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CROSS-LINGUISTIC SEMANTICS FOR QUESTIONS

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Abstract:

The Hamblin-Karttunen approach has led to many insights about questions in English. In this article the results of this rule-by-rule tradition are reconsidered from a crosslinguistic perspective. Starting from the type-driven XLS theory developed in Bittner (1994a, b), it is argued that evidence from simple questions (in English, Polish, Lakhota and Warlpiri) leads to certain revisions. The revised XLS theory then immediately generalizes to complex questions — including scope marking (Hindi), questions with quantifiers (English) and multiple *wh*-questions (English, Hindi, Japanese). Eliminating language- and construction-specific information from the compositional rules, in favor of universal semantic filters, leads to analyses that not only generalize across unrelated languages but are also empirically more accurate, not less.

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1. THE PROBLEM

Suppose a student asks you during an exam to clarify the meaning of one of the questions. Clearly, a cooperative response should not go as far as supplying the true and complete answer. But it should convey what sort of proposition would count as such an answer just in case it were true in the world of the context. In semantic research the intuition that to understand a question is to know what would count as the true and complete answer has provided a fruitful base, resulting in a highly insightful theoretical tradition (Hamblin 1958, 1973, Karttunen 1977, *et al*).

In this article the main results of this tradition are reconsidered from a cross-linguistic perspective. The theoretical issues that inform this inquiry include the following. To what extent is it possible to reassign the role traditionally played by language- and construction-specific rules, and meanings, to universal semantic mechanisms? What would the resulting rules look like? What meanings should be assigned to the interrogative complementizer and the various interrogative operators? In short, to what extent is it possible to formulate a universal theory that can interpret all questions—and declaratives, for that matter—in all languages?

The answers to these questions have important implications for child language acquisition, under the standard assumption that only language-specific aspects of the grammar have to be acquired, the universal components being part of our genetic endowment. One may also hope that eliminating construction-specific details from semantic rules may reveal general semantic phenomena that cut across different kinds of constructions and languages.

Our point of departure is the Cross-Linguistic Semantic Theory (XLS) presented in Bittner 1994a,b (section 2). Analysis of various kinds of simple questions leads to a number of revisions (section 3, summary in Appendix 2). The revised theory is then shown to extend to complex questions without any further stipulations (sections 4–6).

[*] For interesting feedback, I thank two anonymous reviewers for *Linguistics and Philosophy*, as well Veneeta Dayal, Jonathan Ginzburg, Ken Hale, Ken Safir, Roger Schwarzschild, Karina Wilkinson, Ede Zimmermann, participants in the Rutgers seminar on *Compositionality* (Spring 1996), and the audiences at Universität Tübingen, University of Bar-Ilan, MIT, and the Hebrew University in Jerusalem, where portions of this material were presented. Special thanks to Veneeta Dayal for giving me access to the camera-ready copy of Dayal 1996. I am also grateful to her and to Ken Hale for assistance with Hindi and Warlpiri data, respectively. Unattributed examples in Polish, Danish, and Inuit, are from my own fieldwork.

2. CROSS-LINGUISTIC SEMANTICS (XLS)

2.1. *Basic conception*

In Bittner 1994a,b it is shown that a wide variety of declarative constructions in typologically diverse languages can be interpreted by a Cross-Linguistic Semantic Theory (XLS), consisting of a small (and mostly standard) type-driven translation system whose output is assessed by three (mostly standard) semantic filters:

Store Filter: The root node has an empty store (cf. Cooper 1983).

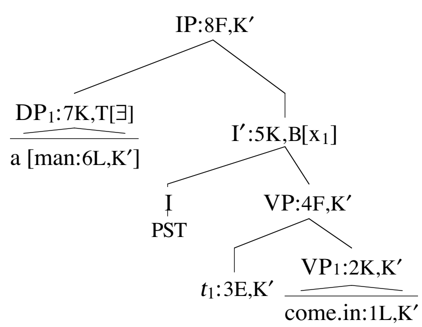
Type Filter: Some segment of every IP has a translation of type *t* (cf. θ-Criterion, Chomsky 1981)

Vacuity Filter: If a node has no translation, then neither does any daughter node (cf. FI, Chomsky 1986b).

The input to the translation rules are syntactic LF representations of the GB Theory (Chomsky 1981 etc). Typically, one reading of a sentence is represented by the *default LF*, identical to the S-Structure (see Bittner 1994a,b, Bittner & Hale 1996b). The LF of any other reading is derived by clause-bound movement (May 1977, Dayal 1996, *et al*).

For example, the default LF (= S-Structure) of the sentence *A man came in* can be interpreted as follows:

(1)



	INITIAL TRANSLATION *Expression* ε_1	*Type of* ε_1	*Store* σ_1		FINAL TRANSLATION *Expression* ε_2	*Type of* ε_2	*Store* σ_2
1L.	come.in′	⟨e,t⟩	∅	1K′.	come.in′	⟨e,t⟩	∅
2K.	come.in′	⟨e,t⟩	∅	2K′.	come.in′	⟨e,t⟩	∅
3E.	x_1	e	$\{x_1\}$	3K′.	x_1	e	$\{x_1\}$
4F.	come.in′(x_1)	t	$\{x_1\}$	4K′.	come.in′(x_1)	t	$\{x_1\}$
5K.	come.in′(x_1)	t	$\{x_1\}$	5B.	λx_1[come.in′(x_1)]	⟨e,t⟩	Ø
6L.	man′	⟨e,t⟩	∅	6K′.	man′	⟨e,t⟩	∅
7K.	man′	⟨e,t⟩	∅	7T.	λP[∃y(man′(y) ∧ P(y))]	⟨⟨e,t⟩,t⟩	∅
8F.	∃y(man′(y) ∧ come.in′(y))	t	Ø	8K′.	∃y(man′(y) ∧ come.in′(y))	t	Ø

Each meaningful constituent is assigned an *initial translation* and a *final translation*.[1] The final translation may be a copy of the initial one (by the rightward copying rule K′). Otherwise, the two translations are related by a semantic transformation—to wit, either variable binding (as 5K and 5B; cf. Rooth 1985) or type lifting (as 7K and 7T; cf. the DRT analysis of indefinites). Each translation has two coordinates: an *expression* and a *store*. The store is just a set of variables (as in Rooth & Partee 1982). Stored variables are visible to both the variable binding rule B and the Store Filter. As a consequence, they both can and must be bound within the interpreted LF.

Initial translations are assigned by four rules, all of which are exemplified in (1). Rule L interprets meaningful lexical items (as in 1L; Montague 1973). The mother of one meaningful daughter inherits its final translation, by the upward copying rule K (e.g., 2K = 1K′; also 5K = 4K′, ignoring tense; and 7K = 6K′, adapting the DRT theory). Two meaningful daughters are combined by rule F, type-driven application (as in 4F, á la Rooth & Partee 1982). Finally, empty categories are interpreted by rule E—the main innovation of the theory presented in Bittner 1994a,b.

Rule E generalizes the PTQ semantics for indexed pronouns to the entire class of gaps that fall under the Empty Category Principle (ECP, see Chomsky 1981, Kayne 1981, Bittner & Hale 1996a). Apart from traces of movement (denoted by t_i), this class includes certain base-generated gaps—to wit, null operators (Op_i) and underlyingly empty X° heads (e.g., D_1 in (16)). As in PTQ, an indexed gap translates into a variable with the same index. However, the variable need not be of the individual type. Instead, rule E determines the type locally, based on the position of the gap and the *initial* translation of a designated local node. Gaps in *ARG positions*—intuitively, missing arguments—are distinguished from other gaps. Formally, an ARG position is defined as the position of a complement, specifier, or internal subject (see ftn. 4). To a gap in an ARG position whose sister has an initial translation of a functional type, $\langle\tau,\upsilon\rangle$, rule E assigns a variable of the argument type, τ. In contrast, a gap in a non-ARG position is assigned a variable of the same type as the initial translation of the node that is sister to the gap's highest projection.

Applied to a subject trace—an ARG with a sister of type $\langle e,t\rangle$—rule E replicates PTQ (as in (1)). Local type determination is motivated by gaps in other environments—e.g., predicate topicalization (t_1, ARG, in (2)), verb raising (t_2, non-ARG in X° position, in (2)), and relative clause extraposition (t_5, non-ARG in XP position, in (3)).

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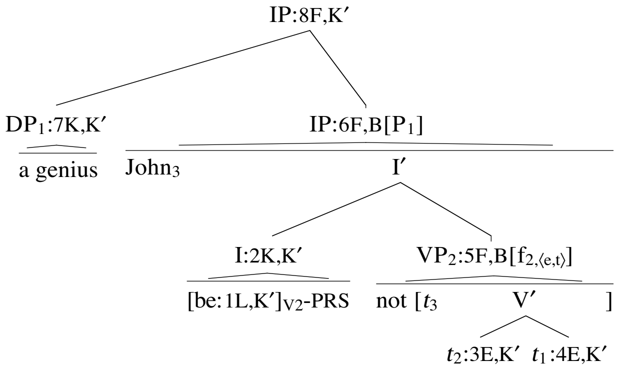
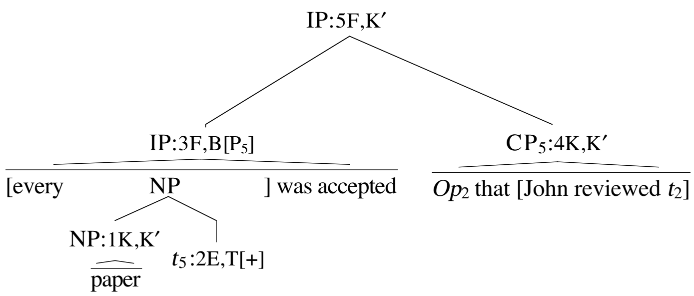
[1] The translation language, *LC*, is defined in Appendix 1 (including the abbreviations used for variables, e.g, $x_1 := v_{1,e}$). *LC* is a variation on Kaplan's (1978) logic of context-dependence (*LD*). It is a higher order language with the simple theory of types presented in Church 1940 (i.e., *t* is the type of a proposition, not of a truth value). It also incorporates the lattice-theoretic analysis of plural individuals presented in Sharvy 1980 (see also Link 1983) and generalizes the lattice-theoretic part-whole relation (≤) to domains of other logical types.

(2)



1L.	$\lambda P[P]$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	$\varnothing$	1K′.	$\lambda P[P]$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	$\varnothing$
2K.	$\lambda P[P]$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	$\varnothing$	2K′.	$\lambda P[P]$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	$\varnothing$
3E.	$f_{2,\langle e,t\rangle}$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	$\{f_{2,\langle e,t\rangle}\}$	3K′.	$f_{2,\langle e,t\rangle}$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	$\{f_{2,\langle e,t\rangle}\}$
4E.	P_1	$\langle e,t\rangle$	$\{P_1\}$	4K′.	P_1	$\langle e,t\rangle$	$\{P_1\}$
5F.	$\neg f_{2,\langle e,t\rangle}(P_1)(x_3)$	t	$\{f_{2,\langle e,t\rangle}, P_1, x_3\}$	5B.	$\lambda f_{2,\langle e,t\rangle}[\neg f_{2,\langle e,t\rangle}(P_1)(x_3)]$	$\langle\langle\langle e,t\rangle,\langle e,t\rangle\rangle,t\rangle$	$\{P_1, x_3\}$
6F.	$\neg P_1(j)$	t	$\{P_1\}$	6B.	$\lambda P_1[\neg P_1(j)]$	$\langle\langle e,t\rangle,t\rangle$	Ø
7K.	genius′	$\langle e,t\rangle$	$\varnothing$	7K′.	genius′	$\langle e,t\rangle$	$\varnothing$
8F.	$\neg$genius′(j)	t	$\varnothing$	8K′.	$\neg$genius′(j)	t	$\varnothing$

(3)



1K.	paper′	$\langle e,t\rangle$	$\varnothing$	1K′.	paper′	$\langle e,t\rangle$	$\varnothing$
2E.	P_5	$\langle e,t\rangle$	$\{P_5\}$	2T.	$\lambda Q\lambda y[Q(y) \wedge P_5(y)]$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	$\{P_5\}$
3F.	$\forall z(\text{paper}'(z) \wedge P_5(z) \rightarrow$ accepted′(z))	t	$\{P_5\}$	3B.	$\lambda P_5[\forall z(\text{paper}'(z) \wedge P_5(z) \rightarrow$ accepted′(x))]	$\langle\langle e,t\rangle,t\rangle$	Ø
4K.	$\lambda x_2[\text{review}'(j, x_2)]$	$\langle e,t\rangle$	Ø	4K′.	$\lambda x_2[\text{review}'(j, x_2)]$	$\langle e,t\rangle$	Ø
5F.	$\forall z(\text{paper}'(z) \wedge \text{review}'(j, z) \rightarrow$ accepted′(z))	t	Ø	5K′.	$\forall z(\text{paper}'(z) \wedge \text{review}'(j, z) \rightarrow$ accepted′(z))	t	Ø

Interpreting these gaps as in PTQ gives wrong results. It predicts either uninterpretability or counterintuitive truth conditions. For example, *A genius, John is not* is predicted to assert the existence of a genius distinct from John. The predictions of rule E, on the other hand, accord with intuitive judgments.

2.2. *Formalization* (*version* 1) [2]

In what follows the translation language is LC (Appendix 1), ME and Var are the sets of meaningful expressions and variables, respectively, and $\Omega \in$ ME is the set of type lifting operators. A partial definition of Ω is given in D1 (v.1) (see Partee 1986, 1987, and Bittner 1994a,b; the symbol '≈' denotes identity of character).

D1 (v.1). *Set of type lifting operators*, Ω := {[=], [ˌ], [+]}

	From	*To*	*Definition*	*Example*
[=]	e	⟨e,t⟩	$\lambda z\lambda y[y = z]$	$[=](j) \approx \lambda y[y = j]$
[∃]	⟨e,t⟩	⟨⟨e,t⟩,t⟩	$\lambda P\lambda Q[\exists y(P(y) \wedge Q(y))]$	$[\exists](man') \approx \lambda Q[\exists y(man'(y) \wedge Q(y))]$
[+]	⟨e,t⟩	⟨⟨e,t⟩,⟨e,t⟩⟩	$\lambda P\lambda Q\lambda y[P(y) \wedge Q(y)]$	$[+](man') \approx \lambda Q\lambda y[man'(y) \wedge Q(y)]$

In XLS, the meaning assigned to an LF depends on the course of the sematic derivation. This, in turn, is determined by an *interpretive base*, consisting of a *lexicon* and a *transformation plan*. For instance, the interpreted LF (1) is based on the lexicon (4a) and the transformation plan (4b). The general definition of these notions follows.

(4) a. $\mathbb{L}$: *come.in* ↦ ⟨come.in′, Ø⟩, *PST* ↦ Ø, *a* ↦ Ø, *man* ↦ ⟨man′, Ø⟩

b. $\mathbb{T}$: I′ ↦ x_1, DP_1 ↦ [∃]

D2 (v.1). Let Λ be an LF; *L*, the set of lexical items in Λ; *N*, the set of nodes in Λ; and $M \subseteq N$. An *interpretive base* $\mathbb{B}$ *for* Λ is a pair of functions $\langle \mathbb{L}, \mathbb{T}\rangle$ such that $\mathbb{L}: L \rightarrow \{\emptyset\} \cup (\text{ME} \times \{\sigma \subseteq \text{Var}: |\sigma| \leq 1\})$ and $\mathbb{T}: M \rightarrow \text{Var} \cup \Omega \cup \Omega^2$. We say that $\mathbb{L}$ is a *lexicon* for Λ, and $\mathbb{T}$ is a *transformation plan* for Λ.

In the semantic derivation determined by an interpretive base $\mathbb{B} = \langle \mathbb{L}, \mathbb{T}\rangle$, each LF constituent is assigned up to two translations, one by the *initial translation function*, $\rightsquigarrow_{1,\mathbb{L},\mathbb{T}}$, and one by the *final translation function*, $\rightsquigarrow_{2,\mathbb{L},\mathbb{T}}$. The rules stated below define these functions by simultaneous recursion. Some of the rules refer to *type-driven application* $\mathbb{F}$—the default compositional operation defined first (cf. Klein and Sag 1985).[3]

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[2] This formalization differs from Bittner 1994a,b. I thank Roger Schwarzschild and an anonymous reviewer for pointing out that what needs to be made formally precise is the intuitive notion of an *interpretation on a particular derivation* (see section 2.1), and that the definitions in Bittner 1994a,b fail to accomplish that. In what follows, version annotations (v.1, v.2, etc) indicate the rules and definitions still to be revised. The definitions are numbered as in Appendix 2, which summarizes the final version of the theory.

[3] Unlike Klein and Sag, I assume binary branching, as is standard in the GB theory (see Kayne 1984, Larson 1988, Bittner 1994a,b, 1996a). Thus, a non-terminal node has either one or two daughters.

D3. *Type-driven application* is that operation $\mathbb{F}$ such that (i) $\mathrm{Dom}\mathbb{F} = \{\langle\varepsilon, \varepsilon'\rangle \in \mathrm{ME}^2\text{: } \varepsilon(\varepsilon') \in \mathrm{ME} \text{ or } \varepsilon'(\varepsilon) \in \mathrm{ME}\}$, and (ii) $\mathbb{F}\text{: } \langle\varepsilon, \varepsilon'\rangle \mapsto$ the unique element of $\mathrm{ME} \cap \{\varepsilon(\varepsilon'), \varepsilon'(\varepsilon)\}$.

L LEXICAL

If $A \in \mathrm{Dom}\mathbb{L}$ and $\mathbb{L}(A) \neq \emptyset$, then $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \mathbb{L}(A)$.

E EMPTY

Let A be an empty category with the index i. Then $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \mathrm{v}_{\mathrm{i},\tau}, \{\mathrm{v}_{\mathrm{i},\tau}\}\rangle$, if either (a) or (b) holds:

a. A is in an ARG position and is sister to B, $B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle\varepsilon_B, \sigma_B\rangle$, and $\varepsilon_B \in \mathrm{ME}_{\langle\tau,\upsilon\rangle}$ for some type υ;

b. A is not in an ARG position and the highest projection of A is sister to B, $B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle\varepsilon_B, \sigma_B\rangle$, and $\varepsilon_B \in \mathrm{ME}_\tau$.[4]

K COPYING

If A is the mother of B, $B \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \beta$, and B has no sister C such that $\exists\gamma(C \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \gamma)$, then $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \beta$.

F APPLICATION

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 $\langle\varepsilon_B, \varepsilon_C\rangle \in \mathrm{Dom}\mathbb{F}$, then

$A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle\mathbb{F}(\varepsilon_B, \varepsilon_C), \sigma_B \cup \sigma_C\rangle$.

K′ COPYING′

If $A \notin \mathrm{Dom}\mathbb{T}$ and $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \alpha$, then $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \alpha$.

B BINDING (v.1)

Let $\mathbb{T}(A) = \mathrm{v}_{\mathrm{i},\tau}$, $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle\varepsilon_A, \sigma_A\rangle$, and $\mathrm{v}_{\mathrm{i},\tau} \in \sigma_A$. Moreover, let i be the index of A or A's sister.

Then $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle\lambda \mathrm{v}_{\mathrm{i},\tau} [\varepsilon_A], \sigma_A - \{\mathrm{v}_{\mathrm{i},\tau}\}\rangle$.

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[4] For the purposes of rule E, an *empty category* is a gap that is subject to the Empty Category Principle. An *ARG position* is the position of a *complement* (daughter of X′, sister to X°), *specifier* (daughter of XP, sister to X′), or *internal subject* (a functional category–DP, KP, IP, or CP—adjoined to, and coindexed with, a lexical category—VP, PP, NP, or AP; see Koopman & Sportiche 1985, Bittner & Hale 1996a,b). A trace (t_i) inherits the category of its antecedent (e.g., in (2), the trace t_2 of the verb *be* is of the category V, and the trace t_1 of the nominal predicate *a genius* is of the category DP). A null operator (Op_i) can be thought of as a category-neutral empty lexical item (see (25a)).

Since rule E applies to terminal nodes, clause (b) does not violate the Principle of Compositionality ("The meaning of a complex constituent is a function of the meanings of its parts"). The principle could be extended to empty terminals in an obvious way, provided that an empty X° head (e.g., in (2), the trace t_2 of the verb) be allowed to "see" as far as its highest projection (here, VP_2)—a semantic parallel to the familiar syntactic privileges of X° heads. Of course, an empty XP has no higher projection (thus, in (3), the trace t_5, of the extraposed relative clause CP_5, is its own highest projection).

T TYPE LIFTING

Let $\mathbb{T}(A) \in \{\omega_1, \langle\omega_1, \omega_2\rangle\}$, $\omega_1, \omega_2 \in \Omega$, $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle\varepsilon_A, \sigma_A\rangle$, and $\omega_1(\varepsilon_A) \in$ ME. Moreover, let A have a sister B such that $B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle\varepsilon_B, \sigma_B\rangle$ and $\langle\varepsilon_A, \varepsilon_B\rangle \notin \text{Dom}\mathbb{F}$. Then:

a. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle\mathbb{F}(\omega_1, \varepsilon_A), \sigma_A\rangle$, if $\mathbb{T}(A) = \omega_1$.

b. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle\mathbb{F}(\omega_2, \mathbb{F}(\omega_1, \varepsilon_A)), \sigma_A\rangle$, if $\mathbb{T}(A) = \langle\omega_1, \omega_2\rangle$ and $\omega_2(\omega_1(\varepsilon_A)) \in$ ME.

The simple semantic transformations, defined in rule B and rule T(a), have already been illustrated in section 2.1. Rule T(b) further permits bi-cyclic type lifting, exemplified in (5). This complex transformation makes it possible, for example, to resolve the initial type mismatch in $[_{XP}$ *John* $[_{X'}$ *and* [*every girl*]]] (cf. Partee 1987).[5]

(5) $\mathbb{F}([\exists], \mathbb{F}([=], j))$

$\approx \mathbb{F}(\lambda P\lambda Q[\exists y(P(y) \wedge Q(y))], \mathbb{F}(\lambda z\lambda y[y = z], j))$	D1 (v. 1)
$\approx \lambda P\lambda Q[\exists y(P(y) \wedge Q(y))](\lambda z\lambda y[y = z](j))$	D3
$\approx \lambda Q[Q(j)]$	Appendix 1

The intuition behind rule T is that type lifting is the semantic counterpart of syntactic movement. Both operations derive output that outranks the input on the relevant order—c-command in syntax, type hierarchy in semantics. There are also similar locality constraints. Both operations involve either one 'cyclic domain'—IP or DP in syntax, scope of $\mathbb{F}$ in semantics—or at most two.[6] Further parallels will emerge in section 3.

Since the requirements of the translation rules may fail to mesh with the interpretive base, both translation functions may be partial. The following definition of a *proper translation* tolerates failure of assignment of initial translations to terminal nodes (e.g., the article *a* in (1), trace t_1^* in (16)). No other translation failures are permitted.

D6. Let Λ be an LF; $\mathbb{B} = \langle\mathbb{L}, \mathbb{T}\rangle$, an interpretive base for Λ; and $\varepsilon \in$ ME. Then ε is a *proper translation* of Λ based on $\mathbb{B}$, iff (i) **root**$(\Lambda) \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle\varepsilon, \varnothing\rangle$, and (ii) the following filters are satisfied by all nodes A and B in Λ:

Initial Filter : If $\exists\alpha(A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \alpha)$ and B dominates A, then $\exists\beta(B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \beta)$.

Final Filter : If $\exists\alpha_1(A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \alpha_1)$, then $\exists\alpha_2(A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \alpha_2)$.

Type Filter : If A is the root of Λ or of a small clause in Λ, then $\exists\langle\varepsilon_A, \sigma_A\rangle(A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle\varepsilon_A, \sigma_A\rangle$ and $\varepsilon_A \in ME_t$).

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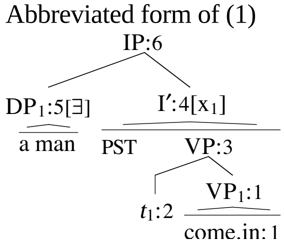
5 Recall that '≈' stands for 'has the same character as.'

