{e}' \rightarrow \boldsymbol{e}'' <_w \boldsymbol{e}$

- $\varepsilon = \langle\boldsymbol{e}_1, \ldots, \boldsymbol{e}_n\rangle \in E_0{}^n$ $(n \geq 1)$ is a *w-event*, $\varepsilon \in E_w$, iff $(\boldsymbol{e}_1 \neq \boldsymbol{e}_n \rightarrow \boldsymbol{e}_1 \propto_w \boldsymbol{e}_2\ \&\ \ldots\ \boldsymbol{e}_{n-1} \propto_w \boldsymbol{e}_n)$

  ε *Cs-precedes* ε' in w, $\varepsilon <_{w+} \varepsilon'$, iff $\exists\langle\boldsymbol{e}_1, \ldots \boldsymbol{e}_n, \ldots \boldsymbol{e}'_1, \ldots \boldsymbol{e}'_m\rangle \in E_w$: $\varepsilon = \langle\boldsymbol{e}_1, \ldots \boldsymbol{e}_n\rangle$ & $\varepsilon' = \langle\boldsymbol{e}'_1, \ldots \boldsymbol{e}'_m\rangle$

  $\varepsilon \cup_w \varepsilon' := \langle\boldsymbol{e}_1, \ldots \boldsymbol{e}_n, \boldsymbol{e}'_1, \ldots \boldsymbol{e}'_m\rangle$, for any $\varepsilon = \langle\boldsymbol{e}_1, \ldots \boldsymbol{e}_n\rangle$, $\varepsilon' = \langle\boldsymbol{e}'_1, \ldots \boldsymbol{e}'_m\rangle \in E_w$ such that $\boldsymbol{e}_n \propto_w \boldsymbol{e}'_1$

  $[\varepsilon]_w := \cup\{|\boldsymbol{e}_i|_w: 1 \leq i \leq n\}$ is the *factual description* in w of $\varepsilon = \langle\boldsymbol{e}_1, \ldots \boldsymbol{e}_n\rangle \in E_w$

- *Notation conventions*:
  - $E := \cup_{w \in W0} E_w$

    $D := O \cup E \cup T \cup L$, and $D_w := O \cup E_w \cup T \cup L$ for any $w \in W_0$
  - $[\varepsilon]_T := \cup_T\{[\boldsymbol{e}_i]_T: 1 \leq i \leq n\}$ is the *Tm-coordinate* of $\varepsilon = \langle\boldsymbol{e}_1, \ldots \boldsymbol{e}_n\rangle \in E_w$

    $[\varepsilon]_L := \cup_L\{[\boldsymbol{e}_i]_L: 1 \leq i \leq n\}$ is the *Sp-coordinate* of $\varepsilon = \langle\boldsymbol{e}_1, \ldots \boldsymbol{e}_n\rangle \in E_w$
  - θ is a *Tm-part* of θ', $\theta \subseteq_T \theta'$, iff $\theta, \theta' \in T$ & $\theta \subseteq \theta'$

    θ is an *Sp-part* of θ', $\theta \subseteq_L \theta'$, iff $\theta, \theta' \in L$ & $\theta \subseteq \theta'$

    ε is a *w-part* of ε, $\varepsilon \subseteq_w \varepsilon'$, iff $\varepsilon, \varepsilon' \in E_w$ & $[\varepsilon]_T \subseteq [\varepsilon']_T$ & $[\varepsilon]_L \subseteq [\varepsilon']_L$ & $[\varepsilon]_w \subseteq [\varepsilon']_w$
  - θ *Tm-overlaps* with θ', $\theta \bigcirc_T \theta'$, iff $\theta, \theta' \in T$ & $\exists\theta'' \in T$: $\theta'' \subseteq_T \theta$ & $\theta'' \subseteq_T \theta'$

Dynamic contexts and assignments:

In what follows, † := {W, D} is Kaplan's *impossible entity*, used to represent 'undefined' values of functions.

I. • *Cases* and *information states*:

$C^n = \{\langle w, a\rangle : w \in W_0 \ \&\ a \in (D_w)^n\}$ is the set of cases with n entities

$C = \cup_{n \in \mathcal{N}} C^n$ is the set of cases

$S^n = \mathcal{P}(C^n)$ is the set of information states about n entities

$S = \cup_{n \in \mathcal{N}} S^n$ is the set of information states

• *Dynamic denotations* (possible and †'s) for all $\tau \in$ *Type*

$\Delta_t = S$	$\dagger_t = \varnothing$
$\Delta_e = (D \cup \{\dagger\})^C$	$\dagger_e$ = the element of $\{\dagger\}^C$
$\Delta_{\tau\upsilon} = \Delta_\upsilon{}^{\Delta\tau}$	$\dagger_{\tau\upsilon}$ = the element of $\{\dagger_\upsilon\}^{\Delta\tau}$

• *Dynamic denotations* for all $\tau \in$ *Sort*

$\Delta_{\sim} = \{f \in \Delta_e \mid \text{Ran } f \subseteq O \cup \{\dagger\}\}$

$\Delta_{\mathbf{T}} = \{f \in \Delta_e \mid \text{Ran } f \subseteq T \cup \{\dagger\}\}$

$\Delta_{\sim\mathbf{T}} = \{f \in \Delta_e \mid \text{Ran } f \subseteq E \cup \{\dagger\}\}$

$\Delta_{\mathbf{T}/\sim} = \{f \in \Delta_e \mid \text{Ran } f \subseteq L \cup \{\dagger\}\}$