6 On syntactic locality see, e.g., Chomsky 1973, 1976, van Riemsdijk & Williams 1986, Dayal 1996.

Moreover, the *initial* translation of the root node, and of any small clause, must be of the propositional type *t* (Type Filter). A *small clause* is an adjunction structure of the form $[_{YP}\ XP_i\ YP_i]$, where the *internal subject* XP_i is a functional category (DP, KP, IP, or CP), and the coindexed *predicate phrase* YP_i is a lexical category (VP, NP, AP, or PP; see Bittner & Hale 1996a,b). Thus, under the standard assumption that a trace inherits the category of its original content, the VP sister of I in (1) is a small clause (constrained by the Type Filter), whereas the NP sister of the determiner *every* in (3) is not. The general prediction of the theory is that only proper translations will represent intuitively available readings. Propriety is a necessary requirement, but it is not always sufficient (see section 3).

The derivations discussed so far all yield properly translated LFs that represent possible readings. However, even minimal changes in the interpretive base lead to improprieties. For example, the interpreted LF (1) is based on a feasible transformation plan (4b). For convenience, this LF is repeated in an abbreviated form below. [7]

(6) Abbreviated form of (1)



1.	come.in′	⟨e,t⟩	∅
2.	x_1	e	$\{x_1\}$
3/4K.	come.in′(x_1)	t	$\{x_1\}$
5K.	man′	⟨e,t⟩	Ø
5T.	λQ[∃y(man′(y) ∧ Q(y))]	⟨⟨e,t⟩,t⟩	Ø
4B.	λx_1[come.in′(x_1)]	⟨e,t⟩	Ø
6.	∃y(man′(y) ∧ come.in′(y))	t	Ø

Modifying the transformation plan as in (7a), (7b), or (7c), leads to a violation, respectively, of the Initial Filter ($A = DP_1$, B = IP), the Final Filter ($A = DP_1$), or the Type Filter (A = IP). Thus, no further readings are predicted.

(7) a. $\mathbb{T}'$: $DP_1 \mapsto [\exists]$

b. $\mathbb{T}''$: $I' \mapsto x_1$, $DP_1 \mapsto [=]$

c. $\mathbb{T}'''$: $I' \mapsto x_1$, $DP_1 \mapsto [+]$

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7 All interpreted LFs are henceforth abbreviated in this way.

3. REVISIONS BASED ON SIMPLE QUESTIONS

In this section the transformational component of the theory—that is, type lifting and variable binding—is revised on the basis of cross-linguistic evidence, primarily from simple questions. It is also argued that in order to be intuitively available for a question, a meaning must be not only proper (D6), but also *answerable* in the sense of Dayal 1996. The evidence is drawn from *wh*/indefinite ambiguities (section 3.1), pied piping (section 3.2), *wh*-quantification over abstract objects (section 3.3), disjunction in declaratives and questions (section 3.4), and the non-occurrence of *wh*-operators in disjunctive questions (section 3.5). The final revisions are based on a sample of declarative constructions, which also show that the revised theory is not question-specific (section 3.6).

3.1. *Wh/indefinite ambiguity: Cross-categoriality and answerability*

Wh/indefinite ambiguities—found in Lakhota (8), Warlpiri (9), and many other languages—suggest that questions differ from declaratives only in the presence of an interrogative complementizer (glossed 'Q'). This complementizer may be realized by an overt morpheme (e.g., *he* in (8a)). Universally, it triggers movement of an interrogative operator to [SPEC, CP]. The movement may take place either overtly at S-Structure (as in (9a)) or covertly at LF (as in (8a); Huang 1982, Nishigauchi 1990, Dayal 1996 *et al.*). What functions as an interrogative operator in a *wh*-question receives indefinite interpretation in a related yes-no question or declarative (as in (8a.ii), (8b), and (9b)).[8]

(8) *Lakhota* (Siouan: North American Plains)

a. hehãni *tuwa* u kte *he*

[tonight *person* come FUT] *Q*

i. 'Who is coming tonight?'

ii. 'Is somebody coming tonight?'

b. hehãni *tuwa* u kte

tonight *person* come FUT

'Somebody is coming tonight.'

---

[8] The Lakhota data are from Williamson 1984. The Warlpiri examples were kindly provided by Ken Hale (p.c.). This pair is not strictly minimal because, in Warlpiri, expressions of the type represented by *nyiya* behave like polarity items. That is, they must be licensed, either by an interrogative complementizer (as in (9a)) or by negation (as in (9b)).

(9) *Warlpiri* (Pama-Nyungan: Central Australia)

a.

nyiya	ka	kurdu-ngku	nga-rni
thing	*Q*-PRS.3SG.3SG	child-ERG	eat-NPST

'What is the child eating?'

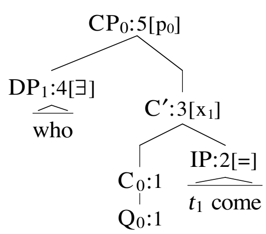
b.

kula-ka	kurdu-ngku	*nyiya*	nga-rni
NEG-PRS.3SG.3SG	child-ERG	*thing*	eat-NPST

'The child isn't eating anything.'

These well-known observations motivate the standard view that *wh*-operators are interpreted like indefinites (Karttunen 1977). Indefinites, in turn, basically denote properties (assuming the DRT theory adapted as in (2) and (6)). The semantic contribution of the interrogative complementizer can then be analyzed as in (10) (cf. declarative (6) and *wh*-questions (8a.i) and (9a); see also Hamblin 1958, 1973, and Karttunen 1977).

(10)



1.	p_0	t	$\{p_0\}$
2T.	$[=]_t(\text{come}'(x_1))$		
≈	$\lambda q[q = \text{come}'(x_1)]$	$\langle t,t\rangle$	$\{x_1\}$
3B.	$\lambda x_1[p_0 = \text{come}'(x_1)]$	$\langle e,t\rangle$	$\{p_0\}$
4T.	$[\exists]_e(^*\text{person}')$		
≈	$\lambda Q[\exists y(^*\text{person}'(y) \wedge Q(y))]$	$\langle\langle e,t\rangle,t\rangle$	Ø
5F.	$\exists y(^*\text{person}'(y) \wedge p_0 = \text{come}'(y))$	t	$\{p_0\}$
5B.	$\lambda p_0[\exists y(^*\text{person}'(y) \wedge p_0 = \text{come}'(y))]$	$\langle t,t\rangle$	Ø

In step 1 of (10) the interrogative complementizer (Q_0) is interpreted, by rule L, in accordance with (L_Q). This lexical constraint is based on evidence from yes/no questions (section 3.4) and complex *wh*-questions (sections 4–6).

L_Q If $Q_i \in \text{Dom}\mathbb{L}$, then $\mathbb{L}: Q_i \mapsto \langle p_i, \{p_i\}\rangle$

Step 2[=] can be licensed by generalizing the type-lifting component. By hypothesis, type-lifting is the semantic counterpart of movement (section 2.2). Since movement is cross-categorial (Move α), suppose that so is type-lifting (Lift α′). That is, guided by the classification of movement operations into cross-categorial families (A-movement, A′-movement, X°-movement, etc), we generalize the type lifting component as follows.

D1 (v.2) *Set of type lifting operators*, $\Omega := \bigcup_\tau\{[=]_\tau, [\exists]_\tau, [+]_\tau\}$

	From	*To*	*Definition*	*Example*
$[=]_\tau$	τ	$\langle\tau,t\rangle$	$\lambda z_\tau\lambda y_\tau[y_\tau = z_\tau]$	$[=]_e(j) \approx \lambda y[y = j]$
$[+]_\tau$	τ	$\langle\tau,\tau\rangle$	$\lambda z_\tau\lambda y_\tau[y_\tau + z_\tau]$	$[+]_{\langle e,t\rangle}(man') \approx \lambda Q[Q + man']$
$[\exists]_\tau$	$\langle\tau,t\rangle$	$\langle\langle\tau,t\rangle,t\rangle$	$\lambda P_\tau\lambda Q_\tau[\exists y_\tau(P_\tau(y_\tau) \wedge Q_\tau(y_\tau))]$	$[\exists]_e(man') \approx \lambda Q[\exists y(man'(y) \wedge Q(y))]$

The indexed families defined in D1 (v. 2) include the operators defined in D1 (v. 1). The following identities hold: $[=]_e \approx [=]$, $[\exists]_e \approx [\exists]$, and $[+]_{\langle e,t\rangle} \approx [+]$ (see examples). Of these, the first two are obvious. The third, $[+] \approx [+]_{\langle e,t\rangle}$, follows from the semantics of the cross-categorial join operator, +, and the other definitions in Appendix 1.

Generalized in this way, the XLS theory will derive not only (10) (where the Type Filter is satisfied by 5F, allowing 5B to qualify as proper), but also other welcome results. However, the theory also overgenerates. For example, in addition to the transformation plan indicated in (10), the plans in (11a) and (12a) will also yield proper translations—to wit, (11b) and (12b), respectively. Thus, the theory wrongly predicts a non-existent ambiguity.

(11) a. $\mathbb{T}'$: $C_0 \mapsto p_0$, $C' \mapsto x_1$, $DP_1 \mapsto [\exists]_e$

b. $\exists y(*person'(y) \wedge come'(y))$

(12) a. $\mathbb{T}''$: $IP \mapsto [+]_t$, $C' \mapsto x_1$, $DP_1 \mapsto [\exists]_e$, $CP_0 \mapsto p_0$

b. $\lambda p_0[\exists y(*person'(y) \wedge [p_0 + come'(y)])]$

$\approx \lambda p_0[\exists y(*person'(y) \wedge come'(y)) \wedge p_0]$

Intuitively, neither of these translations can represent the meaning of a question—that is, of a CP headed by an interrogative complementizer. The reason, I suggest, is that neither of them can be answered. This explanation can be made precise by defining an *answer operator*, which applies to the meaning of a question and returns the true and complete answer. For our present purposes, we may adopt either one of the following definitions.

SUM $\text{Ans}_{\oplus} := \lambda W[\oplus[W]]$

MAX $\text{Ans}_{\iota} := \lambda W[\iota p W(p)]$

$\text{Ans}_{\oplus}$ defines the answer in the familiar way, as the conjunction of the true propositions in the set determined by the meaning of the question (Karttunen 1977, Lahiri 1991, Heim 1994, etc). For instance, suppose that the question *Who came*? is uttered in a context *c* where the persons who came are John and Mary. Then the operator $\text{Ans}_{\oplus}$ applied to the meaning derived in (10) would yield the proposition that the plurality of John and Mary came, under the intuitively plausible assumption that a plurality comes just in case its individual parts do (L_{+}).

(13) $[\![\text{Ans}_{\oplus}(\lambda p_0[\exists y(\text{*person}'(y) \wedge p_0 = \text{come}'(y))]]\!]^c$

$= [\![\oplus\lambda p_0[\exists y(\text{*person}'(y) \wedge p_0 = \text{come}'(y))]]\!]^c$

$= \sup_{\leq t}\{\pi \in (\Delta^{\circ}{}_{t}|\langle w_c, k_c\rangle): [\![\lambda p_0[\exists y(\text{*person}'(y) \wedge p_0 = \text{come}'(y))]]\!]^c(\pi) \in (\Delta^{\circ}{}_{t}|\langle w_c, k_c\rangle)\}$

$= \bigcap_{a}\{[\![\text{come}']\!]^c(a): w_c \in [\![\text{come}']\!]^c(a) \;\&\; w_c \in [\![\text{*person}']\!]^c(a)\}$

$= [\![\text{come}']\!]^c(\sup_{\leq e}\{a \in E: w_c \in [\![\text{come}']\!]^c(a) \;\&\; w_c \in [\![\text{*person}']\!]^c(a)\})$ assuming L_{+}

L_{+} $[\![\text{come}']\!]^c(a) \;\&\; [\![\text{come}']\!]^c(b)$, iff $[\![\text{come}']\!]^c(\sup_{\leq e}\{a, b\})$

An alternative view is that the answer is the most informative proposition (Dayal 1996). That is, it is the proposition that is true and entails any other true proposition in the set determined by the meaning of the question. This view is expressed by the operator $\text{Ans}_{¥}$. Applied to the same question meaning in the same context, $\text{Ans}_{¥}$ returns the same proposition as $\text{Ans}_{\oplus}$.

(14) $[\![\text{Ans}_{\iota}(\lambda p_0[\exists y(\text{*person}'(y) \wedge p_0 = \text{come}'(y))])]\!]^c$

$= [\![\iota p\exists y(\text{*person}'(y) \wedge p = \text{come}'(y))]\!]^c$

$= \max_{\leq t}\{\pi \in (\Delta^{\circ}{}_{t}|\langle w_c, k_c\rangle): w_c \in [\![\lambda p[\exists y(\text{*person}'(y) \wedge p = \text{come}'(y))]]\!]^c(\pi)\}$

$= [\![\text{come}']\!]^c(\sup_{\leq e}\{a \in E: w_c \in [\![\text{come}']\!]^c(a) \;\&\; w_c \in [\![\text{*person}']\!]^c(a)\})$

For (10), then, both $\text{Ans}_{\oplus}$ and $\text{Ans}_{¥}$ predict intuitively correct answers. In contrast, applied to (11b) or (12b)—proper but intuitively unavailable translations—neither yields an acceptable result. This is obvious for (11b), which is not even of the right type, $\langle t,t\rangle$. The type of (12b) is unproblematic. However, neither $\text{Ans}_{\oplus}$ nor $\text{Ans}_{¥}$ returns an acceptable answer. If nobody came in the world of the context, w_c, then both return the contradiction, Ø, which cannot be true in w_c. If somebody did come, then both yield the singleton proposition, $\{w_c\}$, which is not expressible in natural language. Thus, any question interpreted as (12b) will violate the *Answerability Filter* (AF):

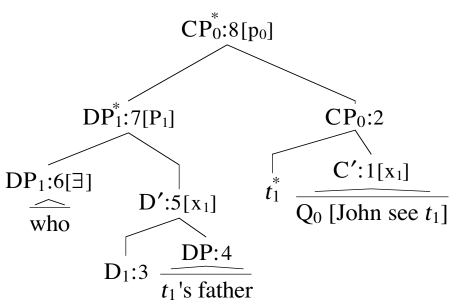
AF. If A is the highest projection of ‘Q_i’ uttered in a context c and $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \alpha, Ø \rangle$, then $\{w_c\} \subset [\![\mathrm{Ans}(a)]\!]^c$.

3.2. *Pied piping: Binding from low types up*

The analysis of simple questions exemplified in (10) generalizes straightforwardly to possessive pied piping, e.g. (15). The reconstruction effect can be analyzed as in (16), without any syntactic copying or downward movement.

(15) Who’s father did John see?

(16)



1F.	$p_0 = \mathrm{see}'(j, x_1)$	t	$\{p_0, x_1\}$
1B/2.	$\lambda x_1[p_0 = \mathrm{see}'(j, x_1)]$	$\langle e,t \rangle$	$\{p_0\}$
3.	P_1	$\langle e,t \rangle$	$\{P_1\}$
4.	$\iota z[\mathrm{fa.of}'(z, x_1)]$	e	$\{x_1\}$
5B.	$\lambda x_1[P_1(\iota z[\mathrm{fa.of}'(z, x_1)])]$	$\langle e,t \rangle$	$\{P_1\}$
6T.	$[\exists]_e(\mathrm{*person}')$		
	$\approx \lambda Q[\exists y(\mathrm{*person}'(y) \wedge Q(y))]$	$\langle\langle e,t \rangle,t \rangle$	∅
7B.	$\lambda P_1[\exists y(\mathrm{*person}'(y) \wedge P_1(\iota z[\mathrm{fa.of}'(z, y)]))$	$\langle\langle e,t \rangle,t \rangle$	Ø
8B.	$\lambda p_0[\exists y(\mathrm{*person}'(y) \wedge p_0 = \mathrm{see}'(j, \iota z[\mathrm{fa.of}'(z, y)]))]$	$\langle t,t \rangle$	Ø

The key syntactic hypothesis in (16) is that the possessed nominal (DP_1^*) has a recursive structure (in the sense of Larson 1988; see also Authier 1992, Watanabe 1993, Vikner 1994, Bittner 1994a, and sections 4–6 below). The lower DP is headed by the possessive determiner (*’s*). The X° head (D_1) of the higher DP is underlyingly empty. It satisfies the Empty Category Principle in virtue of being c-commanded and governed by the coindexed *wh*-operator (DP_1), raised from the embedded [SPEC, DP]. By local type determination, this empty X° head (D_1) is assigned a variable of the same type as the sister (CP_0) of the entire possessed nominal (rule E(b)).[9] Semantically, therefore, it functions as a place holder for that sister. In other words, the sister (CP_0) of the possessed nominal (DP_1^*) is interpreted as if it were in the position of the empty X° head (D_1) of that nominal. Hence the reconstruction effect.

Again, there is a problem with overgeneration. Modifying the transformation plan as in (17a) yields an alternative proper translation for (15)—to wit, (17b). This wrongly predicts that (15) should admit answers of the form *John saw a*, where *a* is an individual whose father is a person.

(17) a. $\mathbb{T}'$: IP $\mapsto [=]_t$, C′ $\mapsto x_1$, D′ $\mapsto P_1$, $DP_1^* \mapsto x_1$, $CP_0 \mapsto [\exists]_e$, $CP_0^* \mapsto p_0$

b. $\lambda p_0[\exists y(\text{*person}'(\iota z[\text{fa.of}'(z, y)]) \wedge p_0 = \text{see}'(j, y))]$

We can block (17b) by restricting binding to proceed in an orderly manner, from low types up. This constraint is built into the revised version of rule B stated below. The definition of the relevant type hierarchy, $\prec$, follows.

B BINDING (v.2)

Let $\mathbb{T}(A) = v_{i,\tau}$, $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_A, \sigma_A \rangle$, and let τ be the $\prec$-least element of $\{\tau' : v_{i,\tau'} \in \sigma_A\}$. Moreover, let *i* be the index of *A* or *A*'s sister. Then $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \lambda v_{i,\tau}[\varepsilon_A], \sigma_A - \{v_{i,\tau}\} \rangle$.

D4.[10] To each type, the following functions **r** and **o** assign a *rank* and an *order*, respectively.

$\mathbf{r}(e) = \mathbf{r}(t) = 0$ $\qquad$ $\mathbf{o}(e) = \mathbf{o}(t) = 0$

$\mathbf{r}(\langle\tau,\upsilon\rangle) = \mathbf{r}(\upsilon) + 1$ $\qquad$ $\mathbf{o}(\langle\tau,\upsilon\rangle) = \max(\{\mathbf{o}(\tau) + 1, \mathbf{o}(\upsilon)\})$

D5. For any types τ, υ, $\tau \prec \upsilon$, iff either (i) $\mathbf{o}(\tau) < \mathbf{o}(\upsilon)$, or (ii) $\mathbf{o}(\tau) = \mathbf{o}(\upsilon)$ and $\mathbf{r}(\tau) < \mathbf{r}(\upsilon)$

This hierarchy ranks types primarily by order, with ties partly resolved by rank. The hierarchy, therefore, is partial: $e, t \prec \langle e,t\rangle, \langle e,e\rangle, \langle t,t\rangle, \langle t,t\rangle \prec \langle e,\langle e,t\rangle\rangle, \ldots, \langle t,\langle t,t\rangle\rangle \prec \langle\langle e,t\rangle,t\rangle$, etc. Rule B (v.2) applies only if the variable specified in the transformation plan ranks *lowest* amongst the competing coindexed variables currently in store. The binding operations in (16) respect this constraint. The transformation plan (17a) does not, because it calls for P_1 (:= $v_{1,\langle e,t\rangle}$)

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9 The initial type of CP_0 is $\langle e,t\rangle$ because of the *wh*-trace (t_1^*) in [SPEC, CP]. This trace is sister to C′, which initially is of type t and has a coindexed individual variable (x_1) in store. Thus, the trace is not assigned any translation (rule E(a)) but it allows the variable to get bound (rule B(a)). This results in $\langle e,t\rangle$ as the final type of C′, and the initial type of CP_0 (rule K).

10 I thank an anonymous reviewer for *Linguistics and Philosophy* for bringing this standard definition to my attention.

to be bound at D′, while the lower ranked x_1 (:= $v_{1,e}$) is still in store. Thus, (17b) cannot be derived because its derivation would involve an illicit application of rule B (v.2), prohibited by the low-types-first constraint.

3.3. *Wh-quantification over abstract objects: Lift binding*

Combined with the universal meaning assignment in L_{wh} (justified in section 4), cross-categorial type-lifting and local type determination for gaps jointly yield another welcome result. The analysis of questions about concrete objects, exemplified in (10) and (18), immediately extends to questions about abstract objects, as in (19)[11] and (20).

L_{wh} If $\mathit{what}_{i,\tau} \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}$: $\mathit{what}_{i,\tau} \mapsto \langle P_{i,\tau}, \emptyset\rangle$

(18) a. $[_{CP0}\ \mathit{what}_{1,e}\ [_{C'}\ \mathrm{did}_0\ \mathrm{John}\ [\mathit{eat}\ t_1]]]$

b. $\lambda p_0[\mathbb{F}(\mathbb{F}([\exists]_e, P_{1,e}), \lambda x_1[p_0 = \mathrm{eat}'(j, x_1)])]$

$\approx \lambda p_0[\exists y(P_{1,e}(y) \wedge p_0 = \mathrm{eat}'(j, y))]$

(19) a. $[_{CP0}\ \mathit{what}_{1,\langle e,t\rangle}\ [_{C'}\ \mathrm{did}_0\ \mathrm{John}\ [\mathit{need}\ t_1]]]$

b. $\lambda p_0[\mathbb{F}(\mathbb{F}([\exists]_{\langle e,t\rangle}, P_{1,\langle e,t\rangle}), \lambda P_{1,e}[p_0 = \mathrm{need}'(j, P_{1,e})])]$

$\approx \lambda p_0[\exists Q(P_{1,\langle e,t\rangle}(Q) \wedge p_0 = \mathrm{need}'(j, Q))]$

(20) a. $[_{CP0}\ \mathit{what}_{1,\langle t,t\rangle}\ [_{C'}\ \mathrm{did}_0\ \mathrm{John}\ [\mathit{ask}\ t_1]]]$

b. $\lambda p_0[\mathbb{F}(\mathbb{F}([\exists]_{\langle t,t\rangle}, P_{1,\langle t,t\rangle}), \lambda W_1[p_0 = \mathrm{ask}'(j, W_1)])]$

$\approx \lambda p_0[\exists W(P_{1,\langle t,t\rangle}(W) \wedge p_0 = \mathrm{ask}'(j, W))]$

Nothing new needs to be said to license these derivations. As it stands, however, the theory wrongly predicts (21a) to be uninterpretable. Specifically, the derivation in (21b) is blocked.

(21) a. $[_{CP0}\ \mathit{what}_{1,t}\ [_{C'}\ \mathrm{did}_0\ \mathrm{John}\ [\mathit{say}\ t_1]]]$

b.* $\lambda p_0[\mathbb{F}(\mathbb{F}([\exists]_t, P_{1,t}), \lambda p_1[p_0 = \mathrm{say}'(j, p_1)])]$

$\approx \lambda p_0[\exists q(P_{1,t}(q) \wedge p_0 = \mathrm{say}'(j, q))]$

---

[11] The theory of intensionality assumed here is Zimmermann 1992, not Montague 1973. This assumption is not crucial.

In (21b) the *initial* types of the *wh*-operator (*what*$_{1,t}$) and its sister (C′) match—being ⟨*t*,*t*⟩ and *t*, respectively. Therefore, the application of the type lifting operator $[\exists]_t$ is blocked as illicit by rule T. But if neither type lifting nor variable binding applies, then the final translation of the root node (CP_0) will still have a variable (p_1) in store, which will render that translation improper. The alternative of applying variable binding (to bind p_1) without type lifting (blocked by rule T) is also excluded. It leads to a final type mismatch—to wit, ⟨*t*,*t*⟩ versus ⟨*t*,*t*⟩—and hence to a violation of the Initial Filter at the next higher node (namely, the root CP_0; see rule F and definition D6).

One solution would be to weaken rule T (as in Partee 1986, Jacobson 1992), by giving up the requirement of initial type mismatch. This, however, would lead to overgeneration elsewhere—for example, for verb coordination and topicalization of objects of extensional verbs. Thus, *John loves and dates a semanticist* cannot mean that John loves one semanticist and dates another (Rooth & Partee 1982). Also, *One mistake, John didn't see* cannot mean that John didn't see any mistakes—a meaning that could be derived if the verb *see* could undergo spontaneous type lifting (by the operator $[\exists]!_e$, independently motivated in section 3.6.3). I therefore do not adopt this approach.

Instead I suggest that type lifting is licensed in the configuration of (21a) because variable binding, which is not contingent on initial type mismatch, results in a type mismatch that needs to be resolved. The following revisions of the relevant elements of the theory make this idea formally precise, by extending rule B to allow *lift binding*—that is, a complex semantic transformation that combines variable binding with type lifting of the result.