• *Notation conventions*:

• If $c = \langle w, a\rangle \in C$, then $w_c = w$ & $a_c = a$

• $a \cdot a' := \langle a_1, \ldots, a_n, a'_1, \ldots, a'_m\rangle$ is the *product*, for all $a = \langle a_1, \ldots, a_n\rangle \in D_w{}^n$, $a' = \langle a'_1, \ldots, a'_m\rangle \in D_w{}^m$

$c \cdot a' := \langle w_c, a_c \cdot a'\rangle$ is the *product*, for all $c \in C$, $a' \in D_{wc}{}^m$

• $\hat{}d := \{\langle c, d\rangle : d \in D_{wc}\} \cup \{\langle c, \dagger\rangle : d \notin D_{wc}\}$ is the (*dynamic*) *concept* of d, for all $d \in D$

$[\check{}\delta]_c := \delta(c)$ is the *extension* of $\delta \in \Delta_e$ in $c \in C$

$[\check{}s]_c := \check{}s := \{w_{c'} : c' \in s\}$ is the *extension* of $s \in S$ (in all $c \in C$)

• For any $B \in \{O, T, E, L\}$:

$[c]_{j,B} = [a_c]_{j,B}$ = $(j + 1)$-st entity $d \in B$ in a_c, counting from the end, if there is such

= †, otherwise

II. A *dynamic M-context* (for $M = \langle W, O, \subseteq_O, F\rangle$) is a structure $k = \langle \mathscr{E}_k, s_k, c_k, \approx_k, F_k\rangle$ such that:

- $\mathscr{E}_k = \langle\langle E_0, W_0, |\,|\rangle, \langle \bigcirc_E, <_E\rangle, \langle \bullet_E, \infty_E\rangle\rangle$ is a pragmatic *M*-event structure such that:

  $\beta \in \mathrm{Con}_{\tau t:\mathbf{T}} \cup \mathrm{Con}_{\tau t:\sim\mathbf{T}} \rightarrow \forall w \in W_0\, \forall d\, (w \in F(\beta)(d) \leftrightarrow \exists \boldsymbol{e} \in E_0: \cap|\boldsymbol{e}|_w \subseteq F(\beta)(d)\})$

  $\beta \in \mathrm{Con}_{\tau et:\mathbf{T}} \cup \mathrm{Con}_{\tau et:\sim\mathbf{T}} \rightarrow \forall w \in W_0\, \forall d, d'\, (w \in F(\beta)(d)(d') \leftrightarrow \exists \boldsymbol{e} \in E_0: \cap|\boldsymbol{e}|_w \subseteq F(\beta)(d)(d')\})$

  $\beta \in \mathrm{Con}_{\tau t:\mathbf{T}}\, \&\, \cap|\boldsymbol{e}|_w \subseteq F(\beta)(d) \rightarrow \forall \iota \in I \cap [\boldsymbol{e}]_T\, \exists \boldsymbol{e}' \in E_0: [\boldsymbol{e}']_T = \{\iota\}\ \&\ \cap|\boldsymbol{e}'|_w \subseteq F(\beta)(d)$

  $\beta \in \mathrm{Con}_{\tau et:\mathbf{T}}\, \&\, \cap|\boldsymbol{e}|_w \subseteq F(\beta)(d)(d') \rightarrow \forall \iota \in I \cap [\boldsymbol{e}]_T\, \exists \boldsymbol{e}' \in E_0: [\boldsymbol{e}']_T = \{\iota\}\ \&\ \cap|\boldsymbol{e}'|_w \subseteq F(\beta)(d)(d')$

- $\varnothing \subset s_k \subseteq W_0$ (*common ground*)

  $c_k = \langle w_k, \langle o_k, o'_k, \{\iota_{k-}\}, \{\iota_k\}, \{\iota_{k+}\}, \{\iota'_k\}, \{\iota'_{k1}\}, \ldots, \{\iota'_{kn}\}\rangle\rangle \in C$ (*context case*) is a case such that:

  $w_k \in W_0$ (*context world*), $o_k, o'_k \in O$ (*speaker*, *addressee*)

  $\iota_{k-} <_I \iota_k <_I \iota_{k+}$ (*past reference point*, *now*, *future reference point*)

  $\pi_k := \langle \iota', \iota'_{k1} \ldots, \iota'_{kn}\rangle \in \langle P\rangle$ (*path from here to there*)

- $\approx_k$ assigns to each $w \in W_0$ a *stage-of* relation $\approx_{k,w} \subseteq E_0 \times O$ such that:

  $\boldsymbol{e} \approx_{k,w} o\ \&\ o \subseteq_O o' \rightarrow \exists \boldsymbol{e}' \in E_0: \boldsymbol{e} \subseteq_w \boldsymbol{e}'\ \&\ \boldsymbol{e}' \approx_{k,w} o'$

- F_k, the *dynamic transform* of F in k, assigns to each $s \in S$ and τ-constant $\alpha \in \mathrm{Con}_\tau$ a dynamic τ-denotation $F_{k,s}(\alpha) \in \Delta_\tau$ as follows:

  - $F_{k,s}(n) = \hat{}\{\iota_k\}$ $\quad$ $F_{k,s}(h) = \hat{}\{\iota'_k\}$

    $F_{k,s}(-) = \hat{}\{\iota_{k-}\}$ $\quad$ $F_{k,s}(dn_j) = \{\langle c, [c]_{j,T}\rangle: c \in s\} \cup \{\langle c, \dagger\rangle: c \notin s\}$

    $F_{k,s}(+) = \hat{}\{\iota_{k+}\}$ $\quad$ $F_{k,s}(dr_j) = \{\langle c, [c]_{j,L}\rangle: c \in s\} \cup \{\langle c, \dagger\rangle: c \notin s\}$

    $F_{k,s}(i) = \hat{}o_k$ $\quad$ $F_{k,s}(it_j) = \{\langle c, [c]_{j,E}\rangle: c \in s\} \cup \{\langle c, \dagger\rangle: c \notin s\}$

    $F_{k,s}(u) = \hat{}o'_k$ $\quad$ $F_{k,s}(he_j) = \{\langle c, [c]_{j,O}\rangle: c \in s\} \cup \{\langle c, \dagger\rangle: c \notin s\}$

  - $F_{k,s}(\alpha) = \hat{}F(\alpha)$ for all $\alpha \in Con_{e:\sim}$

  - $F_{k,s}(\beta)(\delta) = \{c \in s|\ w_c \in F(\beta)([\check{}\delta]_c)\}$ for all $\beta \in Con_{\tau t:\sim}$, $\delta \in \Delta_\tau$

    $= \{c \cdot [\boldsymbol{e}]_T|\ c \in s\ \&\ \boldsymbol{e} \in E_0\ \&\ \cap|\boldsymbol{e}|_{wc} \subseteq F(\beta)([\check{}\delta]_c)\}$ for all $\beta \in Con_{\tau t:\mathbf{T}}$, $\delta \in \Delta_\tau$

    $= \{c \cdot \boldsymbol{e}|\ c \in s\ \&\ \boldsymbol{e} \in E_0\ \&\ \cap|\boldsymbol{e}|_{wc} \subseteq F(\beta)([\check{}\delta]_c)\}$ for all $\beta \in \mathrm{Con}_{\tau t:\sim\mathbf{T}}$, $\delta \in \Delta_\tau$

  - $F_{k,s}(\beta)(\delta)(\delta') = \{c \in s|\ w_c \in F(\beta)([\check{}\delta]_c)([\check{}\delta']_c)\}$ for all $\beta \in \mathrm{Con}_{\tau et:\sim}$, $\delta \in \Delta_\tau$, $\delta' \in \Delta_e$

    $= \{c \cdot [\boldsymbol{e}]_T|\ c \in s\ \&\ \boldsymbol{e} \in E_0\ \&\ \cap|\boldsymbol{e}|_{wc} \subseteq F(\beta)([\check{}\delta]_c)([\check{}\delta']_c)\}$ for all $\beta \in \mathrm{Con}_{\tau et:\mathbf{T}}$, $\delta \in \Delta_\tau$, $\delta' \in \Delta_e$

    $= \{c \cdot \boldsymbol{e}|\ c \in s\ \&\ \boldsymbol{e} \in E_0\ \&\ \cap|\boldsymbol{e}|_{wc} \subseteq F(\beta)([\check{}\delta]_c)([\check{}\delta']_c)\}$ for all $\beta \in \mathrm{Con}_{\tau et:\sim\mathbf{T}}$, $\delta \in \Delta_\tau$, $\delta' \in \Delta_e$

III.• An $\langle M, k\rangle$-*assignment* is a function g that to each basic τ-variable $u \in var_\tau$ ($\tau \in Type \cup Sort$) assigns a dynamic denotation $g(u) \in \Delta_\tau$. Moreover, for any $\delta \in \Delta_\tau$, $g[u/\delta] := (g - \{\langle u, g(u)\rangle\}) \cup \{\langle u, \delta\rangle\}$.

- For any M-context k and $\iota <_I \iota_k$, $k[-/\{\iota\}]$ is like k except that the past reference point is ι.

  For any M-context k and $\iota_k <_I \iota$, $k[+/\{\iota\}]$ is like k except that the future reference point is ι.

Update semantics

I • *Update order*:

$\langle w, a\rangle \leqslant_{[t]} \langle w', a'\rangle$ iff $w = w'$ & $\exists n, m$ ($a \in (D_w)^n$ & $\exists a'' \in (D_w)^m$: $a' = \langle a_1, \ldots, a_n, a''_1, \ldots, a''_m\rangle$)

$s \leqslant_t s'$, iff $s, s' \in \Delta_t$ & $\forall c' \in s' \exists c \in s$: $c \leqslant_{[t]} c'$

- *Part-whole order*:

$\subseteq_{e,\,w} := (\subseteq_O \cup \subseteq_T \cup \subseteq_L \cup \subseteq_w)$, for all $w \in W_0$

$s \subseteq_t s'$, iff $s, s' \in \Delta_t$ & $\forall c \in s\ \exists c' \in s'$: $c \leqslant_{[t]} c'$

- *Information order*:

$\theta \leqslant_T \theta'$ iff $\theta, \theta' \in T$ & $\theta \supseteq \theta'$

$\theta \leqslant_L \theta'$ iff $\theta, \theta' \in L$ & $\theta \supseteq \theta'$

$\leqslant_{e,\,w} := (\subseteq_O \cup \leqslant_T \cup \leqslant_L \cup \subseteq_w)$, for all $w \in W_0$