D2 (v.2). Let Λ be an LF; *L*, the set of lexical items in Λ; *N*, the set of nodes in Λ; and $M \subseteq N$. An *interpretive base* $\mathbb{B}$ for Λ is a pair of functions $\langle \mathbb{L}, \mathbb{T} \rangle$ such that $\mathbb{L}: L \rightarrow \{\emptyset\} \cup (\text{ME} \times \{\sigma \subseteq \text{Var}: |\sigma| \leq 1\})$ and $\mathbb{T}: M \rightarrow \text{Var} \cup (\text{Var}{\times}\Omega) \cup \Omega \cup \Omega^2$. We say that $\mathbb{L}$ is a *lexicon* for Λ, and $\mathbb{T}$ is a *transformation plan* for Λ.

B BINDING (v.3)

Let $\mathbb{T}(A) \in \{v_{i,\tau}, \langle v_{i,\tau}, \omega \rangle\}$, $\omega \in \Omega$, $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_A, \sigma_A \rangle$, and $\tau = \min_{<}(\{\tau' : v_{i,\tau'} \in \sigma_A\})$. Moreover, let *i* be the index of *A* or *A*'s sister. Then:

a. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \lambda v_{i,\tau} [\varepsilon_A], \sigma_A - \{v_{i,\tau}\} \rangle$, if $\mathbb{T}(A) = v_{i,\tau}$.

b. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\omega, \lambda v_{i,\tau} [\varepsilon_A]), \sigma_A - \{v_{i,\tau}\} \rangle$, if $\mathbb{T}(A) = \langle v_{i,\tau}, \omega \rangle$ and $\omega(\lambda v_{i,\tau} [\varepsilon_A]) \in \text{ME}$.

The revised theory still rules out the derivation in (21b). However, it will permit (21c), where lift binding yields an equivalent output. Thus, (21a) is now interpreted in accord with intuitive judgement.

(21) c. $\lambda p_0[\mathbb{F}(P_{1,t}, \mathbb{F}([\exists]_t, \lambda p_1[p_0 = say'(j, p_1)]))]$

$\approx \lambda p_0[\exists q(P_{1,t}(q) \wedge p_0 = say'(j, q))]$

3.4. *Disjunction: Substitution binding and* $[\forall]$*-lifting*

The apparently disparate uses of disjunction pose interesting problems for the theory of compositional semantics. In English, for example, there are ambiguities in intensional contexts (Rooth & Partee 1982), special uses of *or* in questions (e.g., *whether … or not*, Karttunen 1977), and issues of scope (Larson 1985). Nevertheless, comparison with other languages provides evidence that points to a unified cross-linguistic analysis.

In addition to the principles already introduced, we will need two new semantic transformations. One is a bi-cyclic binding operation, which I will call *substitution binding* (cf. bi-cyclic type lifting, rule T(b)). In this operation a stored variable, $v_{i,\tau}$, is bound in the usual manner. The resulting λ-abstract is applied to a functional complex, $v_{i,\langle\upsilon,\tau\rangle}(v_{j,\upsilon})$, constructed on the basis of $v_{i,\tau}$, and a second variable $v_{j,\upsilon}$ provided by the transformation plan. In effect, then, the complex $v_{i,\langle\upsilon,\tau\rangle}(v_{j,\upsilon})$ is substituted for every free occurrence of $v_{i,\tau}$. The two new variables, $v_{i,\langle\upsilon,\tau\rangle}$ and $v_{j,\upsilon}$, are entered into the store. Substitution binding is thereby restricted to LF representations where both of these variables can get bound. Otherwise, the final translation will be ruled out as improper (D6).

D2. Let Λ be an LF; *L*, the set of lexical items in Λ; *N*, the set of nodes in Λ; and $M \subseteq N$. An *interpretive base* $\mathbb{B}$ for Λ is a pair of functions $\langle\mathbb{L}, \mathbb{T}\rangle$ such that $\mathbb{L}$: $L \longrightarrow \{\emptyset\} \cup (\text{ME} \times \{\sigma \subseteq \text{Var}: |\sigma| \leq 1\})$ and
$\mathbb{T}$: $M \longrightarrow \text{Var} \cup \text{Var}^2 \cup (\text{Var}\times\Omega) \cup \Omega \cup \Omega^2$. We say that $\mathbb{L}$ is a *lexicon*, and $\mathbb{T}$, a *transformation plan*, for Λ.

B BINDING

Let $\mathbb{T}(A) \in \{v_{i,\tau}, \langle v_{i,\tau}, \omega\rangle, \langle v_{i,\tau}, v_{j,\upsilon}\rangle\}$, $\omega \in \Omega$, $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle\varepsilon_A, \sigma_A\rangle$, and $\tau = \min_{\prec}(\{\tau': v_{i,\tau'} \in \sigma_A\})$. Moreover, let *i* be the index of *A* or *A*'s sister. Then:

a. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle\lambda v_{i,\tau}[\varepsilon_A], \sigma_A - \{v_{i,\tau}\}\rangle$, if $\mathbb{T}(A) = v_{i,\tau}$

b. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle\mathbb{F}(\omega, \lambda v_{i,\tau}[\varepsilon_A]), \sigma_A - \{v_{i,\tau}\}\rangle$, if $\mathbb{T}(A) = \langle v_{i,\tau}, \omega\rangle$ and $\omega(\lambda v_{i,\tau}[\varepsilon_A]) \in \text{ME}$.

c. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle\mathbb{F}(\lambda v_{i,\tau}[\varepsilon_A], \mathbb{F}(v_{i,\langle\upsilon,\tau\rangle}, v_{j,\upsilon})), (\sigma_A - \{v_{i,\tau}\}) \cup \{v_{i,\langle\upsilon,\tau\rangle}, v_{j,\upsilon}\}\rangle$, if $\mathbb{T}(A) = \langle v_{i,\tau}, v_{j,\upsilon}\rangle$.

We will also need a new family of type lifting operators, $[\forall]_\tau$. Thus, the new system of families is as follows.

D1 (v.3) *Set of type lifting operators*, $\Omega := \bigcup_\tau\{[=]_\tau, [+]_\tau, [\exists]_\tau, [\forall]_\tau\}$

	From	*To*	*Definition*	*Example*
$[=]_\tau$	τ	$\langle\tau,t\rangle$	$\lambda z_\tau\lambda y_\tau[y_\tau = z_\tau]$	$[=]_e(j) \approx \lambda y[y = j]$
$[+]_\tau$	τ	$\langle\tau,\tau\rangle$	$\lambda z_\tau\lambda y_\tau[y_\tau + z_\tau]$	$[+]_{\langle e,t\rangle}(man') \approx \lambda Q[Q + man']$
$[\exists]_\tau$	$\langle\tau,t\rangle$	$\langle\langle\tau,t\rangle,t\rangle$	$\lambda P_\tau\lambda Q_\tau[\exists y_\tau(P_\tau(y_\tau) \wedge Q_\tau(y_\tau))]$	$[\exists]_e(man') \approx \lambda Q[\exists y(man'(y) \wedge Q(y))]$
$[\forall]_\tau$	$\langle\tau,\langle\tau,t\rangle\rangle$	$\langle\langle\tau,\tau\rangle,t\rangle$	$\lambda R_\tau\lambda f_\tau[\forall y_\tau(y_\tau \in Dom[f_\tau] \rightarrow R_\tau(f_\tau(y_\tau), y_\tau)]$	$[\forall]_e(hit') \approx \lambda f[\forall y(y \in Dom[f] \rightarrow hit'(f(y), y))]$

This extension reveals certain symmetry patterns. Operator families that resolve mismatches between sisters of the same initial type involve symmetric relations and operations: =, +, or ∃. Thus, it does not matter which sister undergoes type lifting (e.g., (21b) ≈ (21c)). The family just added resolves an asymmetric mismatch, $\langle\tau,\langle\tau,t\rangle\rangle$ versus $\langle\tau,\tau\rangle$, and it does so by means of an asymmetric operation, ∀. Presumably these patterns reflect general constraints.

Turning now to the theory of disjunction, cross-linguistic evidence points to the following lexical ambiguity: [12]

L_{or} If $or_\tau \in Dom\mathbb{L}$ $(\tau \neq e)$, then $\mathbb{L}$: $or_\tau \mapsto \langle\lambda z_\tau\lambda y_\tau[z_\tau \times y_\tau], \emptyset\rangle$ (*Boolean disjunction*)

L_{OR} If $OR_\tau \in Dom\mathbb{L}$, then $\mathbb{L}$: $OR_\tau \mapsto \langle\lambda z_\tau\lambda y_\tau\lambda x_\tau[[x_\tau = y_\tau] \times [x_\tau = z_\tau]], \emptyset\rangle$ (*identity disjunction*)

The index τ is the lowest type compatible with both disjuncts (Rooth & Partee 1982, henceforth R&P). Boolean disjunction (or_τ) may occur anywhere, whereas identity disjunction (OR_τ) is restricted to intensional contexts. This can be clearly seen, e.g., in Polish, where the two are lexically distinct: *albo* ‘or_τ’ versus *czy* (*tez*) ‘OR_τ’ (see also Karttunen 1977:ftn. 9, on Finnish). Thus, the famous example from R&P is disambiguated in this language.

(22) *Polish*

a. Anna poszukuje kucharki *albo* sluzacej.
   Anna looks.for cook $or_{\langle e,t\rangle}$ maid
   ‘Anna is looking for a cook $or_{\langle e,t\rangle}$ a maid.’ (She’ll be happy if she finds either.)

b. Anna poszukuje kucharki *czy tez* sluzacej.
   Anna looks.for cook $OR_{\langle e,t\rangle}$ maid
   ‘Anna is looking for a cook $OR_{\langle e,t\rangle}$ a maid.’ (I don’t know which.)

---

[12] × is the cross-categorial meet operator, the dual of the join operator +. For type *t*, × and + reduce to ∨ and ∧, respectively, because for any propositions π and π′, $\pi \leq_t \pi'$ iff π logically follows from π′ (i.e., iff $\pi' \subseteq \pi$; see Appendix 1).

So far nothing needs to be added to the theory developed in the foregoing sections. The interpretation of (22a) and (22b) follows from that theory and the lexical meanings in L_{or} and L_{OR}. The essential steps are indicated below.[13]

(23) a. $\mathbb{F}(\mathbb{F}(\text{cook}', \mathbb{F}(\lambda P'\lambda P[P \times P'], \text{maid}')), \lambda P_1[\text{look-for}'(a, P_1)])$

$\approx$ $\text{look-for}'(a, \lambda x[\text{cook}'(x) \vee \text{maid}'(x)])$

b. $\mathbb{F}([\exists]_{\langle e,t\rangle}(\mathbb{F}(\text{cook}', \mathbb{F}(\lambda P'\lambda P\lambda Q[[Q = P] \times [Q = P']], \text{maid}'))), \lambda P_1[\text{look-for}'(a, P_1)])$

$\approx$ $\exists Q([Q = \text{cook}' \vee Q = \text{maid}'] \wedge \text{look-for}'(a, Q))$

$\approx$ $\text{look-for}'(a, \text{cook}') \vee \text{look-for}'(a, \text{maid}')$

(22a) has also a *de re* reading because the verb may denote an extensional relation (cf., in Inuit *ujar-* 'look for_{ext}' vs. *-siur* 'look for_{int}'). Since identity disjunction requires an intensional context, there is no *de re* reading for (22b).

This analysis carries over to English, replicating the account of R&P. It also correctly fails to extend to conjunction (*and*, *but*, etc). Conjunction is always Boolean and thus restricted to narrow scope (as or_τ in (23a)).

The new semantic transformations—that is, substitution binding, and type lifting with $[\forall]_\tau$—are needed to generalize this account to Inuit. The Inuit sentence (24) exhibits the same ambiguity as its English translation.

(24) *Inuit* (Eskimo-Aleut: West Greenland)

Anna kiffa-ssa-mil=*luunniit* igasu-ssar-siur-p-u-q

Anna [maid-future-INS]=$or_{\langle e,t\rangle}$/$OR_{\langle e,t\rangle}$ [cook-future]-look.for-IND-[-tr]-3SG

(i) 'Anna is looking for a cook $\text{or}_{\langle e,t\rangle}$ a maid.' (She'll be happy if she finds either.)

(ii) 'Anna is looking for a cook $OR_{\langle e,t\rangle}$ a maid.' (I don't know which.)

In Bittner 1994a I assumed, following Baker 1988, that Inuit sentences with suffixal verbs (here *-siur* 'look for_{int}') involve syntactic noun movement. However, (24) shows that this cannot be correct since the requisite movement would violate the Coordinate Structure Constraint (Ross 1967). Fortunately, the syntactic results of Bittner 1994a are preserved if noun movement is replaced with base-generated noun adjunction.[14] More precisely, I propose that the two readings (ignoring tense) of the V′ constituent of the Inuit sentence (24) are derived as follows.

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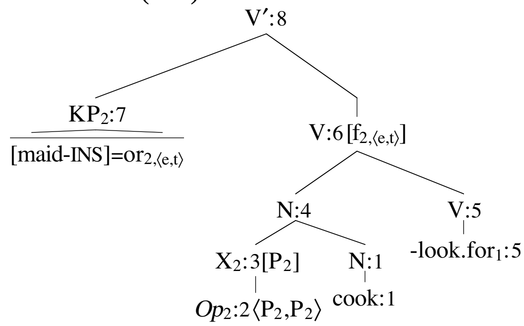
13 I continue to assume Zimmermann's theory of intensional verbs (ftn. 11). Also, for expository reasons, I assume that the object moves out of the VP at LF. In the final version of the theory it will be possible to interpret the object *in situ*.

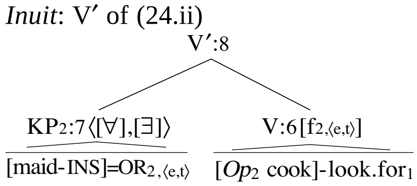
14 See Bittner & Hale 1996a on base-generated antipassives, and Bittner & Hale 1996b on Case assignment in Inuit.

(25) a. *Inuit*: V′ of (24.i)



1.	cook'	$\langle e,t\rangle$	$\varnothing$
2E(b).	P_2	$\langle e,t\rangle$	$\{P_2\}$
2B(c).	$\lambda P_2[P_2](f_{2,\langle e,t\rangle}(P_2))$		
≈	$f_{2,\langle e,t\rangle}(P_2)$	$\langle e,t\rangle$	$\{P_2, f_{2,\langle e,t\rangle}\}$
3.	$\lambda P_2[f_{2,\langle e,t\rangle}(P_2)]$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	$\{f_{2,\langle e,t\rangle}\}$
4.	$f_{2,\langle e,t\rangle}(\text{cook}')$	$\langle e,t\rangle$	$\{f_{2,\langle e,t\rangle}\}$
5.	$\lambda Q[\text{look-for}'(x_1, Q)]$	$\langle\langle e,t\rangle,t\rangle$	$\{x_1\}$
6.	$\lambda f_{2,\langle e,t\rangle}[\text{look-for}'(x_1, f_{2,\langle e,t\rangle}(\text{cook}'))]$	$\langle\langle\langle e,t\rangle,\langle e,t\rangle\rangle,t\rangle$	$\{x_1\}$
7.	$\lambda P[P \times \text{maid}']$		
≈	$\lambda P\lambda y[P(y) \vee \text{maid}'(y)]$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	$\varnothing$
8.	$\text{look-for}'(x_1, \lambda y[\text{cook}'(y) \vee \text{maid}'(y)])$	t	$\{x_1\}$

(25) b. *Inuit*: V′ of (24.ii)



⋮	⋮	⋮	⋮
6.	$\lambda f_{2,\langle e,t\rangle}[\text{look-for}'(x_1, f_{2,\langle e,t\rangle}(\text{cook}'))]$	$\langle\langle\langle e,t\rangle,\langle e,t\rangle\rangle,t\rangle$	$\{x_1\}$
7.	$[\exists]_{\langle\langle e,t\rangle,\langle e,t\rangle\rangle}([\forall]_{\langle e,t\rangle}(\lambda P\lambda Q[[Q = P] \times [Q = \text{maid}']]))$		
≈	$[\exists]_{\langle\langle e,t\rangle,\langle e,t\rangle\rangle}([\forall]_{\langle e,t\rangle}(\lambda P\lambda Q[Q = P \vee Q = \text{maid}']))$		
≈	$[\exists]_{\langle\langle e,t\rangle,\langle e,t\rangle\rangle}(\lambda f_{\langle e,t\rangle}[\forall P(P \in \text{Dom}[f_{\langle e,t\rangle}] \rightarrow f_{\langle e,t\rangle}(P) = P \vee f_{\langle e,t\rangle}(P) = \text{maid}')])$		
≈	$\lambda F_{\langle e,t\rangle}[\exists f_{\langle e,t\rangle}(\forall P[P \in \text{Dom}[f_{\langle e,t\rangle}] \rightarrow f_{\langle e,t\rangle}(P) = P \vee f_{\langle e,t\rangle}(P) = \text{maid}'] \wedge F_{\langle e,t\rangle}(f_{\langle e,t\rangle}))]$	$\langle\text{Type}(6),t\rangle$	$\varnothing$
8.	$\exists f_{\langle e,t\rangle}(\forall P[P \in \text{Dom}[f_{\langle e,t\rangle}] \rightarrow f_{\langle e,t\rangle}(P) = P \vee f_{\langle e,t\rangle}(P) = \text{maid}'] \wedge \text{look-for}'(x_1, f_{\langle e,t\rangle}(\text{cook}')))$		
≈	$\text{look-for}'(x_1, \text{cook}') \vee \text{look-for}'(x_1, \text{maid}')$	t	$\{x_1\}$

From the point of view of English, the complex structure assigned to the Inuit verb is unquestionably exotic. But then, so is Inuit—a highly polysynthetic language where complex words routinely do the work of English sentences and phrases.[15] I propose that Inuit words can do this because certain structures that in English are restricted to syntactic phrases (XP categories) in Inuit are also possible for lexical items (X° categories). The complex structure of the Inuit verb in (25a–b), involving adjunction as well as a null operator (Op_2), is a case in point. In XLS most syntactic details (linear order, syntactic categories, XP/X° distinction, etc) are ignored by the semantic rules. The rules refer only to the bare minimum of syntactic information required for compositional interpretation (Appendix 2). Hence, syntactic differences notwithstanding, Inuit words can be assigned the same meaning as English sentences, or phrases, provided that the respective structures are parallel in the compositionally relevant respects.

In this case, the key parallel in relation to English is the structure of the constituent that is sister to the intensional verb (*-siur* 'look for_{int}' in (25a–b)).[16] In Inuit this constituent consists of a noun (*igasu-* 'cook') and an adjoined null operator (Op_2). The latter satisfies the Empty Category Principle (ECP) in virtue of its local relation to the coindexed word-external object (KP_2). Like any other empty category that is subject to the ECP, the null operator is interpreted by rule E—in this case, clause (b). In (25a) this rule, combined with substitution binding, in effect interprets the word-external object (*kiffa-…=luunniit* 'maid-…=$\text{or}_{\langle e,t\rangle}$') within the verb complex, as if it occupied the position of the null operator that depends on it to satisfy the ECP (cf. pied piping, section 3.2). The result is the narrow scope reading (i) of (24). In (25b), which yields the wide scope reading (ii), the disjunctive clitic is instead interpreted as an identity disjunction (*=luunniit* '=$\text{OR}_{\langle e,t\rangle}$'). As a result, the word-external object is quantified into the position of the null operator—an operation that crucially relies on the option of type lifting with $[\forall]_{\langle e,t\rangle}$.

Thus, it appears that disjunction in declarative sentences is amenable to a unified cross-linguistic account. This account also generalizes to questions, as will be shown on the basis of the representative sample in (26). Following a suggestion of Quine (1967:44–45), I assume that in a doubly marked disjunctive construction (in Polish of the form *czy … czy*, or *albo … albo*) the first element "does the useful work of a left-hand parenthesis." Accordingly, this otherwise vacuous element is glossed '$\text{OR}_{\tau,(}$' or '$\text{or}_{\tau,(}$', as appropriate.

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[15] E.g., *nalunaarasuartaatiliuqatigiiffissualiulirsaaliraluallarami=nnguur=aasii=nnguuq* is an actually attested Inuit word (Bergsland 1955). It means 'there is a rumor that (=*nnguuq*) yet again (=*aasiit*) there is a rumor that (=*nnguuq*) they were actually about to vigorously start an initial attempt to prepare a big place for building a telegraph (= instrument for habitual rapid removal of causes of lack of knowledge) together, but …'. This word is a verb. It consists of a root (*nalu-* 'not to know'), sixteeen derivational suffixes (*-nar* 'cause one to V', …, *-llar* 'vigorously'), a bimorphemic verbal inflection (mood *-a* plus agreement *-mik*), and three clitics (set off by =). Of course, this Inuit word could be made longer. In this regard, it behaves like its sentential English equivalent.

[16] The parallel will hold exactly in the final version of the theory, where Inuit *-siur* will have the same lexical meaning as English *look* $\textit{for}_{\text{int}}$ (see section 3.6.3).

(26) *Polish*

a. *Czy* ktos przyszedl (*czy* nie)? Yes-No question

$OR_{t,(}$ [somebody came] (OR_t not)

'Did somebody come (or not)?'

b. *Czy* Anna studiuje fizyke *albo* matematyke (czy nie)? Yes-No question

$OR_{t,(}$ [Anna studies physics $or_{\langle e,t\rangle}$ math] (OR_t not)

'Does Anna study physics or math (or not)?'

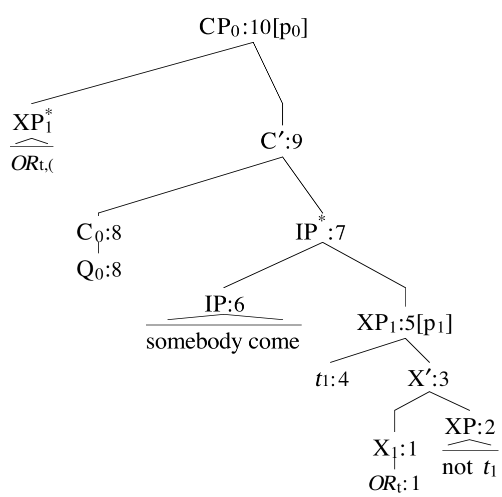
c. *Czy* Anna studiuje fizyke (teraz) *czy* matematyke? Alternative question

$OR_{e,(}$ [Anna studies physics (now)] [OR_e math]

'Does Anna study physics (now) or math?'

Yes-no questions of the type represented by (26a–b) can be interpreted as in (27) (the LF representation of (26a)):

(27)



1.	$\lambda p\lambda q\lambda r[[r = q] \times [r = p]]$		
≈	$\lambda p\lambda q\lambda r[r = q \vee r = p]$	$\langle t,\langle t,\langle t,t\rangle\rangle\rangle$	Ø
⋮	⋮	⋮	⋮
5.	$\lambda p_1\lambda r[r = p_1 \vee r = \neg p_1]$	$\langle t,\langle t,t\rangle\rangle$	Ø
6.	$\exists y(*prs'(y) \wedge come'(y))$	t	Ø
7.	$\lambda r[r = \exists y(*prs'(y) \wedge come'(y)) \vee r = \neg\exists y(*prs'(y) \wedge come'(y))]$	$\langle t,t\rangle$	Ø
8.	p_0	t	$\{p_0\}$
9.	$p_0 = \exists y(*prs'(y) \wedge come'(y)) \vee p_0 = \neg\exists y(*prs'(y) \wedge come'(y))$	t	$\{p_0\}$
10.	$\lambda p_0[p_0 = \exists y(*prs'(y) \wedge come'(y)) \vee p_0 = \neg\exists y(*prs'(y) \wedge come'(y))]$	$\langle t,t\rangle$	Ø

I assume here that, at D-Structure, a yes-no question (e.g., (26a)) differs from a related declarative sentence (cf. (6)) only in that it contains an interrogative complementizer (Q_0) and an IP-adjoined yes-no operator. The latter is an identity disjunction, whose D-Structure representation is $[_{XP1}$ _ $[_{X'}$ OR_t [*not* $OR_{t,(}$]]. The left-hand parenthesis marker ($OR_{t,(}$) is raised, first within the yes-no operator to [SPEC, XP_1], and then out—in the permitted across-the-board fashion (Williams 1977, 1978)—to [SPEC, CP]. The residue of the yes-no operator may be deleted at PF, in which case it will not be overt. But it will still be present in the syntax—crucially including the LF level, which is the input to compositional semantic rules.