$\langle w, a\rangle \leqslant_{[t]} \langle w', a'\rangle$ iff $w = w'$ & $\exists n, m$ ($a \in (D_w)^n$ & $a' \in (D_w)^{n+m}$ & $a_1 \leqslant_{e,\,w} a'_1 \ldots$ & $a_n \leqslant_{e,\,w} a'_n$)

$s \leqslant_t s'$, iff $s, s' \in \Delta_t$ & $\forall c' \in s'\ \exists c \in s$: $c \leqslant_{[t]} c'$

II. Let M be a model for *ELA*, k, a dynamic M-context, g, an $\langle M, k\rangle$-assignment, $s \in S$. The *valuation* $s[\![\ ]\!]^{M,\,k,\,g}$ assigns to each meaningful expression $\alpha \in ME_\tau$ a dynamic denotation $s[\![\alpha]\!]^{M,\,k,\,g} \in \Delta_\tau$ as follows:

B: $s[\![\alpha]\!]^{M,\,k,\,g} = F_{k,\,s}(\alpha)$ for all $\alpha \in Con_\tau$ ($\tau \in Type$)

$s[\![u]\!]^{M,\,k,\,g} = g(u)$ for all $u \in var_\tau$ ($\tau \in Type \cup Sort$)

$\mathbf{v}_\alpha$**:** $s[\![v_{i,\alpha}]\!]^{M,\,k,\,g} = g(v_{i,e})$ if $s \subseteq_t s[\![\alpha]\!]^{M,\,k,\,g}(g(v_{i,e}))$

$= \dagger_e$, otherwise

( ): $s[\![\alpha_{\tau\upsilon}(\beta_\tau)]\!]^{M,\,k,\,g} = s[\![\alpha]\!]^{M,\,k,\,g}(s[\![\beta]\!]^{M,\,k,\,g})$

∈: $s[\![\beta_\tau \in \mathrm{Dom}\ \alpha_{\tau\upsilon}]\!]^{M,\,k,\,g} = \{c \in s \mid s[\![\alpha]\!]^{M,\,k,\,g}(s[\![\beta]\!]^{M,\,k,\,g}) \neq \dagger_\tau\}$ for all $\upsilon \neq e$

$s[\![\beta_\tau \in \mathrm{Dom}\ \alpha_{\tau e}]\!]^{M,k,g} = \{c \in s \mid [\check{}s[\![\alpha]\!]^{M,\,k,\,g}(s[\![\beta]\!]^{M,\,k,\,g})]_c \neq \dagger\}$

At: $s[\![\mathrm{At}(\alpha_e, \varphi)]\!]^{M,k,g} = \{c \cdot a |\ c \in s\ \&\ c \cdot a \in s[\![\varphi]\!]^{M,k,g}$

$\&\ ([a]_{0,T} \neq \dagger \longrightarrow [a]_{0,T} \bigcirc_T [{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c)$

$\&\ ([a]_{0,E} \neq \dagger \longrightarrow [[a]_{0,E}]_T \subseteq_T [{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c)\}$

=: $s[\![\alpha_\tau = \beta_\tau]\!]^{M,k,g} = \{c \in s |\ s[\![\alpha]\!]^{M,k,g} = s[\![\beta]\!]^{M,k,g}\}$ for all $\tau \neq e$

$s[\![\alpha_e = \beta_e]\!]^{M,k,g} = \{c \in s |\ [{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c = [{}^{\smile}s[\![\beta]\!]^{M,k,g}]_c\}$

R$_e$**:** $s[\![\alpha_e \approx \beta_e]\!]^{M,k,g} = \{c \in s |\ [{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c \approx_{k,\,wc} [{}^{\smile}s[\![\beta]\!]^{M,k,g}]_c\}$

$s[\![\alpha_e \bigcirc \beta_e]\!]^{M,k,g} = \{c \in s |\ [{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c \bigcirc_T [{}^{\smile}s[\![\beta]\!]^{M,k,g}]_c\}$

$s[\![\alpha_e \subseteq \beta_e]\!]^{M,k,g} = \{c \in s |\ [{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c \subseteq_{e,\,wc} [{}^{\smile}s[\![\beta]\!]^{M,k,g}]_c\}$

$s[\![\alpha_e < \beta_e]\!]^{M,k,g} = \{c \in s |\ \langle [{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c, [{}^{\smile}s[\![\beta]\!]^{M,k,g}]_c \rangle \in (<_T \cup <_{L,\,\pi k} \cup <_{wc+})\}$

$s[\![\alpha_e \propto \beta_e]\!]^{M,k,g} = \{c \cdot (\{\iota\} \cup_T \{\iota'\}) |\ c \in s\ \&\ \{\iota\} = [{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c\ \&\ \{\iota'\} = [{}^{\smile}s[\![\beta]\!]^{M,k,g}]_c\ \&\ \iota \propto_I \iota'\}$

$\cup\ \{c \cdot (\boldsymbol{e} \cup_{wc} \boldsymbol{e}') |\ c \in s\ \&\ \boldsymbol{e} = [{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c\ \&\ \boldsymbol{e}' = [{}^{\smile}s[\![\beta]\!]^{M,k,g}]_c\ \&\ \boldsymbol{e} \propto_{wc} \boldsymbol{e}'\}$

O$_e$**:** $[{}^{\smile}s[\![{}^{\mathrm{L}}\alpha_e]\!]^{M,k,g}]_c$ $= [[{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c]_L$, if there is such

$= \dagger$, otherwise

$[{}^{\smile}s[\![{}^{\mathrm{T}}\alpha_e]\!]^{M,k,g}]_c$ $= [[{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c]_T$, if there is such

$= \dagger$, otherwise

$[{}^{\smile}s[\![[\alpha_e, \beta_e]]\!]^{M,k,g}]_c = [{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c \cup_T [{}^{\smile}s[\![\beta]\!]^{M,k,g}]_c$, if there is such

$= \dagger$, otherwise

O$_t$**:** $s[\![\neg\varphi]\!]^{M,k,g} = \{c \in s |\ \neg\exists c' : c \leqslant_{[t]} c'\ \&\ c' \in s[\![\varphi]\!]^{M,k,g}\}$

$s[\![\Delta\varphi]\!]^{M,k,g} = \{c \cdot \boldsymbol{e} |\ c \in s\ \&\ \boldsymbol{e} \in E_0\ \&\ \cap|\boldsymbol{e}|_{wc} \subseteq_t \{c' \in C |\ a_{c'} = a_c\}[\![\varphi]\!]^{M,k,g}$

$\&\ \exists\iota, \iota' \in I\ \exists b \in (D_{wc})^n\ ([\boldsymbol{e}]_T = \{\iota\} = [b]_{0,T}\ \&\ c \cdot b \in s[\![\varphi]\!]^{M,k,g}\ \&\ \iota' \propto_I \iota$

$\&\ \neg\exists \boldsymbol{e}' \in E_0\ ([\boldsymbol{e}']_T = \{\iota'\}\ \&\ \cap|\boldsymbol{e}'|_{wc} \subseteq_t \{c'' \in C |\ a_{c''} = a_c\}[\![\varphi]\!]^{M,k,g}))\}$

$s[\![(\varphi \wedge \psi)]\!]^{M,k,g} = \{c \cdot a \cdot b |\ c \in s\ \&\ c \cdot a \in s[\![\varphi]\!]^{M,k,g}\ \&\ c \cdot a \cdot b \in \{c \cdot a\}[\![\psi]\!]^{M,k,g}\}$

∩$_2$**:** $s[\![(\alpha_t \cap \beta_t)]\!]^{M,k,g} = \{c \cdot a \cdot b |\ c \in s\ \&\ c \cdot a \in s[\![\alpha]\!]^{M,k,g}\ \&\ \langle w_c, a \cdot b\rangle \in \{\langle w_c, a\rangle\}[\![\beta]\!]^{M,k,g}\}$

$[{}^{\smile}s[\![(\alpha_e \cap \beta_e)]\!]^{M,k,g}]_c = \leqslant_{e,\,wc}\text{-sup}\{[{}^{\smile}s[\![\alpha]\!]^{M,k,g}]_c, [{}^{\smile}s[\![\beta]\!]^{M,k,g}]_c\}$ if there is such

$= \dagger$, otherwise

∩$_1$**:** $s[\![\cap\alpha_{tt}]\!]^{M,k,g} = \leqslant_t\text{-sup}\{s' \in \Delta_t |\ \{w_k\} \subseteq_t s'\ \&\ s_k \subseteq_t s_k[\![\alpha]\!]^{M,k,g}(s')\}$

$s[\![\cap\alpha_{et}]\!]^{M,k,g} = \{c \cdot a |\ c \in s\ \&\ a = \leqslant_{[t]}\text{-max}\{\langle w_c, b \cdot d\rangle |\ c \cdot b \in s[\![\alpha]\!]^{M,k,g}({}^{\frown}d)\}\}$

***:** $s[\![{}^*\alpha_{et}]\!]^{M,\,k,\,g}(\delta) = \{c \in s |\, [{}^\vee\delta]_c \in \{\subseteq_{e,\,wc}\text{-sup } X\!: \varnothing \subset X \subseteq \{d \in D_{wc} |\, c \in s[\![\alpha]\!]^{M,\,k,\,g}({}^\wedge d)\}\}\}$,

/: $s[\![[-/\alpha_e]\varphi]\!]^{M,\,k,\,g} = \{c \cdot a |\, c \in s \;\&\; \exists\iota \in I\!: \{\iota\} = [{}^\vee s[\![\alpha]\!]^{M,\,k,\,g}]_c \;\&\; \iota <_I \iota_k \;\&\; c \cdot a \in s[\![\varphi]\!]^{M,\,k[-/\{\iota\}],\,g}\}$

$s[\![[+/\alpha_e]\varphi]\!]^{M,\,k,\,g} = \{c \cdot a |\, c \in s \;\&\; \exists\iota \in I\!: \{\iota\} = [{}^\vee s[\![\alpha]\!]^{M,\,k,\,g}]_c \;\&\; \iota_k <_I \iota \;\&\; c \cdot a \in s[\![\varphi]\!]^{M,\,k[+/\{\iota\}],\,g}\}$