Under these syntactic assumptions, the universal rules of the XLS theory will derive the correct meaning for (26a), as in (27), without any stipulations (cf. Karttunen 1977). Alternative final translations, such as (28b) derived on the basis of the transformation plan (28a), are excluded as improper—in this case, by the Type Filter.

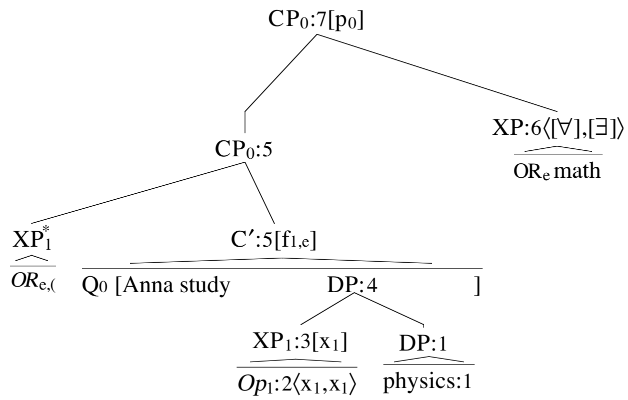
(28) a. $\mathbb{T}'$: $IP^* \mapsto [=]_t$, $C' \mapsto p_1$, $CP_0 \mapsto p_0$

b. $\lambda p_0 \lambda p_1[p_0 = (\exists y[{*}prs'(y) \wedge come'(y)] = p_1 \vee \exists y[{*}prs'(y) \wedge come'(y)] = \neg p_1)]$

In (26b) the Boolean disjunction *albo* 'or$_{\langle e,t\rangle}$' can only be interpreted as part of the scope of the (possibly covert) yes-no operator. The latter involves the identity disjunction *czy* … *czy* '$OR_{t,(}$ … OR_t' in the usual manner. (26b), therefore, is unambiguously a yes-no question. The disjuncts connected by Boolean *albo* are initially of the individual type *e*. However, since the lattice-theoretic meet operation is sometimes undefined for this type—not every pair of individuals has an individual-part in common—*e* is not a possible type index for Boolean disjunction (see L_{or}). Accordingly, the arguments of Boolean *albo* are combined at the next higher type, $\langle e,t\rangle$, following type lifting of both with $[=]_e$.

Questions concerning alternatives other than yes/no involve identity disjunction whose type index matches the type of the alternatives (e.g., in (26c), '$OR_{e,(}$ … OR_e'). Superficially, this identity disjunction heads an alternative operator that appears to replace the yes-no operator. The syntactic evidence, however, is equally compatible with a structure that is compositionally closer to (25a–b)—that is, to the structure assigned to base-generated "noun incorporation" in Inuit. If a compositionally parallel structure is assigned to alternative questions, then the semantic interpretation can proceed—on the model of Inuit (25b)—as follows.

(29)



1.	phs	e	Ø
2.	$\lambda x_1[x_1](f_{1,e}(x_1))$		
≈	$f_{1,e}(x_1)$	e	$\{x_1, f_{1,e}\}$
3.	$\lambda x_1[f_{1,e}(x_1)]$	$\langle e,e\rangle$	$\{f_{1,e}\}$
4.	$f_{1,e}(phs)$	e	$\{f_{1,e}\}$
5.	$\lambda f_{1,e}[p_0 = study'(a, f_{1,e}(phs))]$	$\langle\langle e,e\rangle,t\rangle$	$\{p_0\}$
6.	$[\exists]_{\langle e,e\rangle}([\forall]_e(\lambda y\lambda x[[x = y] \times [x = mth]])$		
≈	$\lambda F[\exists f(\forall z[z \in Dom[f] \rightarrow f(z) = z \vee f(z) = mth] \wedge F(f))]$	$\langle\langle\langle e,e\rangle,t\rangle,t\rangle$	Ø
7.	$\lambda p_0[\exists f(\forall z[z \in Dom[f] \rightarrow f(z) = z \vee f(z) = mth] \wedge p_0 = study'(a, f(phs)))]$		
≈	$\lambda p_0[p_0 = study'(a, phs) \vee p_0 = study'(a, mth)]$	$\langle t,t\rangle$	Ø

Due to local type determination for gaps (here, the null operator Op_1), and the cross-categorial nature of the type lifting component, the same analysis applies to questions about alternatives of other types—including those in (30). The alternative operator may optionally originate adjoined to its focus, in the scope of interrogative complementizer, as in (31). In that case, extraposition at LF derives representations equivalent to those in (30) (cf. (3)).[17]

(30) a. [Does John $need_{int}$ [Op_1 *a car*] to go to work] [$OR_{\langle e,t\rangle}$ *a bicycle*]$_1$?

b. [Did Mary walk [Op_1 *fast*] when you saw her] [$OR_{\langle\langle e,t\rangle,\langle e,t\rangle\rangle}$ *slowly*]$_1$?

c. [Did [Op_1 *everybody*] leave] [$OR_{\langle\langle e,t\rangle,t\rangle}$ *just a few people*]$_1$?

(31) a. [Does John $need_{int}$ [[Op_1 *a car*] [$OR_{\langle e,t\rangle}$ *a bicycle*]$_1$] to go to work?

b. [Did Mary walk [[Op_1 *fast*] [$OR_{\langle\langle e,t\rangle,\langle e,t\rangle\rangle}$ *slowly*]$_1$] when you saw her?

c. [Did [[Op_1 *everybody*] [$OR_{\langle\langle e,t\rangle,t\rangle}$ *just a few people*]$_1$] leave?

17 The equivalence follows if the trace of the alternative operator binds itself, turning into an identity operator.

In both kinds of representations the Empty Category Principle imposes locality constraints on the syntactic relation between the highest empty category in the focus phrase (the null operator in (30), or the trace of the alternative operator in (31)) and its licensing element (the alternative operator itself in English (30)–(31), or its left-parenthesis marker in Polish (29)). Roughly speaking, the relation must be clause-bound—a restriction noted in Larson 1985. [18]

3.5. *Wh-operators in disjunctive questions: Answerability revisited*

Combined with the analysis of the *wh*/indefinite ambiguity, this theory of disjunction further explains the well-known fact that *wh*-operators cannot occur in disjunctive—that is, yes-no or alternative—questions. Thus, on the non-echo interpretation, questions of the type represented in (32) are excluded in all natural languages (see Schauber 1975 on Navajo, Karttunen 1977 on English, Huang 1982 on Chinese, Williamson 1984 on Lakhota, etc).

(32) a.* Did John see which girl?

b.* Does who study math or physics?

Following Huang 1982 and Dayal 1996, I assume that *wh*-operators which are *in situ* at S-Structure raise at LF. The landing site is [SPEC, CP], or a CP-adjoined position. The resulting LFs pose no compositionality problems. For example, (32a) and (32b) would both be assigned proper translations—to wit, (33a) and (33b), respectively. [19]

(33) a. $\lambda p_0[\exists y(\text{girl}'(y) \wedge ([p_0 = \text{see}'(j, y)] \vee [p_0 = \neg\text{see}'(j, y)]))]$

b. $\lambda p_0[\exists y(\text{*prs}'(y) \wedge ([p_0 = \text{study}'(y, \text{phs})] \vee [p_0 = \text{study}'(y, \text{math})]))]$

Nevertheless, we can still explain why questions of this kind are ruled out, if we adopt a particular view of the relation between the denotation of a question and its (true and complete) answer. For simple *wh*-questions, we found that either of the following definitions yields correct results (section 3.1).

SUM $\text{Ans}_{\oplus} := \lambda W[\oplus[W]]$ Karttunen 1977, *et al.*

MAX $\text{Ans}_{\iota} := \lambda W[\iota p W(p)]$ Dayal 1996

[18] Larson (1985) derives locality by positing movement of the left-parenthesis marker out of the alternative operator (cf. (27)). The more recent version of the GB theory I assume would not allow this movement.

[19] In (33a) the contribution of *which* is ignored as irrelevant. See section 5 for analysis and discussion.

Disjunctive questions containing *wh*-operators distinguish between these two theories. Thus, for the questions of (32) the standard summation approach applied to the proper translations in (33) predicts perfectly sensible, but intutively unavailable, answers. In contrast, the maximization approach advocated in Dayal 1996 makes the desired prediction—namely, that questions of the kind represented in (32) are excluded because they violate the Answerability Filter (AF) in every context where their presuppositions are met.

For example, suppose that question (32a) is uttered in a context where the salient girls are Mary and Sue. Suppose further that John saw Mary but did not see Sue. Applied to the translation (33a), the summation approach predicts that the (true and complete) answer is determined as in (34)—that is, it is the proposition that John saw Mary and that he didn't see Sue. Intuitively, this is not a possible answer to (32a). Thus, the intuition that alternative questions with *wh*-operators are uninterpretable is not accounted for under the summation approach.

(34) $[\![\mathrm{Ans}_{\oplus}(\lambda p_0[\exists y(\mathrm{girl}'(y) \wedge [p_0 = \mathrm{see}'(j, y) \vee p_0 = \neg\mathrm{see}'(j, y)])])]\!]^c$

$= [\![\oplus\lambda p_0[\exists y(\mathrm{girl}'(y) \wedge [p_0 = \mathrm{see}'(j, y) \vee p_0 = \neg\mathrm{see}'(j, y)])]]\!]^c$

$= \sup_{\leq t}\{\pi \in (\Delta^\circ{}_t|\langle w_c, k_c\rangle): [\![\lambda p_0[\exists y(\mathrm{girl}'(y) \wedge [p_0 = \mathrm{see}'(j, y) \vee p_0 = \neg\mathrm{see}'(j, y)])]]\!]^c(\pi) \in (\Delta^\circ{}_t|\langle w_c, k_c\rangle)\}$

$= \bigcap\{P(a): w_c \in P(a) \;\&\; w_c \in [\![\mathrm{girl}']\!]^c(a) \;\&\; P \in \{[\![\lambda y[\mathrm{see}'(j, y)]]\!]^c, [\![\lambda y[\neg\mathrm{see}'(j, y)]]\!]^c\}\}$

$= [\![\mathrm{see}'(j, m)]\!]^c \cap [\![\neg\mathrm{see}'(j, s)]\!]^c$

The maximization approach is more successful. On this view, the answer to (32a) in this context would be determined as follows.

(35) $[\![\mathrm{Ans}_\iota(\lambda p_0[\exists y(\mathrm{girl}'(y) \wedge [p_0 = \mathrm{see}'(j, y) \vee p_0 = \neg\mathrm{see}'(j, y)])])]\!]^c$

$= [\![\iota p\exists y(\mathrm{girl}'(y) \wedge [p = \mathrm{see}'(j, y) \vee p = \neg\mathrm{see}'(j, y)])]\!]^c$

$= \max_{\leq t}(\{\pi \in (\Delta^\circ{}_t|\langle w_c, k_c\rangle): w_c \in [\![\lambda p[\exists y(\mathrm{girl}'(y) \wedge [p = \mathrm{see}'(j, y) \vee p = \neg\mathrm{see}'(j, y)])]]\!]^c(\pi)\})$ if it exists;

$\varnothing$, otherwise

$= \max_{\leq t}(\{P(a): w_c \in P(a) \;\&\; w_c \in [\![\mathrm{girl}']\!]^c(a) \;\&\; P \in \{[\![\lambda y[\mathrm{see}'(j, y)]]\!]^c, [\![\lambda y[\neg\mathrm{see}'(j, y)]]\!]^c\}\})$ if it exists;

$\varnothing$, otherwise

$= \max_{\leq t}(\{[\![\mathrm{see}'(j, m)]\!]^c, [\![\neg\mathrm{see}'(j, s)]\!]^c\})$ if it exists;

$\varnothing$, otherwise

$= \varnothing$

Thus, the answer would be the most informative element in the set consisting of two propositions—the proposition that John saw Mary and the proposition that he didn't see Sue. Since neither of these propositions entails the other, there is no most informative proposition. As a consequence, the Answerability Filter cannot be satisfied.

This explanation generalizes to any context where the presupposition of (32a)—that there are at least two salient girls—is satisfied. In any such context the proper translation (33a) will not represent any intuitively available reading because it will violate the Answerability Filter (as in (35)). The same explanation extends to (32b) and other disjunctive questions containing *wh*-operators. These questions, therefore, provide independent support for Dayal's maximization theory of answers—the theory I henceforth adopt.

ANS $\mathrm{Ans} := \mathrm{Ans}_{¥} := \lambda W[\iota p W(p)]$

3.6. *Evidence from declaratives*

The revised XLS theory developed in the foregoing sections will also account for more complex questions provided that the type lifting component is generalized as follows.

D1. *Set of type lifting operators,* $\Omega := \bigcup_{\tau}\{[=]_{\tau}, [=]!_{\tau}, [+]_{\tau}, [+]!_{\tau}, [\exists]_{\tau}, [\exists]!_{\tau}, [\forall]_{\tau}, [\forall]!_{\tau}\}$

	From	*To*	*Definition*
$[=]_{\tau}$	τ	$\langle\tau,t\rangle$	$\lambda z_{\tau}\lambda y_{\tau}[y_{\tau} = z_{\tau}]$
$[=]!_{\tau}$	$\langle\tau,t\rangle$	$\langle\tau,\langle\tau,t\rangle\rangle$	$\lambda P_{\tau}\lambda y_{\tau}\lambda x_{\tau}[P_{\tau}(x_{\tau}) \wedge y_{\tau} = y_{\tau}]$
$[+]_{\tau}$	τ	$\langle\tau,\tau\rangle$	$\lambda z_{\tau}\lambda y_{\tau}[y_{\tau} + z_{\tau}]$
$[+]!_{\tau}$	$\langle\tau,t\rangle$	$\langle\langle\tau,\tau\rangle,t\rangle$	$\lambda P_{\tau}\lambda f_{\tau}[P_{\tau}(\oplus[f_{\tau}])]$
$[\exists]_{\tau}$	$\langle\tau,t\rangle$	$\langle\langle\tau,t\rangle,t\rangle$	$\lambda P_{\tau}\lambda Q_{\tau}[\exists y_{\tau}(P_{\tau}(y_{\tau}) \wedge Q_{\tau}(y_{\tau}))]$
$[\exists]!_{\tau}$	$\langle\tau,\langle e,t\rangle\rangle$	$\langle\langle\tau,t\rangle,\langle e,t\rangle\rangle$	$\lambda A_{\tau}\lambda Q_{\tau}\lambda x_{e}[\exists y_{\tau}(A_{\tau}(x_{e}, y_{\tau}) \wedge Q_{\tau}(y_{\tau}))]$
$[\forall]_{\tau}$	$\langle\tau,\langle\tau,t\rangle\rangle$	$\langle\langle\tau,\tau\rangle,t\rangle$	$\lambda R_{\tau}\lambda f_{\tau}[\forall y_{\tau}(y_{\tau} \in \mathrm{Dom}[f_{\tau}] \rightarrow R_{\tau}(f_{\tau}(y_{\tau}), y_{\tau}))]$
$[\forall]!_{\tau}$	$\langle\langle\tau,t\rangle,\langle\tau,\langle e,t\rangle\rangle\rangle$	$\langle\langle\langle\tau,t\rangle,\tau\rangle,\langle e,t\rangle\rangle$	$\lambda C_{\tau}\lambda h_{\tau}\lambda x_{e}[\forall P_{\tau}(P_{\tau} \in \mathrm{Dom}[h_{\tau}] \rightarrow C_{\tau}(x_{e}, h_{\tau}(P_{\tau}), P_{\tau}))]$

For each cross-categorial family motivated so far, there is a parallel family—marked with "!"—that applies to input of the next higher rank. That is, each kind of operation has a *low* and a *high* variant. This revision makes semantic type lifting even more like syntactic movement (recall sections 2.2 and 3.1), since low and high variants of type lifting operations relate to one another like substitution and adjunction variants of movement (see Chomsky 1986a).

High type lifting is by no means limited to complex questions, as the following evidence from declaratives attests. This evidence also makes the converse point for the semantic transformations of the revised XLS theory: though initially motivated on the basis of simple questions (sections 3.1–3.5), they apply to declaratives as well.

3.6.1. $[=]!_\tau$: *Possessed nominals, ‘same’, and ‘different’*

Possessed nominals may require type lifting because the possessive determiner (*’s*) must combine with a relation (L_{POSS}; see (36a)), whereas its NP complement may initially denote a property (as in (36b)).

L_{POSS} If *’s*$_i \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}$: *’s*$_i \mapsto \langle \lambda R \lambda y[\iota z(R(z, y) \wedge R_i(z, y))], \varnothing \rangle$

(36) a. $[_{DP}$ John $[_{D'}$’s$_1$ *friends*]]

b. $[_{DP}$ John $[_{D'}$ ’s$_1$ *cats*]]

The high operator $[=]!_\tau$ makes it possible to interpret both structures in essentially the same manner, as follows:

(37) a. $\mathbb{F}(j, \mathbb{F}(\lambda R \lambda y[\iota z(R(z, y) \wedge R_1(z, y))], \lambda x[*(\text{friend-of}'(x))]))$

$\approx \iota z(*[\text{friend-of}'(j)](z) \wedge R_1(z, j))$

b. $\mathbb{F}(j, \mathbb{F}(\lambda R \lambda y[\iota z(R(z, y) \wedge R_1(z, y))], \mathbb{F}([=]!_e, *\text{cat}')))$

$\approx \mathbb{F}(j, \mathbb{F}(\lambda R \lambda y[\iota z(R(z, y) \wedge R_1(z, y))], \lambda y \lambda x[*\text{cat}'(x) \wedge y = y]))$

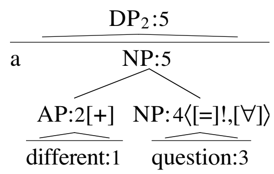
$\approx \iota z[*\text{cat}'(z) \wedge R_1(z, j)]$

Together with other semantic transformations, the operator $[=]!_\tau$ also permits compositional interpretation of internal readings of expressions like *same* and *different* (e.g., (38), see Carlson 1987), without apealing to polyadic quantification or any other non-compositional operations (see also section 3.6.2; cf. Keenan 1987, Moltmann 1992).

(38) Every student answered *the same*/*a different* question.

Both *same* and *different* can be interpreted as properties of functions from individuals to individuals—to be precise, the property that a function has if it assigns the same value to all of its arguments, or different values, respectively. This higher order property can be combined with the first order property denoted by *question* once the latter has undergone type lifting, first by the high operator $[=]!_e$ and then by the low operator $[\forall]_e$, as follows.

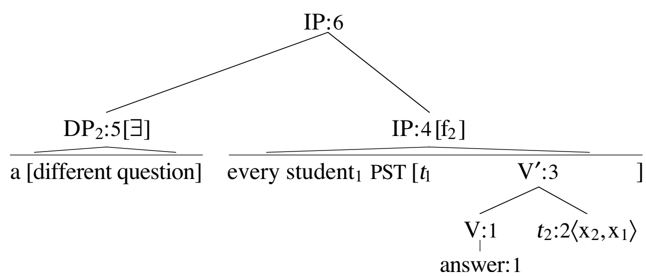
(39)



1/2K.	$\lambda f[\forall x \forall y(x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y))]$	$\langle\langle e,e\rangle,t\rangle$	Ø
3/4K.	qu′	$\langle e,t\rangle$	Ø
4T.	$[\forall]_e([=]!_e(qu'))$		
≈	$[\forall]_e(\lambda y \lambda x[qu'(x) \wedge y = y])$		
≈	$\lambda f[\forall y(y \in Dom[f] \rightarrow qu'(f(y)))]$	$\langle\langle e,e\rangle,t\rangle$	Ø
2T.	$[+]_{\langle\langle e,e\rangle,t\rangle}(\lambda f[\forall x \forall y(x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y))])$		
≈	$\lambda F \lambda f[\forall x \forall y(x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y)) \wedge F(f)]$	$\langle\langle\langle e,e\rangle,t\rangle,\langle\langle e,e\rangle,t\rangle\rangle$	Ø
5.	$\lambda f[\forall x \forall y(x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y)) \wedge \forall z(z \in Dom[f] \rightarrow qu'(f(z)))]$	$\langle\langle e,e\rangle,t\rangle$	Ø

The resulting property of functions can then be quantified into the object position as in (40).

(40)



1.	ans′	$\langle e,\langle e,t\rangle\rangle$	Ø
2.	$\lambda x_2[x_2](f_2(x_1))$		
≈	$f_2(x_1)$	e	$\{x_1, f_2\}$
3.	$ans'(f_2(x_1))$	$\langle e,t\rangle$	$\{x_1, f_2\}$
4.	$\lambda f_2[\forall y(std'(y) \rightarrow ans'(y, f_2(y)))]$	$\langle\langle e,e\rangle,t\rangle$	Ø
5.	$[\exists]_{\langle e,e\rangle}(\lambda f[\forall x \forall y(x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y))$		
	$\wedge \forall z(z \in Dom[f] \rightarrow qu'(f(z)))])$	$\langle\langle\langle e,e\rangle,t\rangle,t\rangle$	Ø
6.	$\exists f(\forall x \forall y[x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y)]$		
	$\wedge \forall z[z \in Dom[f] \rightarrow qu'(f(z))] \wedge \forall z[std'(z) \rightarrow ans'(z, f(z))])$	t	Ø

The operations required for this step—from substitution binding of the gap t_2, to existential type lifting of the antecedent DP_2—have already been motivated on independent grounds. As shown in section 3.4, they are also needed to interpret identity disjunction in structures with incorporated disjuncts (e.g., (25)), and in alternative questions (29).

3.6.2. $[+]!_\tau$: *Multiple occurrences of 'same' or 'different'*

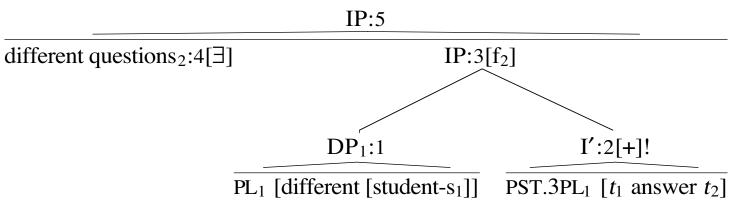
Intuitively, (41a) entails (41b). The converse does not hold: in a context where the students worked in groups (41b) would be true, but (41a) false, if the students within each group were assigned the same questions.

(41) a. Every student answered different questions.

b. Different students answered different questions.

(41a), of course, can be analyzed like (38). The following analysis of (41b) crucially relies on the high operator [+]!.

(42)

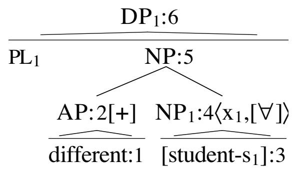


1.	$\iota g[\forall x \forall y[x \in Dom[g] \wedge y \in Dom[g] \wedge x \neq y \rightarrow g(x) \neq g(y)] \wedge \forall z(z \in Dom[g] \rightarrow std'(g(z)) \wedge g(z) = z)]$		
≈	$\iota g[\forall z(z \in Dom[g] \rightarrow std'(g(z)) \wedge g(z) = z)]$	$\langle e,e \rangle$	Ø
2.	$[+]!_{\langle e,t \rangle}(DIS_{1,e}(\lambda x_1[ans'(x_1, f_2(x_1))]))$		
≈	$\lambda g[DIS_{1,e}(\lambda x_1[ans'(x_1, f_2(x_1))])(\oplus g)]$	$\langle\langle e,e \rangle,t \rangle$	$\{f_2\}$
3.	$\lambda f_2[DIS_{1,e}(\lambda x_1[ans'(x_1, f_2(x_1))])(\oplus \iota g[\forall z(z \in Dom[g] \rightarrow std'(g(z)) \wedge g(z) = z)])]$	$\langle\langle e,e \rangle,t \rangle$	Ø
4.	$[\exists]_{\langle e,e \rangle}(\lambda f[\forall x \forall y(x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y))$		
	$\wedge \forall z(z \in Dom[f] \rightarrow {*}qu'(f(z)))])$	$\langle\langle\langle e,e \rangle,t \rangle,t \rangle$	Ø
5.	$\exists f(\forall x \forall y[x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y)] \wedge \forall z[z \in Dom[f] \rightarrow {*}qu'(f(z))]$		
	$\wedge DIS_{1,e}(\lambda x_1[ans'(x_1, f(x_1))])(\oplus \iota g[\forall z(z \in Dom[g] \rightarrow std'(g(z)) \wedge g(z) = z)]))$		
≈	$\exists f(\forall x \forall y[x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y)] \wedge \forall z[z \in Dom[f] \rightarrow {*}qu'(f(z))]$		
	$\wedge DIS_{1,e}(\lambda x_1[ans'(x_1, f(x_1))])(\iota z {*}std'(z)))$	t	Ø

This operator applies to I′, which initially denotes a property of individual sums, and lifts it to a property of functions—to wit, the property that a function has if the sum of all the individuals in its domain has the input property. The input property is formed by the distributive operator ($DIS_{1,e}$) contributed by the plural inflection ($PST.3PL_1$). The distributive operator is defined as in Schwarzschild 1996 (see Appendix 1) and thus has an indexical component. It distributes down to the cells of the contextually salient cover—here, down to the salient groups of students if there are such, otherwise down to the individual students. Hence the dependence of (41b) on the context.

The subject (DP_1), which contributes the function whose domain is distributed over, is interpreted collectively. The key steps are shown in (43), where the collective reading is attributed to the plural morphology: $\text{PL}_1 \ldots \text{-}s_1$.

(43)



1/2K.	$\lambda f[\forall x \forall y(x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y))]$	$\langle\langle e,e\rangle,t\rangle$	Ø
3/4K.	$\lambda y[std'(y) \wedge y = x_1]$	$\langle e,t\rangle$	$\{x_1\}$
4B(b).	$\lambda f[\forall z(z \in Dom[f] \rightarrow std'(z) \wedge f(z) = z)]$	$\langle\langle e,e\rangle,t\rangle$	Ø
2T.	$\lambda F \lambda f[\forall x \forall y(x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y)) \wedge F(f)]$	$\langle\langle\langle e,e\rangle,t\rangle,\langle\langle e,e\rangle,t\rangle\rangle$	Ø
5.	$\lambda f[\forall x \forall y(x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y))$ $\wedge \forall z(z \in Dom[f] \rightarrow std'(z) \wedge f(z) = z)]$	$\langle\langle e,e\rangle,t\rangle$	Ø
6.	$\iota f[\forall x \forall y(x \in Dom[f] \wedge y \in Dom[f] \wedge x \neq y \rightarrow f(x) \neq f(y))$ $\wedge \forall z(z \in Dom[f] \rightarrow std'(z) \wedge f(z) = z)]$	$\langle e,e\rangle$	Ø

Interpreted in this way, the subject (DP_1) denotes the greatest identity function ranging over singular students. Since functions are ordered according to their domains and values as follows (Appendix 1),[20]

$$\leq \qquad f_1 \leq f_2 := \forall x(x \in Dom[f_1] \rightarrow x \in Dom[f_2] \wedge f_1(x) \leq f_2(x))$$

the greatest function will have all of the singular students in its domain. Thus, what is distributed over is the plurality of all the students (final reduction in step 5 of (42)). This accounts for the entailment from (41a) to (41b).

3.6.3. $[\exists]!_\tau$: *Noun incorporation revisited*

The high operator [∃]! can be motivated based on evidence from noun incorporation. For the Inuit sentence (44) the key steps in the interpretation are shown in (45). The extensional verb *-si* 'get' is lifted by $[\exists]!_e$ to resolve the initial type mismatch between this verb and the V-adjoined noun.[21]

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[20] This part-whole order is independently supported by evidence from veridical perception reports (Bittner 1996a), correlatives (Bittner 1996b), and indirect binding (Sharvit 1996).

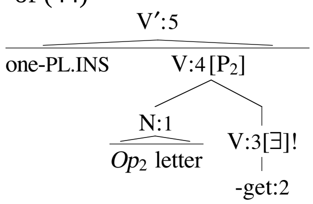
[21] The V-adjoined noun *allagar-* 'letter' is grammatically plural—hence plural agreement in the stranded modifier *ataatsi-nik* 'one-PL.INS' (Rischel 1972). The number neutral translation *letter′ assigned to *allagar-* (* is defined as in Link 1983) is motivated by the fact that the unmodified sentence *Juuna allagar-si-v-u-q* means 'Juuna received one or more letters.'

(44) Juuna ataatsi-nik allagar-si-v-u-q

Juuna one-PL.INS letter-get-IND-[-tr]-3SG

'Juuna received one letter.'

(45) V′ of (44)



1.	$\lambda y[P_2(y) \wedge {}^*letter'(y)]$	$\langle e,t\rangle$	$\{P_2\}$
2.	get'	$\langle e,\langle e,t\rangle\rangle$	Ø
3.	$[\exists]!_e(get')$		
≈	$\lambda Q\lambda x[\exists y(get'(x, y) \wedge Q(y))]$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	Ø
4.	$\lambda P_2\lambda x[\exists y(get'(x, y) \wedge P_2(y) \wedge {}^*letter'(y))]$	$\langle\langle e,t\rangle,\langle e,t\rangle\rangle$	Ø
5.	$\lambda x[\exists y(get'(x, y) \wedge 1'(y) \wedge {}^*letter'(y))]$		
≈	$\lambda x[\exists y(get'(x, y) \wedge letter'(y))]$	$\langle e,t\rangle$	Ø

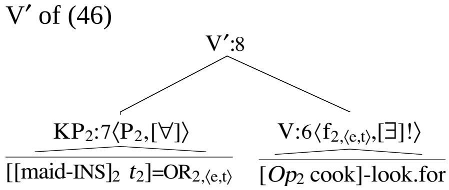
In (46) (= (24.ii)) both the verb and the stranded operator are of a higher type. The interpretation proceeds as in (47) (revised from (25b)), with the operator triggering type lifting, of the entire verb+noun complex, with $[\exists]!_{\langle\langle e,t\rangle,\langle e,t\rangle\rangle}$.

(46) Anna kiffa-ssa-mil=luunniit igasu-ssar-siur-p-u-q

Anna [maid-future-INS]=$OR_{\langle e,t\rangle}$ [cook-future]-look.for-IND-[-tr]-3SG

'Anna is looking for a cook $OR_{\langle e,t\rangle}$ a maid.' (I don't know which.)

(47) V′ of (46)



6.	$[\exists]!_{\langle\langle e,t\rangle,\langle e,t\rangle\rangle}(\lambda f_{2,\langle e,t\rangle}[look\text{-}for'(f_{2,\langle e,t\rangle}(cook'))])$		
≈	$\lambda F_{\langle e,t\rangle}\lambda x[\exists f_{\langle e,t\rangle}(look\text{-}for'(x, f_{\langle e,t\rangle}(cook)) \wedge F_{\langle e,t\rangle}(f_{\langle e,t\rangle}))]$	$\langle\langle\langle\langle e,t\rangle,\langle e,t\rangle\rangle,t\rangle,\langle e,t\rangle\rangle$	Ø
7.	$[\forall]_{\langle e,t\rangle}(\lambda P_2\lambda Q[[Q = P_2] \times [Q = maid']])$		
≈	$\lambda f_{\langle e,t\rangle}[\forall P(P \in Dom[f_{\langle e,t\rangle}] \rightarrow f_{\langle e,t\rangle}(P) = P \vee f_{\langle e,t\rangle}(P) = maid')]$	$\langle\langle\langle e,t\rangle,\langle e,t\rangle\rangle,t\rangle$	Ø
8.	$\lambda x[\exists f_{\langle e,t\rangle}(look\text{-}for'(x, f_{\langle e,t\rangle}(cook')) \wedge \forall P(P \in Dom[f_{\langle e,t\rangle}] \rightarrow f_{\langle e,t\rangle}(P) = P \vee f_{\langle e,t\rangle}(P) = maid'))]$		
≈	$\lambda x[look\text{-}for'(x, cook') \vee look\text{-}for'(x, maid')]$	$\langle e,t\rangle$	Ø

This analysis explains why an incorporated noun, in Inuit and other languages, is interpreted as indefinite unless it is construed with a referential expression—a stranded demonstrative, object agreement, or the like (see, e.g., Mithun 1984, 1986, Sadock 1986, Rosen 1989). A referential expression, of course, can be turned into a predicate by type lifting with $[=]_e$. This makes it type-wise indistinguishable from the property denoting modifier in (45). In the resulting interpretation the existential quantifier contributed by $[\exists]!_e$ will quantify over a singleton domain—an operation equivalent to a specific or definite interpretation of the incorporated object.

3.6.4. $[\forall]!_\tau$: *'Consider' as a higher order attitude*

The verb *consider* presents an interesting compositionality problem. Syntactic evidence points to a structure with a small clause complement, as indicated in (48) (see Stowell 1981, 1989).

(48) John *considers* $[_{AP}$ Ann$_i$ $[_{APi}$ very smart]]

As expected, small clauses can be coordinated, as in (49a) or (49b). Surprisingly, however, mixed coordinations of the kind represented in (50a) are excluded, even though their finite counterparts in complements of propositional attitude verbs—e.g., *believe* in (50b)—are acceptable.

(49) a. John *considers* $[_{AP}$ $[_{AP1}$ the players weak] or $[_{AP2}$ the coach incompetent]]

b. John *considers* it$_i$ $[_{AP}$ $[_{AP1}$ t_i obvious that Anne is smart] and $[_{AP2}$ t_i possible that Bill is brilliant]]]

(50) a.* John *considers* $[_{AP}$ $[_{AP1}$ Anne smart] and $[_{AP2}$ (it) obvious that Bill is brilliant]]

b. John *believes* $[_{CP}$ $[_{CP1}$ that Anne is smart] and $[_{CP2}$ that it is obvious that Bill is brilliant]]

Thus, the two kinds of complements must be interpreted differently—a conclusion strengthened by the contrast between the arguments in (51) and (52), of which the first is intuitively valid and the second, invalid.

(51) John *considers* [the players weak or the coach incompetent].

∴ [John *considers* the players weak] or [John *considers* the coach incompetent].

(52) John *believes* [that the players are weak or that the coach is incompetent].

∴ [John *believes* that the players weak] or [John *believes* that the coach is incompetent].

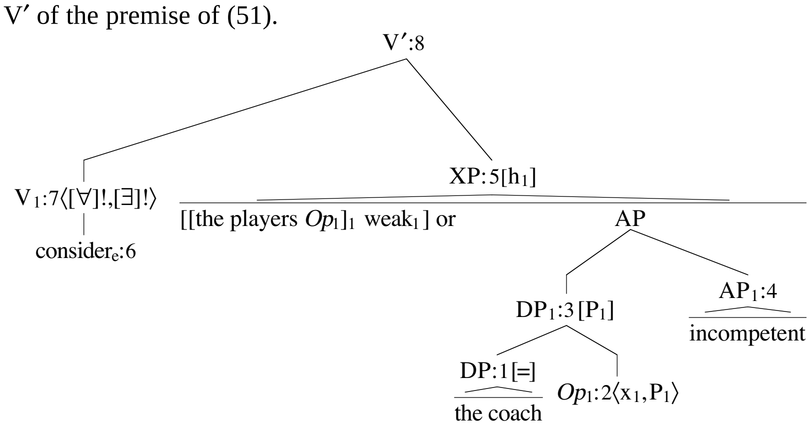
For example, the premise of (52) (with *believe*) is true, but the conclusion, false, in the following situation. While watching a mediocre game, John can think of two possible explanations—either the players are weak or the coach is incompetent—but he hasn't decided between them. This is not a counterexample to the argument in (51) (with *consider*), since consultants judge not only the conclusion, but also the premise, to be false in this situation.

Given Hintikka's (1969) semantics for propositional attitudes, the usual type assignment to *believe*—$\langle t,\langle e,t\rangle\rangle$—will account for (50b) and (52). Suppose that *consider* is instead of type $\langle\langle\tau,t\rangle,\langle\tau,\langle e,t\rangle\rangle\rangle$. This will explain the validity of the argument in (53), and of (51) on the analysis in (54) (Abbreviations: c := ιy[coach′(y)], pl := ιy[*player′(y)]).

(53) John considers $[_{AP}$ *Anne* smart]. Anne is Bill's wife.

∴ John considers $[_{AP}$ *Bill's wife* smart].

(54) V′ of the premise of (51).



1F.	c	e	Ø
2.	$\lambda x_1[x_1](h_1(P_1))$		
≈	$h_1(P_1)$	e	$\{P_1, h_1\}$
1T.	$\lambda y[y = c]$	$\langle e,t\rangle$	Ø
3.	$\lambda P_1[h_1(P_1) = c]$	$\langle\langle e,t\rangle,t\rangle$	$\{h_1\}$
4.	incompetent′	$\langle e,t\rangle$	Ø
5.	$\lambda h_1[h_1(\text{weak}') = \text{pl} \vee h_1(\text{incompetent}') = c]$	$\langle\langle\langle e,t\rangle,e\rangle,t\rangle$	Ø
6.	consider′	$\langle\langle e,t\rangle,\langle e,\langle e,t\rangle\rangle\rangle$	Ø
7.	$[\exists]!_{\langle\langle e,t\rangle,e\rangle}([\forall]!_e(\text{consider}'))$		
≈	$[\exists]!_{\langle\langle e,t\rangle,e\rangle}(\lambda h\lambda x[\forall Q(Q \in \text{Dom}[h] \rightarrow \text{consider}'(x, h(Q), Q))])$		
≈	$\lambda H\lambda x[\exists h(\forall Q[Q \in \text{Dom}[h] \rightarrow \text{consider}'(x, h(Q), Q)] \wedge H(h))]$	$\langle\langle\langle\langle e,t\rangle,e\rangle,t\rangle,\langle e,t\rangle\rangle$	Ø
8.	$\lambda x[\exists h(\forall Q[Q \in \text{Dom}[h] \rightarrow \text{consider}'(x, h(Q), Q)] \wedge [h(\text{weak}') = \text{pl} \vee h(\text{incompetent}') = c])]$		
≈	$\lambda x[\text{consider}'(x, \text{pl}, \text{weak}') \vee \text{consider}'(x, c, \text{incompetent}')]$	$\langle e,t\rangle$	Ø

In general, *consider*$_\tau$ can be lifted by [Å]!$_\tau$ to a higher order attitude. The object of this attitude is a function of type $\langle\langle\tau,t\rangle,t\rangle$ (henceforth *instantiation function*). In (54), this leads to (55a), which is equivalent to the desired (55b):

(55) a. $\exists$h($\forall$Q[Q $\in$ Dom[h] $\rightarrow$ consider′(j, h(Q), Q)] $\wedge$ [h(weak′) = pl $\vee$ h(incompetent′) = c])

b. consider′(j, pl, weak′) $\vee$ consider′(j, c, incompetent′)

(55a) , (55b). Let h_0 be an instantiation function that verifies (55a). *Case* 1: h_0: ⟦weak′⟧ $\mapsto$ ⟦pl⟧. It follows that the property ⟦weak′⟧ is in the domain of h_0 (see Appendix 1), so John attributes this property to h_0(⟦weak′⟧)—that is, to the players. Thus, the disjunction in (55b) is true. *Case* 2: h_0: ⟦incompetent′⟧ $\mapsto$ ⟦c⟧. Now we infer that John considers the coach incompetent—again, enough to verify (55b).

(55b) , (55a). *Case* 1. John considers the players weak. In that case, (55a) is verified by the instantiation function that maps ⟦weak′⟧ onto ⟦pl⟧, and every other property, onto Kaplan's †. *Case* 2. John considers the coach incompetent. Analogous, but use the function that maps ⟦incompetent′⟧ onto ⟦c⟧, and every other property, onto †.

The compositional derivation in (54) crucially relies on the option of lifting the verb *consider*$_e$, initially of type $\langle\langle e,t\rangle,\langle e,\langle e,t\rangle\rangle\rangle$, with the high operator [$\forall$]!$_e$. Because of the cross-categorial nature of the type lifting component, and the local type assignment to gaps (here Op_1), this analysis immediately generalizes to (49b), with the propositional variant of the verb, *consider*$_t$ of type $\langle\langle t,t\rangle,\langle t,\langle e,t\rangle\rangle\rangle$. The differences in the syntactic structure—the introduction of an expletive subject (it_i), and the change in the category (DP vs. CP) and position (internal subject vs. complement) of the phrase that serves as the argument of the adjectival predicate—do not matter, being ignored by the semantic rules.

This theory also correctly excludes the mixed coordination in (50a). By local type determination, the null operators in the two conjuncts introduce variables of different types—type *e* in AP_1, *t* in AP_2 (rule E(b)). This type difference is preserved by any substitution binding that may subsequently apply (rule B(c)). It is, therefore, not possible to bind all the variables that are stored in (50a), and so no proper translation can be derived (definition D6).

In summary, the cross-linguistic evidence presented in the foregoing sections supports the claim that it is possible to interpret simple questions, as well as some compositionally challenging declaratives, by enriching the universal semantic theory presented in Bittner 1994a,b with certain semantic transformations. I now turn to show that the resulting theory also provides solutions to more complex compositionality puzzles in the realm of interrogative semantics.

4. SCOPE MARKING: AN ALTERNATIVE TO LONG WH-MOVEMENT

4.1. *The phenomenon*

In many languages questions that in English would involve long *wh*-movement can instead be expressed by scope marking constructions of the type represented by (56b) in Warlpiri (Hale, p.c.) and (57b) in Hindi (Dayal, p.c.).

(56) *Walpiri* (Pama-Nyungan: Central Australia)

a.

nyarrpa	_	wangka-ja?
how	PRF.3SG	say-PST

'What did he say?'

b.

nyarrpa	_	wangka-ja	kuja-pala	kurdu-jarra	*nyarrpara*-kurra	ya-nu?
how	PRF.3SG	say-PST	[COMP-3DU	child-DU	*where*-DAT	go-PST]

'Where did he say that the (two) children went?'

(57) *Hindi* (Indic: North Central India)

a.

jaun	*kyaa*	soctaa	hai?
John	*what*	think	AUX

'What does John think?'

b.

jaun	*kyaa*	soctaa	hai	ki	*kis*-ne	*kis*-ko	dekhaa?
John	*what*	think	AUX	[that	*who*-ERG	*who*-ACC	saw]

'Who does John think saw whom?'

In some languages—e.g., German (van Riemsdijk 1983) and Iraqi Arabic (Wahba 1992)—scope marking alternates with long *wh*-movement. In others—including Warlpiri and Hindi (Dayal 1994)—it is the only grammatical device for expressing complex questions. In general, a scope marking construction is based on a simple question of the kind represented by (56a) or (57a). In addition, there is a subordinate question either in the complement position of the verb (as in German) or in an extraposed position (as in Walrpiri and Hindi). The term "scope marking" refers to the fact that the domain of quantification for the question as a whole is determined by the subordinate *wh*-expressions, while the interrogative pronoun in the matrix apparently only determines their scope.

4.2. *Scope marking as indirect wh-dependency*

Dayal (1994, 1996) presents evidence that, universally, the subordinate question in a scope marking construction is adjoined to the matrix CP at LF. The resulting LF representation is interpreted essentially like the LF of the related simple question. The interrogative pronoun in the matrix clause contributes a variable of type $\langle t,t \rangle$. In the simple question this variable remains free and gets its value from the contextually salient assignment function (see (21c)). In a scope marking question, on the other hand, the variable gets bound by the CP-adjoined question, which thus indirectly determines the domain of quantification. In other words, Dayal's analysis of the CP-adjoined question in a scope marking construction is analogous to Bach and Cooper's (1978) analysis of a DP-adjoined relative clause.

The latter analysis has been criticized as non-compositional (Janssen 1983), but this problem can be solved by keeping track of bindable variables by means of storage (as in XLS). An interrogative pronoun would then be ambiguous, translating into $\langle P_{i,t}, \varnothing \rangle$ in simple questions (see L_{wh}, section 3.3), but into $\langle P_{i,t}, \{P_{i,t}\} \rangle$ in scope marking structures. In other words, interrogative pronouns would come in two varieties, resembling in this regard personal pronouns where we find the deictic *him*$_i \rightsquigarrow \langle x_i, \varnothing \rangle$ along with the reflexive *himself*$_i \rightsquigarrow \langle x_i, \{x_i\} \rangle$.

This solution, however, gives rise to another problem. For personal pronouns, deictic and reflexive varieties are morphologically distinct in most languages (as they are in English). In contrast, no language distinguishes the interrogative pronoun used in scope marking questions from its counterpart in simple questions. The only attested paradigm is the one illustrated in (56) and (57), where the form of the interrogative pronoun is the same in questions of either kind. The problem, therefore, is why this lexical ambiguity, unlike any other, should occur in unrelated and typologically very different languages—including Warlpiri, Hindi, German, Iraqi Arabic, Hungarian, etc.

4.3. *Resumptive anaphora instead of variable binding*

I propose that scope marking is a dislocation construction—a structural type that also includes the sentences of (58).

(58) a. [*It*$_i$ surprised John] [that Bill was smart]$_{CPi}$

b. [John]$_{DPi}$ [I see *him*$_i$]

Semantically, the dislocated constituent does not bind the resumptive (personal or interrogative) pronoun. Instead, these two elements are anaphorically linked by a semantic mechanism that mimics variable binding—as follows.

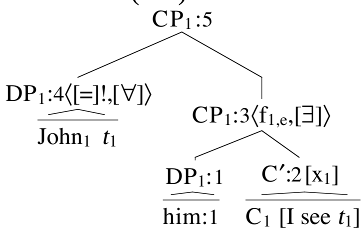
(59) a. $[_{D'1}$ John$_1$ $[_{DP1*}$ $t_1]]$ — dislocated nominal in (58b)

$\rightsquigarrow$ $\lambda x_1[\mathbb{F}([=](j), x_1)] \approx \lambda x_1[x_1 = j]$

b. $[_{C'1}$ Q_1 $[_{CP1*}$ where-DAT$_2$ t_1 [children t_2 go.to]]] — dislocated question in (56b)

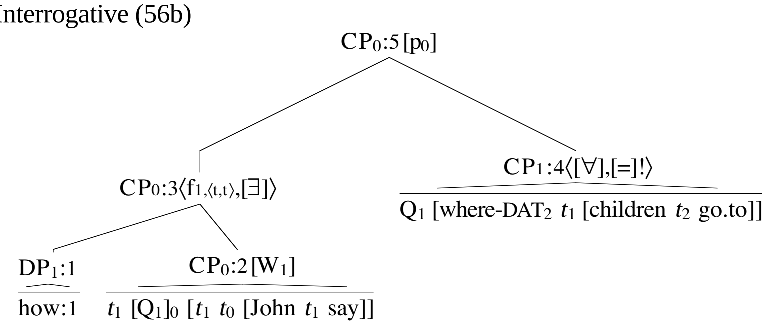
$\rightsquigarrow$ $\mathbb{F}([=], \lambda p_1[\exists x(loc'(x) \wedge p_1 = go\text{-}to'(ch, x))]) \approx \lambda W[W = \lambda p[\exists x(loc'(x) \wedge p = go\text{-}to'(ch, x))]]$

(60) a. Declarative (58b)



1.	x_1	e	Ø
2.	$\lambda x_1[see'(i, f_{1,e}(x_1))]$	$\langle e,t\rangle$	$\{f_{1,e}\}$
3.	$[\exists](\lambda f_{1,e}[see'(i, f_{1,e}(x_1))])$		
≈	$\lambda F_e[\exists f_e(see'(i, f_e(x_1)) \wedge F_e(f_e))]$	$\langle\langle\langle e,e\rangle,t\rangle,t\rangle$	Ø
4.	$[\forall]([=]!(\lambda x_1[x_1 = j])$		
≈	$\lambda f_e[\forall y(y \in Dom[f_e] \rightarrow f_e(y) = j)]$	$\langle\langle e,e\rangle,t\rangle$	Ø
5.	$\exists f_e(see'(i, f_e(x_1)) \wedge \forall y[y \in Dom[f_e] \rightarrow f_e(y) = j])$		
≈	$see'(i, j)$	t	Ø

b. Interrogative (56b)



1.	W_1	$\langle t,t\rangle$	Ø
2.	$\lambda W_1[\exists q(f_{1,\langle t,t\rangle}(W_1)(q) \wedge p_0 = say'(j, q))]$	$\langle\langle t,t\rangle,t\rangle$	$\{p_0, f_{1,\langle t,t\rangle}\}$
3.	$[\exists](\lambda f_{1,\langle t,t\rangle}[\exists q(f_{1,\langle t,t\rangle}(W_1)(q) \wedge p_0 = say'(j, q))])$		
≈	$\lambda F_{\langle t,t\rangle}[\exists f_{\langle t,t\rangle}(\exists q[f_{\langle t,t\rangle}(W_1)(q) \wedge p_0 = say'(j, q)] \wedge F_{\langle t,t\rangle}(f_{\langle t,t\rangle}))]$	$\langle\langle\langle\langle t,t\rangle,\langle t,t\rangle\rangle,t\rangle,t\rangle$	$\{p_0\}$
4.	$[\forall]([=]!(\lambda W[W = \lambda p[\exists x(loc'(x) \wedge p = go\text{-}to'(ch, x))]]))$		
≈	$\lambda f_{\langle t,t\rangle}[\forall W(W \in Dom[f_{\langle t,t\rangle}] \rightarrow f_{\langle t,t\rangle}(W) = \lambda p[\exists x(loc'(x) \wedge p = go\text{-}to'(ch, x))])]$	$\langle\langle\langle t,t\rangle,\langle t,t\rangle\rangle,t\rangle$	Ø
5.	$\lambda p_0[\exists f_{\langle t,t\rangle}(\exists q[f_{\langle t,t\rangle}(W_1)(q) \wedge p_0 = say'(j, q)] \wedge \forall W[W \in Dom[f_{\langle t,t\rangle}] \rightarrow f_{\langle t,t\rangle}(W) = \lambda p[\exists x(loc'(x) \wedge p = go\text{-}to'(ch, x))]])]$		
≈	$\lambda p_0[\exists q(\exists x[loc'(x) \wedge q = go\text{-}to'(ch, x)] \wedge p_0 = say'(j, q))]$		
≈	$\lambda p_0[\exists x(loc'(x) \wedge p_0 = say'(j, go\text{-}to'(ch, x)))]$	$\langle t,t\rangle$	Ø

The dislocated constituent has a recursive XP structure (see section 3.2). This makes it possible to lift its basic meaning (scope of [=] in (59a–b)) to the higher order property of being a function that maps each of its arguments onto that meaning (step 4 of (60a–b)). By interpreting the resumptive pronoun as an argument of such a function (steps 1–3), we get the anaphoric link (reduction in step 5). In interrogative dislocation—i.e., scope marking—the key functional dependency ($f_{1,\langle t,t\rangle}$) is introduced by the recursive structure of the matrix CP (as in (61)).