ι: $s[\![\iota u\, \varphi]\!]^{M,\,k,\,g} = \leqslant_t\text{-max}\{s' \in \Delta_t |\, \{w_k\} \subseteq_t s' \;\&\; s_k \subseteq_t s_k[\![\varphi]\!]^{M,\,k,\,g[u/s']}\}$, if there is such, else $\dagger_t$,

for $u \in var_\tau$ $(\tau \in Type - \{e\})$

$[{}^\vee s[\![\iota u\, \varphi]\!]^{M,\,k,\,g}]_c = \leqslant_{e,\,wc}\text{-max}\{d \in D_{wc} |\, {}^\wedge d \in \Delta_\tau \;\&\; c \in s[\![\varphi]\!]^{M,\,k,\,g[u/{}^\wedge d]}\}$, if there is such, else †,

for $u \in var_\tau$ $(\tau \in \{e\} \cup Sort)$

$= \leqslant_{e,\,wc}\text{-max}\{d \in D_{wc} |\, s \subseteq_t s[\![\alpha]\!]^{M,\,k,\,g}({}^\wedge d) \;\&\; c \in s[\![\varphi]\!]^{M,\,k,\,g[u/{}^\wedge d]}\}$, if there is such, else †,

for $u = v_{i,\alpha}$ $(\alpha \in ME_{et})$

∃: $s[\![\exists u\, \varphi]\!]^{M,\,k,\,g} = \{c \in s |\, \exists\delta\!: \delta \in \Delta_\tau \;\&\; c \in s[\![\varphi]\!]^{M,\,k,\,g[u/\delta]}\}$, for $u \in var_\tau$ $(\tau \in Type - \{e\})$

$= \{c \cdot d |\, d \in D_{wc} \;\&\; {}^\wedge d \in \Delta_\tau \;\&\; c \in s[\![\varphi]\!]^{M,\,k,\,g[u/{}^\wedge d]}\}$, for $u \in var_\tau$ $(\tau \in \{e\} \cup Sort)$

$= \{c \cdot d |\, s \subseteq_t s[\![\alpha]\!]^{M,\,k,\,g}({}^\wedge d) \;\&\; c \in s[\![\varphi]\!]^{M,\,k,\,g[u/{}^\wedge d]}\}$, for $u = v_{i,\alpha}$ $(\alpha \in ME_{et})$

λ: $s[\![\lambda u\, [\alpha_\upsilon]]\!]^{M,\,k,\,g}(\delta) = s[\![\alpha]\!]^{M,\,k,\,g[u/\delta]}$, if $u \in var_\tau$ and $\delta \in \Delta_\tau$

$= s[\![\alpha]\!]^{M,\,k,\,g[u'/\delta]}$, if $u = v_{i,\alpha}$ $(\alpha \in ME_{et})$, $u' = v_{i,e}$, $\delta \in \Delta_e$, and $s \subseteq_t s[\![\alpha]\!]^{M,\,k,\,g}(\delta)$

$= \dagger_\upsilon$, otherwise

III. • φ is *true* in k, wrt M and g, $\vDash_{M,\,k,\,g} \varphi$, iff $\{w_k\} \subseteq_t s_k[\![\varphi]\!]^{M,\,k,\,g}$

- *s supports* φ in k, wrt M and g, $s \vDash_{M,\,k,\,g} \varphi$, iff $s \subseteq_t s[\![\varphi]\!]^{M,\,k,\,g}$
- $\varphi_1, \ldots, \varphi_n$ *entail* ψ, $\varphi_1, \ldots, \varphi_n \vDash \psi$, iff $\forall s\, \forall M, k, g\!: s[\![\varphi_1]\!]^{M,\,k,\,g} \ldots [\![\varphi_n]\!]^{M,\,k,\,g} \vDash_{M,\,k,\,g} \psi$

APPENDIX 2: CROSS-LINGUISTIC SEMANTICS (XLS)

What follows is a slightly revised version of the Cross-Linguistic Semantics presented in Bittner 1998 (see also Bittner 1994a, b, 1997a, b). The revisions, which are motivated in this work, are in the following definitions:

- D1 (set of *type lifting operators* expanded up to closure and revised to yield a more symmetric system)
- D4 (*type hierarchy*, $\prec$, generalized to sorts and tightened so that $\tau \prec \upsilon \rightarrow \mathbf{r}(\tau) \leq \mathbf{r}(\upsilon)$)
- D5 (*type-driven application*, $\mathbb{F}$, generalized to recognize mismatch in sort as well as in type)
- Rule E (determines the type as well as the sort of stored variables introduced by *empty categories*)

The translation language is *ELA*. The following abbreviations are used:

- $Var = \cup_\tau Var_\tau$, $ME = \cup_\tau ME_\tau$
- $\varepsilon(\varepsilon') \in ME_\perp$ iff $\varepsilon, \varepsilon', \varepsilon(\varepsilon') \in ME$ and $\exists M, k, g$: $\vDash_{M,k,g} (\varepsilon' \in \text{Dom } \varepsilon)$

Inductive base

D1 Set of *type lifting operators*, ${}^{\Uparrow}ME := \cup_\tau\{[\cap]_\tau, [\cap]!_\tau, [=]_\tau, [=]!_\tau, [\exists]_\tau, [\exists]!_\tau, [\propto]_\tau, [\propto]!_\tau, [\forall]_\tau, [\forall]!_\tau, [()]_\tau, [()]!_\tau\}$

	From	*To*	*Definition*
$[\cap]_\tau$	τ	$\tau\tau$	$\lambda v_\tau \lambda u_\tau[u \cap v]$
$[\cap]!_\tau$	τt	$(tt)t$	$\lambda P_{\tau t}\lambda W_{tt}[W(\cap P)]$
$[=]_\tau$	τ	τt	$\lambda v_\tau \lambda u_\tau[u = v]$
$[=]!_\tau$	τt	$\tau\tau t$	$\lambda P_{\tau t}\lambda v_\tau \lambda u_\tau[P(u) \wedge v = v]$
$[\exists]_\tau$	τt	$(\tau t)t$	$\lambda P_{\tau t}\lambda Q_{\tau t}\, \exists v_\tau(P(v) \wedge Q(v))$
$[\exists]!_\tau$	τet	$(\tau t)et$	$\lambda A_{\tau et}\lambda Q_{\tau t}\lambda u_e\, \exists v_\tau(Q(v) \wedge A(u, v))$
$[\propto]_\tau$	τt	$t\tau t$	$\lambda P_{\tau t}\lambda q_t \lambda v_\tau\, (.P(v) \wedge \Delta q. \cap it_1 \propto it_0)$
$[\propto]!_\tau$	τet	$(\tau t)\tau et$	$\lambda A_{\tau et}\lambda Q_{\tau t}\lambda v_\tau \lambda u_e\, (.A(u, v) \wedge \Delta Q(v). \cap it_1 \propto it_0)$
$[\forall]_\tau$	$\tau\tau t$	$e(\tau\tau)t$	$\lambda R_{\tau\tau t}\lambda t \lambda f_{\tau\tau}\, \forall v_\tau(v \in \text{Dom } f \longrightarrow \text{At}(t, R(f(v), v)))$
$[\forall]!_\tau$	$(\tau t)\tau et$	$e((\tau t)\tau)et$	$\lambda C_{(\tau t)\tau et}\lambda t \lambda h_{(\tau t)\tau}\lambda u_e\, \forall Q_{\tau t}(Q \in \text{Dom } h \longrightarrow \text{At}(t, C(u, h(Q), Q)))$
$[()]_\tau$	$\tau\tau t$	$(\tau\tau)\tau\tau t$	$\lambda R_{\tau\tau t}\lambda f_{\tau\tau}\lambda v_\tau \lambda u_\tau\, R(u, f(v))$
$[()]!_\tau$	$(\tau t)\tau et$	$e((\tau t)t)(\tau t)et$	$\lambda C_{(\tau t)\tau et}\lambda t \lambda \mathscr{P}_{(\tau t)t}\lambda Q_{\tau t}\lambda u_e\, \mathscr{P}(\lambda v_\tau\, \text{At}(t, C(u, v, Q)))$

D2 Let T be a tree; L, the set of lexical items in T; N, the set of nodes in T; and $M \subseteq N$.

An *interpretive base* for T is a pair of functions $\mathbb{B} = \langle \mathbb{L}, \mathbb{T}\rangle$ such that:

- $\mathbb{L}$: $L \longrightarrow \{\emptyset\} \cup (ME \times \{\emptyset\}) \cup (ME \times \{\{u\} \mid u \in Var\})$
- $\mathbb{T}$: $M \longrightarrow {}^{\Uparrow}ME \cup ({}^{\Uparrow}ME)^2 \cup Var \cup (Var \times {}^{\Uparrow}ME) \cup (Var)^2$

We say that $\mathbb{L}$ is a *lexicon* for T, and $\mathbb{T}$, a *transformation plan* for T.

Initial and final translations

Relative to an interpretive base $\mathbb{B} = \langle \mathbb{L}, \mathbb{T}\rangle$ tree constituents are assigned up to two translations each, one by the *initial translation* function $\rightsquigarrow_{1,\mathbb{L},\mathbb{T}}$ and one by the *final translation* function $\rightsquigarrow_{2,\mathbb{L},\mathbb{T}}$. Rules (L–T) below define these two functions by simultaneous recursion, relying in part on the notions defined in (D3–D5).

D3 An *ARG* is a complement, specifier, or internal subject.

D4 *Type-driven application*, $\mathbb{F}$, is the following binary operation in *ME*:

- Dom $\mathbb{F} = \{\langle \varepsilon, \varepsilon' \rangle \in ME^2 | \ \varepsilon(\varepsilon') \in ME_\perp \text{ or } \varepsilon'(\varepsilon) \in ME_\perp\}$
- If $\langle \varepsilon, \varepsilon' \rangle \in$ Dom $\mathbb{F}$, then $\mathbb{F}(\varepsilon, \varepsilon') = \varepsilon(\varepsilon')$ or $\varepsilon'(\varepsilon)$, whichever is in *ME*

D5
- *Order*: $\mathbf{o}(\tau) = 0$ for all $\tau \in Sort \cup \{e, t\}$ $\quad \mathbf{o}(\tau\upsilon) = \max\{\mathbf{o}(\tau) + 1, \mathbf{o}(\upsilon)\}$, for all $\tau, \upsilon \in Type \cup Sort$
- *Rank*: $\mathbf{r}(\tau) = 0$ for all $\tau \in Sort \cup \{e, t\}$ $\quad \mathbf{r}(\tau\upsilon) = (\mathbf{r}(\upsilon) + 1)$, for all $\tau, \upsilon \in Type \cup Sort$
- $\tau \prec \upsilon$, iff $[\mathbf{o}(\tau) < \mathbf{o}(\upsilon)\ \&\ \mathbf{r}(\tau) \leq \mathbf{r}(\upsilon)]$ or $[\mathbf{o}(\tau) = \mathbf{o}(\upsilon)\ \&\ \mathbf{r}(\tau) < \mathbf{r}(\upsilon)]$ or $[\tau \in Sort\ \&\ \upsilon \in Type]$

LEXICAL (L). If $A \in$ Dom $\mathbb{L}$ and $\mathbb{L}(A) \neq \varnothing$, then $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \mathbb{L}(A)$.