(61) Sister of resumptive ‘how’ in (60b)

1.	$\lambda p_1[p_1](W_1(p_0))$		
≈	$W_1(p_0)$	t	$\{p_0, W_1\}$
2.	$[\exists](\lambda p_0[W_1(p_0)])$		
≈	$\lambda W[\exists q(W_1(q) \wedge W(q))]$	$\langle\langle t,t\rangle,t\rangle$	$\{W_1\}$
3B/4K.	$\lambda p_1[p_0 = say'(j, p_1)]$	$\langle t,t\rangle$	$\{p_0\}$
5B/6K.	$\lambda W_1[\exists q(W_1(q) \wedge p_0 = say'(j, q))](f_{1,\langle t,t\rangle}(W_1))$		
≈	$\exists q(f_{1,\langle t,t\rangle}(W_1)(q) \wedge p_0 = say'(j, q))$	t	$\{p_0, W_1, f_{1,\langle t,t\rangle}\}$

Declarative dislocation is simpler because the key functional dependency ($f_{1,e}$ in (60a)) can be introduced by the trace of the resumptive pronoun. The pronoun itself raises to [SPEC, CP], as shown in (60a–b), either covertly at LF (as in English (58b) and Hindi (57b)) or overtly at S-Structure (as in Danish (62) and Warlpiri (56b)).

(62) *Danish*

Jonas, *ham* har du _ set _

Jonas_i, $[_{CP}$ $\textit{him}_i$ have_j $[_{IP}$ you t_j seen $t_i]]$

This theory preserves the insights of Dayal’s analysis because resumptive anaphora resembles variable binding. The resumptive pronoun contributes a variable (x_1 in (60a), W_1 in (60b)) that is semantically identified with the dislocated constituent. The identification does not depend on the value assigned to this variable, so the dislocation construction (e.g., *John, I see him*) does not inherit the context dependence of the matrix clause (*I see him*). Resumptive anaphora also mimics variable binding in more complex structures, allowing, for example, recursive dislocation in declarative constructions (e.g., (63a)) as well as scope marking interrogatives ((63b) from Dayal 1994).

(63) a. *it*$_i$ was obvious to John [that *it*$_j$ surprised Mary [that Bill was smart]$_{CPj}$]$_{CPi}$ *English*

b. jaun *kyaa* soctaa hai anu *kyaa* kahegii meri kis-se baat karegii *Hindi*

John *what*$_i$ think AUX [Anu *what*$_j$ say.FUT [Mary who-INS talk do.FUT]$_{CPj}$]$_{CPi}$

'Who does John think Anu will say that Mary will talk to?'

Other parallels between declarative and interrogative dislocation favor resumptive anaphora over variable binding. If resumptive pronouns were bound, then the storage component of their meaning would set them apart from deictic pronouns (section 4.2). Thus, the fact that no language distinguishes resumptive and deictic pronouns favors the resumptive anaphora theory, where a single meaning will do (see (60a–b)). Also, only this theory explains the well-known fact that irreducibly quantified DPs cannot be dislocated (see (64a)). Due to unresolvable type mismatch, they are excluded by the Initial Filter. On the variable binding approach, the exclusion of these DPs would be a mystery.

(64) a. [*one*/**each*/**none* of the boys]$_{DPi}$, I see him$_i$. *English*

b.* jaun kyaa soctaa hai ki *meri-ne anu-ko* dekhaa *Hindi*

John what$_i$ think AUX [that *Mary Anu-ACC* saw]$_{CPi}$

('John thinks that Mary saw Anu.')

Scope marking constructions of the type represented by (64b) in Hindi are also universally ruled out (Dayal 1994). The reason is that the dislocated CP is declarative instead of interrogative (cf. (57b)). Thus, if the matrix CP is interrogative (as CP_0 in (60b)), then the interpretation will fail because of type mismatch: the initial type (t) of the dislocated CP is too low for the requisite type, $\langle\langle\langle t,t\rangle,\langle t,t\rangle\rangle,t\rangle$, to be reached by permitted, mono- or bi-cyclic, semantic transformations. The declarative interpretation is also blocked, by whatever constraint prevents indefinites (*kya* 'thing', section 3.1) from serving as resumptive elements (see, e.g., the Novelty Condition of Heim 1982).

Thus, by analyzing the anaphoric link in scope marking as resumption rather than binding, we can subsume this class of questions under dislocation, explaining the observed declarative/interrogative parallels in a unified manner.

5. QUESTIONS WITH QUANTIFIERS

Questions with functional and list answers present some of the most difficult compositionality problems. Cross-linguistically, this class consists of questions that contain either quantifiers (this section) or multiple *wh*-operators (section 6). In what follows it is shown that the universal operations of the XLS theory account for both subclasses, obviating the need for any construction-specific rules posited in previous accounts (Karttunen & Peters 1980, Higginbotham & May 1980, Groenendijk & Stokhof 1982, Engdahl 1982, 1986, Chierchia 1992, etc).

5.1. *Three-way ambiguity*

Engdahl (1980) noted that a *wh*-question with a quantifier (e.g., (65.Q)) may admit not only an answer that specifies an individual (A1) but also one that specifies a function (A2).

(65) Q: Which woman does every Englishman_1 admire most?

A1: Queen Elizabeth. *individual answer*

A2: His_1 mother. *functional answer*

Karttunen and Peters (1980) further observed that it may also be possible to answer such a question with a list (as in (66) uttered in the context of (67)).

(66) Q: Which customer is each clerk now serving?

A: Clerk 1 is serving A_1, clerk 2, B_1, and clerk 3, C_1. *list answer*

(67)

A_3	B_3	C_3
A_2	B_2	C_2
A_1 : clerk 1	B_1 : clerk 2	C_1 : clerk 3

List answers must be distinguished from functional answers because they are licensed under different conditions. Matrix questions allow list answers only if the quantifier has universal force (thus not in (68b); Karttunen & Peters 1980, Szabolcsi 1993). In contrast, any quantificational force is compatible with a functional answer (see (68a)).

(68) a. Which relative of his_1 does *almost every/no* married man_1 like? (His_1 mother-in-law.)

b. Which customer is *almost every/no* clerk_i now serving? (* list answer)

The licensing condition for functional answers is syntactic. The quantifier must c-command the underlying position of the *wh*-operator—a constraint that fails to be met in (69a) (Chierchia 1991, 1992). This constraint does not apply to list answers—as (69b), which could be uttered in the context of (70), attests (Karttunen & Peters 1980).

(69) a. [Which relative of $\text{his}_1]_2$ [t_2 likes *no married* man_1]? (* functional answer)

b. [Which $\text{clerk}]_2$ [t_2 is now serving *each customer*]? (Clerk 1 is serving A, and clerk 2, B.)

(70) A : clerk 1 B : clerk 2 : clerk 3

Thus, the evidence from possible answers indicates that *wh*-questions with quantifiers allow three distinct readings—individual, functional, and lists—the latter two, subject to characteristic licensing conditions. Since cross-linguistic comparison does not reveal any lexical ambiguity (cf. section 3.4), the source of this three-way ambiguity must be sought elsewhere. I propose that the ambiguity stems from the cross-categorial nature of the key logical items. These include the interrogative determiner (in English *which*) and the part-whole relation that this determiner selects (*of* in (71a–b)).[22] The respective lexical meanings are universally determined by L_{which} (cf. L_{wh}) and $L_{\leq}$.[23]

(71) a. $[_{NPi}\ \textit{which}_{i,\tau}\ N_i\ [_{PP}\ \text{woman}\ \textit{of}_\tau\ t_i/\textit{pro}_i]]$

b. $[_{NPi}\ \textit{which}_{i,e}\ N_i\ [_{PP}\ \text{one}\ \textit{of}_e\ \text{them}_i]$

L_{which} If $\textit{which}_{i,\tau} \in \text{Dom}\mathbb{L}$, then $\mathbb{L}$: $\textit{which}_{i,\tau} \mapsto \langle x_{i,\tau}, \{x_{i,\tau}\}\rangle$

$L_{\leq}$ If $\textit{of}_\tau \in \text{Dom}\mathbb{L}$, then $\mathbb{L}$: $\textit{of}_\tau \mapsto \langle \lambda z_\tau \lambda y_\tau [y_\tau \leq z_\tau], \emptyset\rangle$

L_{prn} If $\alpha \in \{\textit{he}_i, \ldots, \textit{pro}_i\}$ and $\alpha \in \text{Dom}\mathbb{L}$, then $\mathbb{L}$: $\alpha \mapsto \langle x_i, \emptyset\rangle$

Depending on the type index τ, these meanings will either restrict the domain of *wh*-quantification to a contextually salient plurality (yielding an individual answer or a list) or not (relational answer). List answers further involve the cross-categorial distributive operator $\text{DIS}^+_{i,\tau}$ (see Appendix 1, and section 3.6.2). Hence their dependence on universal quantifiers (see L_{each}), whose underlying structure (shown in (72)) is parallel to that of *which*-phrases (see (71)).[24]

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[22] Only singular *which*-phrases will be considered here. See Krifka 1992, Srivastav 1992, and Dayal 1996, on plurals.

[23] It appears that the meanings of all logical vocabulary items—be they type-lifting operators or overt morphemes—are both universal and cross-categorial. E.g., see section 3.3 on $\textit{what}_{i,\tau}$; section 3.4, and Gazdar 1980, on $\textit{and}_\tau$, $\textit{or}_\tau$, and $\textit{OR}_\tau$; Rooth 1985 on $\textit{only}_\tau$, and $\textit{even}_\tau$; and Jacobson 1994, Bittner 1996b, and Sharvit 1996, on $\textit{the}_\tau$, $\textit{every}_\tau$, etc.

[24] Indeed, in Finnish a single ambiguous item *kukin* is used for both ‘which’ and ‘each’ (Karttunen & Peters 1980).

L_{each} If $each_{i,\tau} \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}$: $each_{i,\tau} \mapsto \langle\lambda P_\tau[DIS^+_{i,\tau}(P_\tau)(x_{i,\tau})], \{x_{i,\tau}\}\rangle$

(72) a. $[_{NPi}$ *each*$_{i,\tau}$ N_i $[_{PP}$ woman *of*$_\tau$ t_i/*pro*$_i$]]

b. $[_{NPi}$ *each*$_{i,e}$ N_i $[_{PP}$ one *of*$_e$ them$_i$]

The following sections make these intuitive ideas precise for individual answers, list answers, and functional answers, in turn.

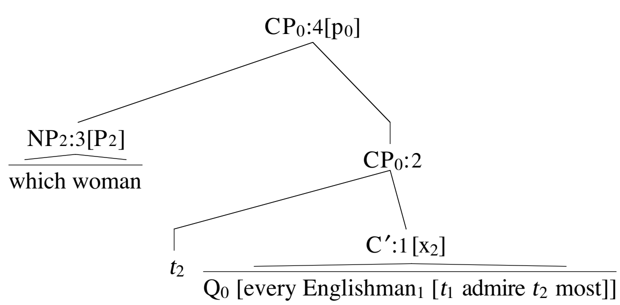
5.2. *Individual answers*

The reading of (73a) (= (65)) that requires an individual answer is represented in (73b). By hypothesis, the head N of the *which*-phrase is empty. Compositionally, this reading can therefore be analyzed as pied-piping, as in (74a–b) (cf. (16)). The interpretation of the *which*-phrase is shown separately to facillitate comparison with alternative readings.

(73) a. Which woman does every Englishman admire most? (Queen Elizabeth.)

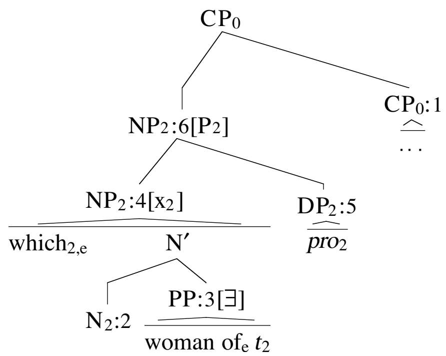
b. $\lambda p[\exists y(wm'(y) \wedge y \leq x_2 \wedge p = \forall x[Emn'(x) \rightarrow adm'(x, y)])]$

(74) a.



1F.	$p_0 = \forall x(Emn'(x) \rightarrow adm'(x, x_2))$	t	$\{x_2, p_0\}$
1B/2K.	$\lambda x_2[p_0 = \forall x(Emn'(x) \rightarrow adm'(x, x_2))]$	$\langle e,t\rangle$	$\{p_0\}$
3.	$\lambda P_2[\exists y(wm'(y) \wedge y \leq x_2 \wedge P_2(y))]$	$\langle\langle e,t\rangle,t\rangle$	Ø
4.	$\lambda p_0[\exists y(wm'(y) \wedge y \leq x_2 \wedge p_0 = \forall x(Emn'(x) \rightarrow adm'(x, y)))]$	$\langle t,t\rangle$	Ø

(74) b.



1.	$\lambda x_2[p_0 = \forall x(\text{Emn}'(x) \rightarrow \text{adm}'(x, x_2))]$	$\langle e,t\rangle$	$\{p_0\}$
2.	P_2	$\langle e,t\rangle$	$\{P_2\}$
3.	$\lambda Q[\exists y(\text{wm}'(y) \wedge y \leq x_2 \wedge Q(y))]$	$\langle\langle e,t\rangle,t\rangle$	$\{x_2\}$
4.	$\lambda x_2[\exists y(\text{wm}'(y) \wedge y \leq x_2 \wedge P_2(y))]$	$\langle e,t\rangle$	$\{P_2\}$
5.	x_2	e	Ø
6.	$\lambda P_2[\exists y(\text{wm}'(y) \wedge y \leq x_2 \wedge P_2(y))]$	$\langle\langle e,t\rangle,t\rangle$	Ø

5.3. *List answers via generalized distributivity*

The cross-categorial meaning assigned by L_{each} licenses distributive readings for questions with universal quantifiers:

(75) a. Which customer is *each* clerk now serving? (Clerk 1 is serving A_1, clerk 2, B_1, and clerk 3, C_1.)

b. $\text{DIS}^{+}_{0,t}(\lambda q[\exists y(\text{clk}'(y) \wedge y \leq x_1 \wedge q = \iota r\exists z[\text{cst}'(z) \wedge z \leq x_2 \wedge r = \text{srv}'(y, z)])])$

(76) a. Which clerk is serving *each* customer? (Clerk 1 is serving A, and clerk 2, B.)

b. $\text{DIS}^{+}_{0,t}(\lambda q[\exists z(\text{cst}'(z) \wedge z \leq x_2 \wedge q = \iota r\exists y[\text{clk}'(y) \wedge y \leq x_1 \wedge r = \text{srv}'(y, z)])])$

These distributive readings yield list answers by the usual maximization operation Ans (section 3.4). For example, for (76a) we predict list answers of the form derived in (77a). In the context of (70), this would reduce to (77b).

(77) a. $[\![\text{Ans}(\text{DIS}^{+}_{0,t}(\lambda q[\exists z(\text{cst}'(z) \wedge z \leq x_2 \wedge q = \iota r\exists y[\text{clk}'(y) \wedge y \leq x_1 \wedge r = \text{srv}'(y, z)])]))]\!]^c$

$= [\![\iota p[p \leq \iota q^*[\mathbf{min}[P_{0,t}]](q) \wedge \forall q(\mathbf{min}[P_{0,t}](q) \wedge q \leq p \rightarrow$

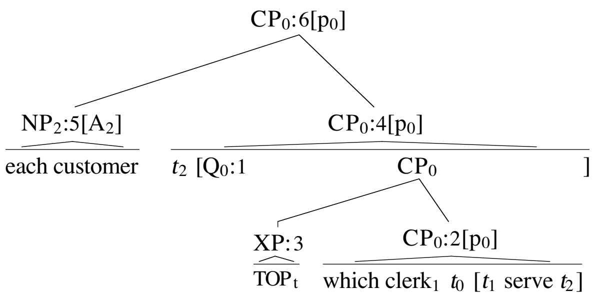
$\exists z(\text{cst}'(z) \wedge z \leq x_2 \wedge q = \iota r\exists y[\text{clk}'(y) \wedge y \leq x_1 \wedge r = \text{srv}'(y, z)])]]\!]^c$

$= \bigcap_a\{[\![\lambda z[\text{Ans}(\lambda r\exists y[\text{clk}'(y) \wedge y \leq x_1 \wedge r = \text{srv}'(y, z)])]]\!]^c(a)\text{: } w_c \in [\![\lambda z[\text{cst}'(z) \wedge z \leq x_2]]\!]^c(a)\}$

b. $[\![\text{srv}']\!]^c(\text{A})(\text{clerk 1}) \cap [\![\text{srv}']\!]^c(\text{B})(\text{clerk 2})$

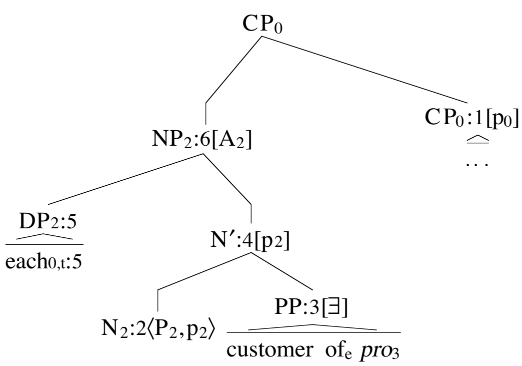
Compositionally, distributive list readings can be derived as in (78a–b) (the interpreted LF of (76a)).

(78) a.



1.	p_0	t	$\{p_0\}$
2.	$\lambda p_0[\exists z(clk'(z) \wedge z \leq x_1 \wedge p_0 = srv'(z, x_2))]$	$\langle t,t\rangle$	$\{x_2\}$
3.	$\lambda W[\iota r W(r)]$	$\langle\langle t,t\rangle,t\rangle$	Ø
4K.	$\lambda x_2[p_0 = \iota r\exists z(clk'(z) \wedge z \leq x_1 \wedge r = srv'(z, x_2))]$	$\langle e,t\rangle$	$\{p_0\}$
4B.	$\lambda p_0\lambda x_2[p_0 = \iota r\exists z(clk'(z) \wedge z \leq x_1 \wedge r = srv'(z, x_2))]$	$\langle t,\langle e,t\rangle\rangle$	Ø
5.	$\lambda A_2[DIS^+_{0,t}(\lambda q[\exists y(cst'(y) \wedge y \leq x_2 \wedge A_2(q)(y))])(p_0)]$	$\langle\langle t,\langle e,t\rangle\rangle,t\rangle$	$\{p_0\}$
6.	$\lambda p_0[DIS^+_{0,t}(\lambda q[\exists y(cst'(y) \wedge y \leq x_2 \wedge q = \iota r\exists z[clk'(z) \wedge z \leq x_1 \wedge r = srv'(z, y)])])(p_0)]$	$\langle t,t\rangle$	Ø

b.



1K.	$\lambda x_2[p_0 = \iota r\exists z(clk'(z) \wedge z \leq x_1 \wedge r = srv'(z, x_2))]$	$\langle e,t\rangle$	$\{p_0\}$
2.	$\lambda P_2[P_2](A_2(p_2))$		
≈	$A_2(p_2)$	$\langle e,t\rangle$	$\{p_2, A_2\}$
3.	$[\exists](\lambda y[cst'(y) \wedge y \leq x_2])$		
≈	$\lambda Q[\exists y(cst'(y) \wedge y \leq x_2 \wedge Q(y))]$	$\langle\langle e,t\rangle,t\rangle$	Ø
4.	$\lambda p_2[\exists y(cst'(y) \wedge y \leq x_2 \wedge A_2(p_2)(y))]$	$\langle t,t\rangle$	$\{A_2\}$
5.	$\lambda P_t[DIS^+_{0,t}(P_t)(p_0)]$	$\langle\langle t,t\rangle,t\rangle$	$\{p_0\}$
6.	$\lambda A_2[DIS^+_{0,t}(\lambda p_2[\exists y(cst'(y) \wedge y \leq x_2 \wedge A_2(p_2)(y))])(p_0)]$	$\langle\langle t,\langle e,t\rangle\rangle,t\rangle$	$\{p_0\}$

The CP structure assigned to (76a) in (78a) is recursive, as for other questions with list readings (see section 6). The interrogative complementizer (Q_0) originates in the lower CP and moves up to the underlyingly empty matrix C°. In its derived position this complementizer licenses a (covert) topic operator in its immediate scope ($\mathbb{L}$: $\mathrm{TOP}_\tau \mapsto \langle\lambda P_\tau[\iota x_\tau P_\tau(x_\tau)], \varnothing\rangle$). It also allows the universal NP to raise to matrix [SPEC, CP], before this NP raises to its final CP-adjoined position. The resulting LF yields the desired list reading, given the universal XLS semantics for empty-headed phrases and the universal lexical constraints L_{which}, $L_{\leq}$ and L_{each}. No construction-specific semantic operations or meanings are required (cf., e.g., Karttunen & Peters 1980, Groenendijk & Stokhof 1982, Chierchia 1992)

5.4. *Functional answers and generalized partitivity*

To extend this account to functional answers I transpose the theory of Engdahl 1986 (see also Groenendijk & Stokhof 1982). In Engdahl's theory, the functional reading of (79a) (= (65)) is assigned the IL translation (79b). Due to the highly intensional type assignments (see (80a)), this analysis yields the correct functional answer—namely, the proposition that is true in a world *w* just in case every Englishman admires whoever is his mother in *w*.

(79) a. Which woman does every Englishman_1 admire most? (His_1 mother.)

b. $\lambda p[\exists W(\forall x[\mathbf{woman'}(W(x))] \wedge {}^\vee p \wedge p = {}^\wedge \forall x[\mathbf{Englishman'}(x) \rightarrow \mathbf{admire'}_*({}^\vee x, {}^\vee W(x))])]$

(80) a. Engdahl 1986 (Montague's 1973 type theory)

VARIABLE	TYPE	DENOTATION
x, y, …	$\langle s,e\rangle$	individual concept
p, q, …	$\langle s,t\rangle$	proposition
W, …	$\langle\langle s,e\rangle,\langle s,e\rangle\rangle$	function from individual concepts to individual concepts

b. This work (Church's 1940 simple type theory)

VARIABLE	TYPE	DENOTATION
x, y, …	e	individual
p, q, …	t	proposition
f, g, …	$\langle e,e\rangle$	function from individuals to individuals

The simple type theory of Church (1940), assumed in this work, restricts intensionality to types built on the propositional type *t*. Thus, individual concepts, which play a crucial role in Engdahl's account, cannot be expressed (see (80b)). Care is therefore required to preserve Engdahl's results concerning the interaction of functional answers with intensional operators (e.g., ˆ in (79b)). As noted by Roger Schwarzschild (p.c.), replacing Engdahl's intensional functional variable (W in (79b)) with an extensional one (f in (81)) yields the wrong proposition—namely, one that is true in *w* iff every Englishman loves the (constant) individual that is his mother in w_c, the world of the context.