EMPTY (E). Let A be an empty category with the index i, $v_{i,\tau} \in var_\tau$. Then $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle v_{i,\tau}, \{v_{i,\tau}\}\rangle$, if either (a) or (b):

a. A is an *ARG* & $\exists B, \varepsilon, \sigma$: B is sister to A & $B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon, \sigma\rangle$ & $\tau = \prec\text{-max}\{\tau' | \ \varepsilon(v_{i,\tau'}) \in ME_\perp\}$.

b. A is not an *ARG* & $\exists B, \varepsilon, \sigma$: B is sister to the highest projection of A & $B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon, \sigma\rangle$

& $\tau = \prec\text{-min}\{\tau' | \ \lambda v_{i,\tau'}[v_{i,\tau'}](\varepsilon) \in ME_\perp\}$.

COPYING (K). If A is the mother of B, $B \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \beta$, and $\neg\exists C, \gamma(C$ is sister to B & $C \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \gamma)$, then $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \beta$.

APPLICATION (F). If A is the mother of B and C, $B \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \varepsilon_B, \sigma_B\rangle$, $C \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \varepsilon_C, \sigma_C\rangle$, and $\langle \varepsilon_B, \varepsilon_C\rangle \in$ Dom $\mathbb{F}$, then $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\varepsilon_B, \varepsilon_C), \sigma_B \cup \sigma_C\rangle$.

COPYING′ (K′). If $A \notin$ Dom $\mathbb{T}$ and $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \alpha$, then $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \alpha$.

TYPE LIFTING (T). Let $\mathbb{T}(A) \in {}^{\Uparrow}ME \cup ({}^{\Uparrow}ME)^2$, $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_A, \sigma_A\rangle$, and let A have a sister B such that $\exists \varepsilon_B, \sigma_B\ (B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_B, \sigma_B\rangle\ \&\ \langle \varepsilon_A, \varepsilon_B\rangle \notin \text{Dom } \mathbb{F})$. Then:

a. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\omega, \varepsilon_A), \sigma_A\rangle$, if $\mathbb{T}(A) = \omega \in {}^{\Uparrow}ME$ and $\omega(\varepsilon_A) \in ME_\perp$.

b. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\mathbb{F}(\omega, \varepsilon_A), \omega'), \sigma_A\rangle$, if $\mathbb{T}(A) = \langle \omega, \omega'\rangle \in ({}^{\Uparrow}ME)^2$ and $\omega'(\omega(\varepsilon_A)) \in ME_\perp$.

BINDING (B). Let $\mathbb{T}(A) \in Var_\tau \cup (Var_\tau \times {}^{\Uparrow}ME) \cup (Var_\tau \times Var_\upsilon)$, $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_A, \sigma_A\rangle$, let the first variable in $\mathbb{T}(A)$ and either A or A's sister have the index i, and let $\tau = \prec\text{-min}\{\tau' | \ \exists v \in Var_{\tau'}: v \in \sigma_A\ \&\ v \text{ has the index } i\}$. Then:

a. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \lambda u_i\, \varepsilon_A, \sigma_A - \{u_i\}\rangle$, if $\mathbb{T}(A) = u_i \in Var_\tau$

b. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\lambda u_i\, \varepsilon_A, \omega), \sigma_A - \{u_i\}\rangle$, if $\mathbb{T}(A) = \langle u_i, \omega\rangle \in Var_\tau \times {}^{\Uparrow}ME$ and $\omega(\lambda u_i\, \varepsilon_A) \in ME_\perp$.

c. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\lambda u_i\, \varepsilon_A, \mathbb{F}(v_{i,\upsilon\tau}, u')), (\sigma_A - \{u_i\}) \cup \{v_{i,\upsilon\tau}, u'\}\rangle$, if $\mathbb{T}(A) = \langle u_i, u'\rangle \in Var_\tau \times Var_\upsilon$.

Semantic Filters

A meaningful expression $\varepsilon \in ME$ represents a possible reading of a syntactically well-formed LF tree T of a language with the lexicon $\mathscr{L}$ iff, for some $\mathbb{L} \subseteq \mathscr{L}$ and $\mathbb{B} = \langle \mathbb{L}, \mathbb{T} \rangle$, ε is a *proper translation* of T based on $\mathbb{B}$ (see D6).

D6 $\varepsilon \in ME$ is a *proper translation* of T based on $\mathbb{B}$, iff the following filters are satisfied by all nodes A and B in T:

FINAL: $(\exists \varepsilon_1, \sigma_1: A \leadsto_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_1, \sigma_1 \rangle) \rightarrow (\exists \varepsilon_2, \sigma_2: A \leadsto_{2,\mathbb{L},\mathbb{T}} \langle \varepsilon_2, \sigma_2 \rangle)$.

INITIAL: $(B$ dominates A & $\exists \varepsilon_1, \sigma_1: A \leadsto_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_1, \sigma_1 \rangle) \rightarrow (\exists \varepsilon'_1, \sigma'_1: B \leadsto_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon'_1, \sigma'_1 \rangle)$.

STORE: A is the root of $T \rightarrow A \leadsto_{2,\mathbb{L},\mathbb{T}} \langle \varepsilon, \emptyset \rangle$.

TYPE: A is the root of T or of a small clause in $T \rightarrow \exists \varphi \in ME_t\ \exists \sigma \subseteq Var_t: A \leadsto_{1,\mathbb{L},\mathbb{T}} \langle \varphi, \sigma \rangle$.

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