(81) $\lambda p[\exists f(\forall z[z \in Dom[f] \rightarrow wm'(f(z)) \wedge f(z) \leq x_2] \wedge p = \forall x[Emn'(x) \rightarrow adm'(x, f(x))])]$

For equivalent results, Engdahl's intensional functional variable (W) must be factored out into an extensional functional variable (f) and an intensional relational variable (R)—as in (82) (the salient reading of (79a)) and (83).

(82) $\lambda p[\exists R(\lambda y\lambda x[wm'(x)] \leq R \wedge p = \exists f(\forall z[z \in Dom[f] \rightarrow R(f(z), z)] \wedge \forall x[Emn'(x) \rightarrow adm'(x, f(x))]))]$

(83) a. Which one of his_1 relatives does Mary *expect* every $Englishman_1$ to admire most? (His_1 mother.)

b. $\lambda p[\exists R(rl\text{-}of' \leq R \wedge p = expect'(m, \exists f(\forall z[z \in Dom[f] \rightarrow R(f(z), z)] \wedge \forall x[Emn'(x) \rightarrow adm'(x, f(x))])))]$

Purely extensional readings of the kind represented by (81) must also be accounted for. Though not salient for (79a), they are clearly available for structurally parallel questions—for example, (84a) can be interpreted as (84b).

(84) a. Which candidate did no $senator_1$ criticize? ($Himself_1$.)

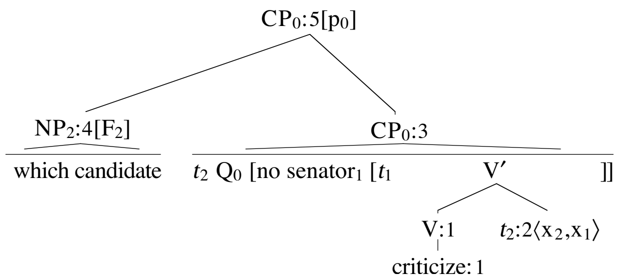
b. $\lambda p[\exists f(\forall z[z \in Dom[f] \rightarrow cnd'(f(z)) \wedge f(z) \leq x_2] \wedge p = \neg\exists x[snr'(x) \wedge crt'(x, f(x))])]$

Compositionally, the required factorization can be accomplished if we assume that a functional *wh*-operator may license a null operator in its local domain (recall disjunctive *wh*-operators in section 3.4). The null operator is absent in purely extensional readings (e.g., in (85a), which represents (84b)), but it is involved in intensional readings, determining the scope of the existential quantifier over functions ((∃f) in (86a–b), assigned to (82)). The rest of the factorization is accomplished by semantic means—to wit, suitable type lifting within the *wh*-operator (as in (85b) and (86b)), and substitution binding applied to the trace, and to the null operator if present (as in (85a) and (86a)).[25]

---

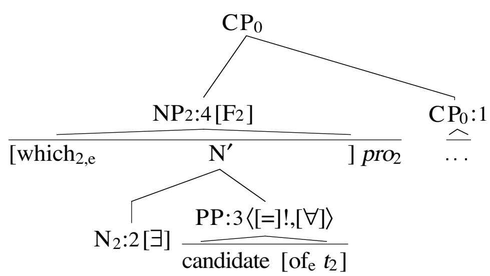
[25] In (83a) the lexical meaning of the pronoun he_1—$\langle x_1, \emptyset\rangle$, by L_{prn}—does not provide any bindable variable. Following Kratzer 1991, I assume that the bound variable reading arises because the pronoun may be deleted at LF. The resulting trace contributes a bindable variable, being interpreted as $\langle x_1, \{x_1\}\rangle$ by rule E. The option of LF deletion, and hence bound variable reading, is syntactically restricted—e.g., a pronoun cannot delete if its antecedent is in a dislocated position (see section 4.3 on resumptive anaphora).

(85) a.



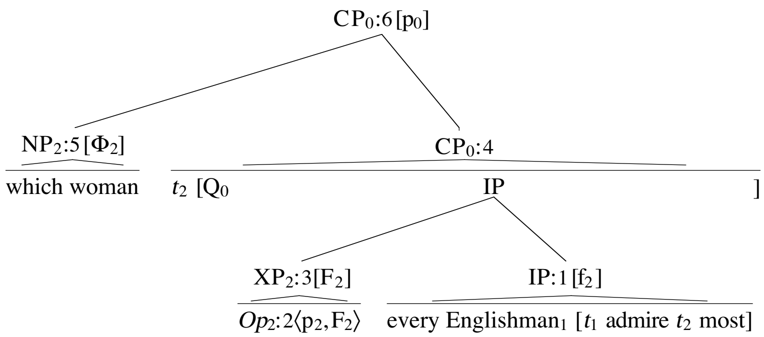
1.	crt′	⟨e,⟨e,t⟩⟩	Ø
2.	$\lambda x_2[x_2](f_2(x_1))$		
≈	$f_2(x_1)$	e	$\{x_1, f_2\}$
3.	$\lambda f_2[p_0 = \neg\exists x(snr'(x) \wedge crt'(x, f_2(x)))]$	⟨⟨e,e⟩,t⟩	$\{p_0\}$
4.	$\lambda F_2[\exists f(\forall z(z \in Dom[f] \rightarrow cnd'(f(z)) \wedge f(z) \leq x_2) \wedge F_2(f))]$	⟨⟨⟨e,e⟩,t⟩,t⟩	Ø
5.	$\lambda p_0[\exists f(\forall z[z \in Dom[f] \rightarrow cnd'(f(z)) \wedge f(z) \leq x_2] \wedge p_0 = \neg\exists x[snr'(x) \wedge crt'(x, f(x))]])]$	⟨t,t⟩	Ø

b.



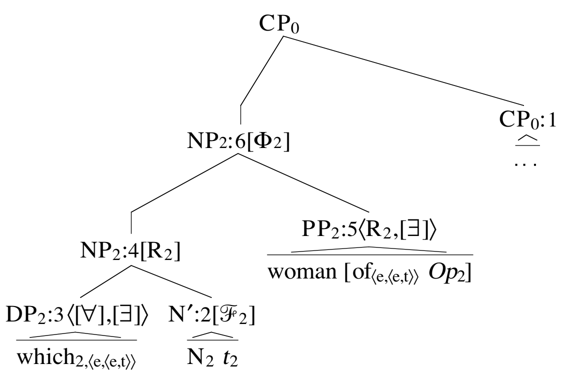
1.	$\lambda f_2[p_0 = \neg\exists x(snr'(x) \wedge crt'(x, f_2(x)))]$	⟨⟨e,e⟩,t⟩	$\{p_0\}$
2.	$[\exists](F_2)$		
≈	$\lambda G[\exists f(F_2(f) \wedge G(f))]$	⟨⟨⟨e,e⟩,t⟩,t⟩	$\{F_2\}$
3.	$[\forall]([=]!(\lambda y[cnd'(y) \wedge y \leq x_2]))$		
≈	$\lambda f[\forall z(z \in Dom[f] \rightarrow cnd'(f(z)) \wedge f(z) \leq x_2)]$	⟨⟨e,e⟩,t⟩	$\{x_2\}$
4.	$\lambda F_2[\exists f(F_2(f) \wedge \forall z(z \in Dom[f] \rightarrow cnd'(f(z)) \wedge f(z) \leq x_2))]$	⟨⟨⟨e,e⟩,t⟩,t⟩	Ø

(86) a.



1.	$\lambda f_2[\forall x(\mathrm{Emn}'(x) \rightarrow \mathrm{adm}'(x, f_2(x)))]$	$\langle\langle e,e\rangle,t\rangle$	$\varnothing$
2.	$\lambda p_2[p_2](\mathscr{F}_2(F_2))$		
≈	$\mathscr{F}_2(F_2)$	t	$\{F_2, \mathscr{F}_2\}$
3.	$\lambda F_2[\mathscr{F}_2(F_2)]$	$\langle\langle\langle e,e\rangle,t\rangle,t\rangle$	$\{\mathscr{F}_2\}$
4.	$\lambda\mathscr{F}_2[p_0 = \mathscr{F}_2(\lambda f_2[\forall x(\mathrm{Emn}'(x) \rightarrow \mathrm{adm}'(x, f_2(x)))])]$	$\langle\langle\langle\langle e,e\rangle,t\rangle,t\rangle,t\rangle$	$\{p_0\}$
5.	$\lambda\Phi_2[\exists R(\lambda z\lambda y[\mathrm{wm}'(y)] \leq R \wedge \Phi_2(\lambda F[\exists f(\forall z[z \in \mathrm{Dom}[f] \rightarrow R(f(z), z)] \wedge F(f))]))]$	$\langle\langle\langle\langle\langle e,e\rangle,t\rangle,t\rangle,t\rangle,t\rangle$	$\varnothing$
6.	$\lambda p_0[\exists R(\lambda z\lambda y[\mathrm{wm}'(y)] \leq R$		
	$\wedge\ p_0 = \exists f(\forall z[z \in \mathrm{Dom}[f] \rightarrow R(f(z), z)] \wedge \forall x[\mathrm{Emn}'(x) \rightarrow \mathrm{adm}'(x, f(x))]))]$	$\langle t,t\rangle$	$\varnothing$

b.



1.	$\lambda\mathscr{F}_2[p_0 = \mathscr{F}_2(\lambda f_2[\neg\exists x(\mathrm{m.mn}'(x) \wedge \mathrm{like}'(x, f_2(x)))])]$	$\langle\langle\langle\langle e,e\rangle,t\rangle,t\rangle,t\rangle$	$\{p_0\}$
2.	$\lambda\mathscr{F}_2[\Phi_2(\mathscr{F}_2)]$	$\langle\langle\langle\langle e,e\rangle,t\rangle,t\rangle,t\rangle$	$\{\Phi_2\}$
3.	$[\exists]([\forall](R_2))$		
≈	$\lambda F[\exists f(\forall z[z \in \mathrm{Dom}[f] \rightarrow R_2(f(z), z)] \wedge F(f))]$	$\langle\langle\langle e,e\rangle,t\rangle,t\rangle$	$\{R_2\}$
4.	$\lambda R_2[\Phi_2(\lambda F[\exists f(\forall z[z \in \mathrm{Dom}[f] \rightarrow R_2(f(z), z)] \wedge F(f))])]$	$\langle\langle e,\langle e,t\rangle\rangle,t\rangle$	$\{\Phi_2\}$
5.	$[\exists](\lambda R_2[[=]!(\mathrm{wm}') \leq R_2])$		
≈	$\lambda\mathscr{R}[\exists R(\lambda z\lambda y[\mathrm{wm}'(y)] \leq R \wedge \mathscr{R}(R))]$	$\langle\langle\langle e,\langle e,t\rangle\rangle,t\rangle,t\rangle$	$\varnothing$
6.	$\lambda\Phi_2[\exists R(\lambda z\lambda y[\mathrm{wm}'(y)] \leq R \wedge \Phi_2(\lambda F[\exists f(\forall z[z \in \mathrm{Dom}[f] \rightarrow R(f(z), z)] \wedge F(f))]))]$	$\langle\langle\langle\langle\langle e,e\rangle,t\rangle,t\rangle,t\rangle,t\rangle$	$\varnothing$

Thus, the insights of Engdahl 1986 can be derived from the universal principles of the XLS theory. In addition, this theory explains why extensional and intensional functional readings differ in regard to the contextual restrictions on the domain of *wh*-quantification. The key is the generalized part-whole relation, ≤. In extensional readings, this is interpreted as a relation between *individuals* ($\leq_e$), yielding restricted quantification over parts of a contextually salient plurality (as in (85b); see also sections 5.2, 5.3, 6). In contrast, in intensional readings, the part-whole relation ranks *intensional relations* according to their information content ($\leq_{\langle e,\langle e,t\rangle\rangle}$). The *wh*-phrase contributes such a relation (in (86b), λzλy[wm′(y)]), and the quantification ranges over the infinite set of relations that are at least as informative.

5.5. *Weak Crossover effects*

Chierchia (1991, 1992) proposed that structural constraints of the kind represented in (87) (recall section 5.1) instantiate the so-called weak crossover phenomenon (Wasow 1972, 1979).

(87) a. Which woman does every man$_i$ love? (His$_i$ mother.)

b. Which woman loves every man$_i$? (*His$_i$ mother.)

The phenomenon was originally noted in the context of bound variable pronouns, where its manifestations include the contrast in (88). Descriptively speaking, the bound variable reading of (88b) is blocked (*) by the weak crossover configuration at LF (89b). The *crossover* arises because the quantified antecedent "moves over" the pronoun, and the effect is *weak* because the pronoun does not c-command the trace.

(88) a. Every man$_i$ loves *his*$_i$ mother.

b.* *His*$_i$ mother loves every man$_i$.

(89) a. every man$_i$ [t_i loves [*his*$_i$ mother]$_j$]

b. * every man$_i$ [[*his*$_i$ mother]$_j$ loves t_i]

Chierchia extends this paradigm to LF representations of functional readings of questions. For example, in his theory (87a–b) would be represented at LF as (90a–b).

(90) a. which woman$_j$ Q [every man$_i$ [t_i love t_j^i]]

b. * which woman$_j$ Q [every man$_i$ [t_j^i love t_i]]

Chierchia's representations involve multiply indexed "functional traces" (t_j^i). His claim is that the syntactic similarity of these traces to nominal arguments with bound variable pronouns (e.g., [*his*$_i$ *mother*]$_j$ in (89b)) is responsible for the parallel behavior with respect to the weak crossover constraint. Implicit in this claim is the view that the constraint at issue is syntactic, since the parallel is located in the syntactic representation rather than its semantic value. To be sure, this view is widespread, as the abundance of syntactic theories of weak crossover attests (Chomsky 1976, Higginbotham 1980, Koopman & Sportiche 1982, Safir 1986, *et al*). However, there are also dissenting voices, which instead locate the constraint in semantics (e.g., Engdahl 1986, Jacobson 1994).

There are reasons to believe that the semantic approach is closer to the truth. In the syntactic GB theory, assumed by Chierchia (1991, 1992) and in this work, there is a large class of constraints on syntactic coindexation relations. This class includes the conditions of the A-Binding Theory, A′-Binding Theory, Control Theory, the Empty Category Principle, and so forth. All of these constraints are clearly syntactic, being stated in purely syntactic terms—c-command, government, subject, clause, etc. Comparison with the weak crossover constraint reveals fundamental differences suggesting that the latter cannot be purely, or even primarily, syntactic.

For example, clearly syntactic constraints are concerned only with syntactic coindexation relations irrespective of their semantic interpretation as variable binding or coreference. Weak crossover, on the other hand, is sensitive to this semantic distinction, as the contrast between (88b) (variable binding) and (91) (coreference) attests.

(91) *His*$_i$ mother loves *John*$_i$.

Weak crossover is also distinguished from true syntactic constraints by its sensitivity to logical type. The weak crossover effect is strongest if the bound variable pronoun is contained in a constituent of the individual type *e* (as in (92a)). In contrast, for other types (e.g., $\langle\langle e,t\rangle,t\rangle$ in (92b), or *t* in (92c)), the effect is much weaker or absent.

(92) a.* [$_{DP}$ *The* woman he$_i$ loved] betrayed [every man I know]$_i$.

b. [$_{DP}$ *At least one* woman he$_i$ loved] betrayed [every man I know]$_i$.

c. [$_{CP}$ *That* he$_i$ was betrayed] had long term effects on [every man I know]$_i$.

Finally, if the syntactic representations that Chierchia assigns to functional traces ($t_j^{i1,\ldots,in}$) were correct, then weak crossover would also be alone in paying attention to the superscripted (argument) indices. The only index that interacts with clearly syntactic constraints is the subscripted (functional) index (as the vast literature on syntactic indices attests).[26] I conclude that only the latter index is present in the syntax, as assumed throughout this work. That is, a functional trace is identified as such by its meaning (e.g., $\langle f_j(x_i), \{x_i, f_j\}\rangle$), not by its syntax ($t_j$). On this view, the explanation for weak crossover must have a semantic component; it cannot be purely syntactic.

The above examples suggest that weak crossover (WCO) is triggered by constituents that introduce a bindable variable u, but whose truth-conditional meaning is more complex than u. This conclusion is based on the facts summarized in Table 1, and it motivates the definition of a *heavy u-term*—intuitively, WCO trigger—that follows.

Table 1 *WCO triggers and look-alikes*

LF constituent	*Translation expression*, ε	*Type of* ε	*Store*	*WCO trigger*?
t_j	x_j	*e*	$\{x_j\}$	*No*, see (87a)
t_j	$f_j(x_i)$	*e*	$\{x_i, f_j\}$	*Yes*, see (87b)
[*the* [woman *he*$_i$ loved]]	$\iota y[wm'(y) \wedge love'(x_i, y)]$	*e*	$\{x_i\}$	*Yes*, see (92a)
[*the* [woman *he*$_i$ loved]]	$\iota y[wm'(y) \wedge love'(x_i, y)]$	*e*	Ø	*No*, cf. (91)
[*at least one* [woman *he*$_i$ loved]]	$\lambda P[\exists y(wm'(y) \wedge love'(x_i, y) \wedge P(y))]$	$\langle\langle e,t\rangle,t\rangle$	$\{x_i\}$	*No*, see (92b)

D7. Let $\mathbb{B} = \langle \mathbb{L}, \mathbb{T}\rangle$ be an interpretive base for an LF Λ; *A*, a node in Λ; and $u \in Var_\tau$. We say that (i) *A* is a *u-term* (based on $\mathbb{B}$), iff $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \varepsilon, \sigma\rangle$, $\varepsilon \in ME_\tau$ and $u \in \sigma$, (ii) *A* is a *light u-term* (based on $\mathbb{B}$), iff $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle u, \{u\}\rangle$, and (iii) *A* is a *heavy u-term* (based on $\mathbb{B}$), iff *A* is a *u*-term (based on $\mathbb{B}$) that is not light.

The weak crossover constraint (WCO) can be stated in terms of this semantic notion. Unlike a true semantic filter, it is not inviolable (cf. section 3). Instead, it appears to reflect a processing preference for semantically "balanced" LFs.

WCO A heavy *u*-term whose sister contains a light *u*-term must be contained in the sister of a light *u*-term.

The excluded bound variable readings are represented by unbalanced interpreted LFs. For example, in (89b) the heavy x_i-term, [*his*$_i$ *mother*]$_j$, is not balanced by any light x_i-term higher up—as it is, in the acceptable (89a), by the subject trace ($t_i \rightsquigarrow \langle x_i, \{x_i\}\rangle$). The parallel with functional readings of questions is captured in the semantics. By virtue of its interpretation, a functional trace (second t_j in Table 1) is classified as a heavy *u*-term (here, $u = x_i$). In

[26] Chierchia would alternatively allow his argument indices to be part of a complex trace-internal structure. This only aggravates the problem, since the question then becomes why syntactic principles detect *neither* these extra indices *nor* the extra structure.

LFs of the kind represented in (90b)—with Chierchia's t_j^i replaced by conventional t_j—the functional trace induces semantic imbalance, on a par with overt WCO-triggers ([*his*$_i$ *mother*]$_j$ in (89b), [*the woman he*$_i$ *loved*]$_j$ in (92a), etc).

6. LIST ANSWERS TO MULTIPLE WH-QUESTIONS

6.1. *Coverage and uniqueness*

Answers to questions with multiple *wh*-quantifiers pair elements drawn from the domains of these quantifiers. Typically, the expected answer is a list of several pairs, as in (93). Under certain conditions (Wachowich 1974, 1975, Pope 1976, Bolinger 1978, *et al*), a single pair may also be acceptable, as in (94).

(93) Q: Which course was taught by which professor last semester?

A: Semantics was taught by Prof. A, Syntax, by Prof. B, and Phonology, by Prof. C. *list answer*

(94) Q: Which girl hit which boy first?

A: Mary hit Johnny first. *single pair*

Given the maximization theory of answers (section 3), only the single pair reading is captured by the standard Hamblin-Karttunen semantics. For example, on the reading of (94.Q) represented in (95), the answer will be a proposition of the form '*a* hit *b*,' where *a* is a girl and *b*, a boy (see (96)). In a context where several propositions of this form are true, none of them will qualify as most informative. Thus, this reading of (94.Q) will be infelicitous.

(95) $\lambda p[\exists z(\text{boy}'(z) \wedge z \leq x_2 \wedge \exists y[\text{girl}'(y) \wedge y \leq x_1 \wedge p = \text{hit}'(y, z)])]$

(96) $[\![\text{Ans}(\lambda p[\exists z(\text{boy}'(z) \wedge z \leq x_2 \wedge \exists y[\text{girl}'(y) \wedge y \leq x_1 \wedge p = \text{hit}'(y, z)])])]\!]^c$

$= \max_{\leq t}(\{[\![\text{hit}']\!]^c(a, b): w_c \in [\![\text{hit}']\!]^c(a, b) \cap [\![\lambda y[\text{grl}'(y) \wedge y \leq x_1]]\!]^c(a) \cap [\![\lambda z[\text{boy}'(z) \wedge z \leq x_2]]\!]^c(b)\})$

Of course, the standard view is that answers are obtained not by maximization, but rather by summation—as in (97). (95) could then represent the list reading because the answer could be a conjunction 'a_1 hit b_1, a_2 hit b_2, etc'.

(97) $[\![\text{Ans}_{\oplus}(\lambda p[\exists z(\text{boy}'(z) \wedge z \leq x_2 \wedge \exists y[\text{girl}'(y) \wedge y \leq x_1 \wedge p = \text{hit}'(y, z)])])]\!]^c$

$= \sup_{\leq t}(\{[\![\text{hit}']\!]^c(a, b): w_c \in [\![\text{hit}']\!]^c(a, b) \cap [\![\lambda y[\text{grl}'(y) \wedge y \leq x_1]]\!]^c(a) \cap [\![\lambda z[\text{boy}'(z) \wedge z \leq x_2]]\!]^c(b)\})$

The problem is that this representation is too permissive. It fails to account for the evidence that list answers to multiple *wh*-questions involve functional dependencies (Dayal 1996). The S-Structure relations predictably determine which *wh*-operator contributes the *domain set* of the dependency, and which contributes the *range set* (see below). A complete list answer is expected to satisfy the following two requirements concerned with *coverage* (COV, discussed under different terms in Comorovski 1989, 1996, and Kiss 1993) and *uniqueness* (UNI, see Dayal 1996).

COV A complete list answer must pair each element from the domain set.

UNI Each element in the domain set must be paired with a unique element from the range set.

In a monoclausal question the domain set is determined by the *wh*-operator that is highest at S-Structure, and the range set, by the operator that is lowest. Thus, if the contextually relevant courses are Syntax, Semantics, and Phonology, and the professors are A, B, and C, the question in (98) (repeated from (93)) readily admits list answers like A1 and A2, which satisfy COV as well as UNI. In contrast, the answer A3—which fails to satisfy COV—is intuitively incomplete, whereas A4—a violation of UNI—appears to deny the presupposition of this question.

(98) Q: *Which course*$_{\text{Dom}}$ was taught by *which professor*$_{\text{Ran}}$ last semester?

A1: Semantics was taught by Prof. A, Syntax, by Prof. B, and Phonology, by Prof. C.

A2: Semantics was taught by Prof. A, Syntax, by Prof. B, and Phonology, by Prof. A.

A3: Semantics was taught by Prof. A, and Syntax, by Prof. B. (*incomplete*)

A4: Semantics was taught by Prof. A and Prof. B, and Syntax, by Prof. B and Prof. C, and Phonology, by Prof. C. (*denial of presupposition of* Q)

Though presuppositions can be denied, their presence is revealed by the intuitive oddity of questions with odd presuppositions—as the sample in (99) attests.

(99) a. # Which course was attended by which student last semester?

(*Presuppose*: Each course was attended by a unique student.)

b. # Which presidential candidate gave which speech during the campaign?

(*Presuppose*: Each candidate gave a unique speech during the campaign.)

List answers to biclausal questions are also constrained by COV and UNI. To this extent, the pattern is the same as for monoclausal questions. However, the relation between the S-Structure hierarchy of the *wh*-operators and their semantic import is reversed. In biclausal questions, it is the *lowest* operator (*which prize* in (100)) which determines the domain set, and the highest operator (*which teacher*) which determines the range set.

(100) Q: *Which teacher*$_{\text{Ran}}$ knows [which student won *which prize*$_{\text{Dom}}$]?

A1: Ms. A knows which student won the math prize, and Mr. B knows which student won the poetry prize.

A2: Ms. A knows which student won the math prize, and she also knows which student won the poetry prize.

A3: Ms. A knows which student won the math prize. (*incomplete*)

A4: Ms. A and Mr. B know which student won the math prize, and Mr. B and Mr. C know which student won the poetry prize. (*denial of presupposition of* Q)

This reversal suggests that the explanation for COV and UNI lies in the map from syntax to semantics.

6.2. *Local lists as functional answers*

Dayal (1996) accounts for COV and UNI by building a functional dependency into the meaning of the question (as in (101b), which represents (101a)). She assumes that answers are determined by maximization—an assumption that can be justified on independent grounds (see section 3)—and thus correctly predicts list answers that satisfy these semantic constraints (e.g., (101c), if the students are John and Mary, and the prizes include those mentioned here).

(101) a. Which student won which prize?

b. $\lambda p[\exists f(\text{Dom } f = \text{std}' \wedge \forall y[\text{prz}'(f(y))] \,\&\, p = \bigcap\lambda q[\exists y(\text{std}'(y) \wedge q = {}^\wedge\text{win}'(y, f(y)))])]$

c. Mary won the math prize and John won the poetry prize.

To derive these question meanings compositionally, Dayal further adopts Chierchia’s (1992) syntactic theory of functional traces (t_5^1 in the LF representation (102a)) and posits a construction-specific meaning for the interrogative complementizer (102b).

(102) a. $[_{\text{CP0}}$ which prize$_5$ $[_{\text{CP0}}$ which student$_1$ C^0_{+wh} $[_{\text{IP}}$ t_1 win $t_5^1]]]$

b. $C^0_{+wh} \rightsquigarrow \langle\lambda S\lambda Q\lambda P[\exists f(\text{Dom } f = Q \wedge \forall y P(f(y)) \wedge p_0 = \bigcap\lambda q[\exists y(Q(y) \wedge q = {}^\wedge S(y)(f(y)))])], \{p_0\}\rangle$

(102b) is essentially the meaning of the question, modulo three λ-bound variables: a relational variable (S) and two property variables (Q and P). These serve as place-holders, in order, for the IP, the domain *wh*-operator, and the range *wh*-operator. The construction-specific meaning (102b) is therefore crucial to Dayal's account of COV and UNI.

The two parts of Dayal's theory are largely independent, and there is evidence that the second half cannot be correct. In languages with overt interrogative complementizers (Lakhota, Japanese, Yoruba, etc), the same item appears in multiple *wh*-questions as in all other questions. This would be quite a coincidence if this complementizer were ambiguous as Dayal claims. Compounding the problem, further lexical ambiguity would have to be posited to account for more complex questions—including, for example, three more complementizer meanings for (103a–c).

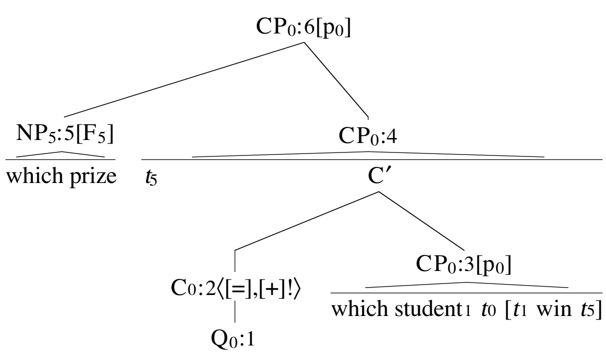
(103) a. Which student$_i$ displayed which one of *her*$_i$ paintings?

b. Which professor$_i$ assigned which (one) of *his*$_i$ articles to which (one) of *his*$_i$ students?

c. Which actress$_i$ thanked which of *her*$_i$ reviewers$_j$ for which (one) of *his*$_j$ reviews (first)?

In the XLS theory, an interrogative complementizer can only have one meaning (L_Q). However, it may project a recursive CP structure (see sections 3.2, 4.3, 5.3). Therefore, a multiple *wh*-question can be interpreted as follows.

(104)



1L/2K.	p_0	t	$\{p_0\}$
$3[p_0]$.	$\lambda p_0[\exists y(std'(y) \wedge y \leq x_1 \wedge p_0 = win'(y, f_5(y))]$	⟨t,t⟩	$\{f_5\}$
2T.	$[+]!([=](p_0))$		
≈	$\lambda f_t[p_0 = \oplus[f_t]]$	⟨⟨t,t⟩,t⟩	$\{p_0\}$
4.	$\lambda f_5[p_0 = \oplus\lambda q[\exists y(std'(y) \wedge y \leq x_1 \wedge q = win'(y, f_5(y))]]$	⟨⟨e,e⟩,t⟩	$\{p_0\}$
5.	$\lambda F_5[\exists f(\forall z[z \in Dom[f] \rightarrow prz'(f(z)) \wedge f(z) \leq x_5] \wedge F_5(f))]$	⟨⟨⟨e,e⟩,t⟩,t⟩	Ø
6.	$\lambda p_0[\exists f(\forall z[z \in Dom[f] \rightarrow prz'(f(z)) \wedge f(z) \leq x_5]$ $\wedge\ p_0 = \oplus\lambda q[\exists y(std'(y) \wedge y \leq x_1 \wedge q = win'(y, f(y))])]$	⟨t,t⟩	Ø

On this view, questions with multiple *wh*-operators are semantically parallel to declarative sentences with multiple occurrences of *same* or *different* (section 3.6.2). Both constructions involve the cross-categorial summation operation $\oplus$ (Appendix 1)—the former in the propositional domain, where $\oplus$ amounts to $\cap$ and derives a conjunctive list (as in (104)), the latter in the individual domain, where $\oplus$ forms a plurality (as in (42)). There are also similarities to questions with quantifiers, on their list readings (section 5.3) as well as extensional functional readings (section 5.4). For example, in regard to list readings, the type lifting operator [+]! which introduces the summation operation in (104) is semantically on a par with the universal quantifier which is the source of the distributivity operator in (78).

Due to the WCO constraint, the functional dependency (f_5) can only be introduced by the object trace (t_5), as in Dayal's theory. This, in turn, implies that the antecedent *wh*-operator (NP_5) determines the range set—yielding UNI as in (104). No lexical stipulations, such as (102b), are required. The analysis in (104) also accounts for COV, given the intuitively plausible meaning postulate R∃ (necessarily, if *a* hit *b*, then *a* and *b* exist; likewise for winning, etc).

R∃ $\forall x \forall y(\text{exist}'(x) \wedge \text{exist}'(y) \leq R(x, y))$, where $R \in \{\text{hit}', \text{win}', \ldots\} \subseteq ME_{\langle e,\langle e,t\rangle\rangle}$

To see this, consider a context *c* where the relevant students—that is, the students in the plurality $g_c(x_1)$—are John and Mary. As usual, the (true and complete) answer to (104) is determined by maximization, as in (105).

(105) $[\![\text{Ans}(\lambda p_0[\exists f(\forall z[z \in \text{Dom}[f] \rightarrow \text{prz}'(f(z)) \wedge f(z) \leq x_5]$

$\wedge\ p_0 = \oplus\lambda q[\exists y(\text{std}'(y) \wedge y \leq x_1 \wedge q = \text{win}'(y, f(y)))])])]\!]^c$

$= [\![\iota p \exists f(\forall z[z \in \text{Dom}[f] \rightarrow \text{prz}'(f(z)) \wedge f(z) \leq x_5]$

$\wedge\ p = \oplus\lambda q[\exists y(\text{std}'(y) \wedge y \leq x_1 \wedge q = \text{win}'(y, f(y)))])]\!]^c$

$= \max_{\leq t}(\{\sup_{\leq t}\{[\![\text{win}']\!]^c(a, f(a)): w_c \in [\![\text{win}']\!]^c(a, f(a))\ \&\ w_c \in [\![\lambda y[\text{std}'(y) \wedge y \leq x_1]]\!]^c(a)\}:$

$w_c \in [\![\lambda f[\forall z[z \in \text{Dom}[f] \rightarrow \text{prz}'(f(z)) \wedge f(z) \leq x_5]]]\!]^c(f)\})$

$= \max_{\leq t}(\{[\![\text{win}']\!]^c(\text{John}, f(\text{John})) \cap [\![\text{win}']\!]^c(\text{Mary}, f(\text{Mary})):$

$w_c \in [\![\text{win}']\!]^c(\text{John}, f(\text{John})) \cap [\![\text{win}']\!]^c(\text{Mary}, f(\text{Mary}))\ \&$

$\text{for all } a \in \Delta_e[\text{if } f(a) \neq \dagger, \text{then } w_c \in [\![\text{prz}']\!]^c(f(a))\ \&\ f(a) \leq_e g_c(x_5)]\})$

Let *a* be one of the students, John or Mary, and let f_0 be a function whose domain does not include *a*—that is, f_0: $a \mapsto \dagger$ (Appendix 1). Since † does not exist in any world (Appendix 1, following Kaplan 1978), and since only existing entities can be won (meaning postulate (R_ι)), the conjunct $[\![\text{win}']\!]^c(a, f_0(a))$ must be false in the world of the context (w_c). But then, so must be the entire conjunctive list based on f_0. Thus, the truth requirement in the definition of the answer (built into the semantics of ι, see Appendix 1) can only be met by a conjunctive list that is based on a function whose domain includes all of the contextually relevant students—i.e., a list that satisfies COV.

This theory applies equally well to more complex questions exemplified in (103). For instance, (103b) and (103c) can be interpreted as in (106) and (107), respectively.

(106) a. [which one of his$_i$ students$_k$ [which one of his$_i$ articles$_j$ Q_n [which professor$_i$ t_n [$_{IP}$ t_i assign t_j to t_k]]$_n$]$_n$]$_n$

b. $\lambda p_n[\exists g(\forall z[z \in Dom[g] \longrightarrow std'(g(z)) \wedge R_k(g(z), z) \wedge z \leq x_k]$

$\wedge\ \exists f(\forall y[y \in Dom[f] \longrightarrow art'(f(y)) \wedge R_j(f(y), y) \wedge y \leq x_j]$

$\wedge\ p_n = \oplus\lambda q[\exists x(prf'(x) \wedge q = \text{assign-to}'(x, f(x), g(x)))])])]$

(107) a. [which one of his$_i$ articles$_k$ [which one of her$_i$ reviewers$_j$ Q_n [$_{CPn}$ which actress$_i$ t_n [$_{IP}$ t_i thank t_j for t_k]]$_n$]$_n$]$_n$

b. $\lambda p_n[\exists g(\forall z[z \in Dom[g] \longrightarrow art'(g(z)) \wedge R_k(g(z), z) \wedge z \leq x_k]$

$\wedge\ \exists f(\forall y[y \in Dom[f] \longrightarrow rvr'(f(y)) \wedge R_j(f(y), y) \wedge y \leq x_j]$

$\wedge\ p_n = \oplus\lambda q[\exists x(act'(x) \wedge q = \text{thank-for}'(x, f(x), g(f(x))))])])]$

The derivation proceeds as in (104), modulo adjustments motivated on independent grounds in section 3.6.1 (on possessed DPs), footnote 25 (on bound pronouns), and section 4.3 (on substitution binding; note esp. 5B in (61)).

6.3. *Long distance lists as indirect functional dependencies*

Long distance list answers are typically elicited by questions exhibiting the *wh-triangle* configuration (Dayal 1996). That is, there is one *wh*-operator in the matrix clause, and at least two in the immediately subordinate clause.

(108) *Which* teacher knows [*which* student won *which* prize]?

Questions of this kind have been extensively studied (Baker 1968, Karttunen 1977, Dayal 1996, etc). However, none of the proposed analyses yields list answers that respect the constraints of COV and UNI (section 6.1). Indeed, given the maximization approach to answers—motivated in Dayal 1996 and in this work—none of these analyses even predicts that the answer will be a list. For example, the standard theory of Karttunen (1977)—where the *in situ* *wh*-operator undergoes long movement at LF (as *which prize* in (109a))—predicts only single pair answers (e.g., $[\![(109c)]\!]^c = [\![\text{Ans}(109b)]\!]^c$ for a suitable context *c*). The same single pair answers are predicted by the indirect dependency theory of Dayal (1996)—where the entire embedded question moves locally (as CP_5 in (110a)).

(109) a. $[_{CP0}$ *wh* prize_3 $[_{CP0}$*wh* teacher_1 Q_0 t_1 know $[_{CP5}$ *wh* student_2 Q_5 t_2 win $t_3]]]$

b. $\lambda p_0[\exists z(prz'(z) \wedge \exists x[tch'(x) \wedge p_0 = know'(x, Ans(\lambda r[\exists y(std'(y) \wedge r = win'(y, z))]))])]$

c. Ms. A knows which student won the math prize.

(110) a. $[_{CP5}$ *wh* $\text{prize}_{3,echo}$ $[_{CP5}$ *wh* student_2 Q_5 t_2 win $t_3]]$ $[_{CP0}$*wh* teacher_1 Q_0 t_1 know $t_5]$

b. $\lambda p_0[\exists W(\exists z[prz'(z) \wedge W = \lambda r[\exists y(std'(y) \wedge r = win'(y, z))]] \wedge \exists x[tch'(x) \wedge p_0 = know'(x, Ans(W))])]$

$\approx$ $\lambda p_0[\exists z(prz'(z) \wedge \exists x[tch'(x) \wedge p_0 = know'(x, Ans(\lambda r[\exists y(std'(y) \wedge r = win'(y, z))]))])]$

c. Ms. A knows which student won the math prize.

Fortunately, the desired list answers (with multiple pairs, as in (111c)) can be derived, via (111b), from the LF in (111a). This LF is like Dayal's (110a), modulo by now familiar covert elements (sections 3.4, 4.3, 5.3).

(111) a. $[_{CP5}$ ***Op***$_0$ *wh prize*$_3$ Q_5-$[$***Op***$_5]_{C0}$ $[_{CP0}$ **TOP** *wh* student_2 t_0 t_2 win $t_3]]$ $[_{CP0}$ t_5 Q_0 $[$*wh teacher*$_1$ t_0 t_1 know $t_5]]$

b. $\lambda p_0[\exists f_t(\forall p[p \in Dom[f_t] \rightarrow \exists x(tch'(x) \wedge x \leq x_1 \wedge f_t(p) = know'(x, p))] \wedge$

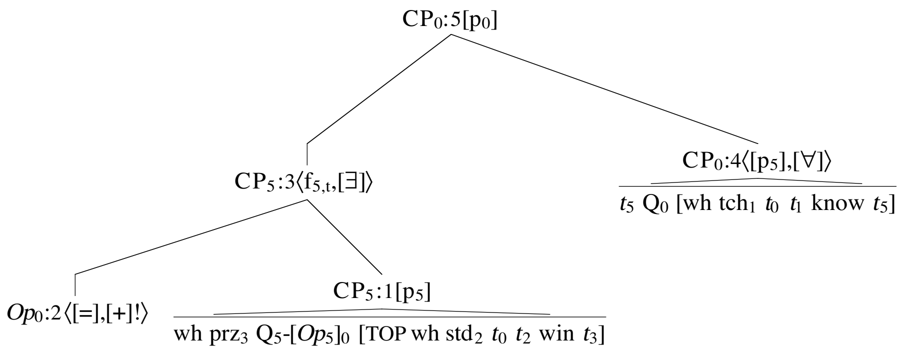
$p_0 = \oplus\lambda q[\exists z(prz'(z) \wedge z \leq x_3 \wedge q = f_t(Ans(\exists y[std'(y) \wedge y \leq x_2 \wedge r = win'(y, z)])))])]$

c. Ms. A knows which student won the math prize, and Mr. B knows which student won the poetry prize.

On this view, long distance lists arise indirectly, via a functional dependency in the propositional domain. The direct dependency (f_t) is local: it maps a proposition π onto a proposition of the form '*a* knows π', where *a* is a teacher. The appearance of a non-local dependency between individuals arises because in each conjunct (q) of the predicted answer (p_0), the propositional argument of this dependency is linked to a unique prize—being the answer to a question 'Which student won *b*?,' where *b* is a prize. The conjunct itself is the value assigned to this argument—that is, it is a proposition of the form '*a* knows (the answer to the question) which student won *b*', where *a* is a teacher. Hence the appearance of a non-local functional dependency from prizes (COV) to teachers (UNI).

The compositional derivation (112) proceeds essentially as for local lists (see also sections 3.4, 4.3, and 5.3). This, of course, is expected since the direct functional dependency—in the propositional domain—is in fact local.

(112)



1.	$\lambda p_5[\exists z(prz'(z) \wedge z \leq x_3 \wedge p_5 = f_{5,t}(\iota r \exists y[std'(y) \wedge y \leq x_2 \wedge r = win'(y, z)]))]$	$\langle t,t \rangle$	$\{f_{5,t}\}$
2.	$[+]!([=](p_0)$		
≈	$\lambda f_t[p_0 = \oplus f_t]$	$\langle\langle t,t \rangle,t \rangle$	$\{p_0\}$
3.	$[\exists](\lambda f_{5,t}[p_0 = \oplus\lambda q[\exists z(prz'(z) \wedge z \leq x_3 \wedge q = f_{5,t}(\iota r \exists y[std'(y) \wedge y \leq x_2 \wedge r = win'(y, z)]))]])$		
≈	$\lambda F_t[\exists f_t(F_t(f_t)$		
	$\wedge\ p_0 = \oplus\lambda q[\exists z(prz'(z) \wedge z \leq x_3 \wedge q = f_t(\iota r \exists y[std'(y) \wedge y \leq x_2 \wedge r = win'(y, z)]))])]$	$\langle\langle\langle t,t \rangle,t \rangle,t \rangle$	$\{p_0\}$
4.	$[\forall](\lambda p_5 \lambda p_0[\exists x(tch'(x) \wedge x \leq x_1 \wedge p_0 = know'(x, p_5))])$		
≈	$\lambda f_t[\forall p(p \in Dom[f_t] \rightarrow \exists x(tch'(x) \wedge x \leq x_1 \wedge f_t(p) = know'(x, p)))]$	$\langle\langle t,t \rangle,t \rangle$	$\varnothing$
5.	$\lambda p_0[\exists f_t(\forall p[p \in Dom[f_t] \rightarrow \exists x(tch'(x) \wedge x \leq x_1 \wedge f_t(p) = know'(x, p))]$		
	$\wedge\ p_0 = \oplus\lambda q[\exists z(prz'(z) \wedge z \leq x_3 \wedge q = f_t(\iota r \exists y[std'(y) \wedge y \leq x_2 \wedge r = win'(y, z)]))])]$	$\langle t,t \rangle$	$\varnothing$

The shift from an individual dependency (monoclausal questions) to a propositional dependency (biclausal questions) requires certain realignments in the map from syntax to semantics. The semantic role that in monoclausal questions is played by the interrogative complementizer (Q_0 in (113a), repeated from (104)) is taken over by a null operator adjoined to the indirect question (Op_0 in (113b), repeated from (112)). Consequently, the sisters of these elements play semantically parallel roles, as do their aunts (that is, sisters of mother nodes). To be precise, the former account for COV (as in (113), recall (105)) and the latter, for UNI (as in (114)).

(113) *Coverage*

a. $\mathbf{Q}_0$ [*which student*$_1$ t_0 [$_{IP}$ t_1 win t_5]]

⤳ $p_0 = \oplus\lambda q[\exists y(std'(y) \wedge y \leq x_1 \wedge q = win'(y, f_{5,e}(y))]$

b. $\boldsymbol{Op}_0$ [*which prize*$_1$ Q_5-[Op_5]$_0$ [TOP which student$_1$ t_0 [$_{IP}$ t_1 win t_2]]]

⤳ $p_0 = \oplus\lambda q[\exists z(prz'(z) \wedge z \leq x_3 \wedge q = f_{5,t}(\iota r \exists y[std'(y) \wedge y \leq x_2 \wedge r = win'(y, z)]))]$

(114) *Uniqueness*

a. $[_{NP5} \ldots [_{PP}\ \textit{prize}\ \text{of}\ t_5]]$

$\rightsquigarrow$ $[\forall]([=]!(\lambda z[\text{prz}'(z) \wedge z \leq x_5]))$

$\lambda f_e[\forall z(z \in \text{Dom}[f_e] \longrightarrow \text{prz}'(f_e(z)) \wedge f_e(z) \leq x_5)]$

b. $[_{CP0}\ t_5\ Q_0\ [_{CP0}\ \textit{which teacher}_1\ t_0\ [_{IP}\ t_1\ \text{know}\ t_5]]]$

$\rightsquigarrow$ $[\forall](\lambda p_5 \lambda p_0[\exists x(\text{tch}'(x) \wedge x \leq x_1 \wedge p_0 = \text{know}'(x, p_5))])$

$\lambda f_t[\forall p[p \in \text{Dom}[f_t] \longrightarrow \exists x(\text{tch}'(x) \wedge x \leq x_1 \wedge f_t(p) = \text{know}'(x, p)))]$

These realignments explain the reversal, between monoclausal and biclausal questions, of the relation between the S-Structure positions of *wh*-operators and the roles that they (indirectly) play *vis-à-vis* COV and UNI (section 6.1).

The indirect functional dependency theory derives these results in addition to the correct results of Dayal 1996. Thus, both theories are supported by the cross-linguistic evidence that Dayal presents that long distance list answers are primarily licensed in a configuration that she dubs the *wh-triangle*.[27] That is, the matrix verb has an interrogative complement with at least two *wh*-operators, and it further takes another *wh*-operator as a higher argument. The verb can also take propositional complements (as *know* in (108)). In terms of this theory, the verb denotes an attitude to propositions, which may be answers derived by TOP_t (≈ Ans, as in (112); cf. Heim 1994). The number and distribution of the *wh*-operators reflect the prerequisites of the proposed compositional derivation.

The evidence for the *wh*-triangle requirement includes Mahajan's (1990) observation that list answers are blocked if the matrix *wh*-operator is separated from the indirect question complement by an intervening clause, as in (115).

(115) Which teacher$_1$ did [John *say* [t_1 knows [$_{CP5}$ which student won which prize]]]?

This is a problem for direct dependency theories (e.g., Karttunen 1977), which allow (the equivalent of) non-local movement at LF. In contrast, maintaining locality at LF by positing an indirect dependency predicts this constraint.

Further evidence comes from languages where *wh*-operators are *in situ* at S-Structure (as in Hindi (116) and Japanese (117)). What these languages show is that, even if embedded *wh*-operators cannot take matrix scope (as the (a) sentences attest), list answers are still available in the *wh*-triangle configuration (e.g., the questions in (b)).

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[27] See Dayal 1996 for a discussion of some exceptions.

(116) *Hindi* (Dayal 1996)

a. anu _ jaantii hai ki *kyaa* karnaa hai

Anu t_n know AUX [that *what* do-INF AUX]$_n$

'Anu knows what is to be done.' (NOT 'What is such that Anu knows that it has to be done?')

b. *kaun* laRkaa _ jaantaa hai ki merii-ne *kahaaN* *kaunsii* kitaab khariidii

which boy t_n know AUX [that Mary-ERG *where* *which* book bought]$_n$

'Which boy knows where Mary bought which book?' (OK list answer)

(117) *Japanese* (Dayal 1996)

a. Tanaka-kun-wa Mary-ga *doko*-de *dono* hon-o kat-ta ka sitte-imasu ka ?

Tanaka-HON-TOP [Mary-NOM *where*-OBL *which* book-ACC buy-PST Q] know Q

'Does Tanaka know where Mary bought which book?'

(NOT 'Which book does Tanaka know where Mary bought?')

b. *dono* sensei-wa Mary-ga *doko*-de *dono* hon-o kat-ta *ka* sitte-imasu *ka* ?

which professor-TOP [Mary-NOM *where*-OBL *which* book-ACC buy-PST Q] know Q

'Which professor knows where Mary bought which book?' (OK list answer)

The lack of correlation is a problem for the direct dependency view. Indirect dependency theories fare better. The (a)-sentences are just further evidence for maintaining locality at LF. The availability of list answers to *wh*-triangle questions is compatible with the locality constraints. It relies only on local extraposition movement taking place either overtly at S-Structure (as in Hindi (116b)) or covertly at LF (as in English (108) and Japanese (117b)). Positing an indirect *functional* dependency further makes it possible to unify the semantic account of multiple *wh*-questions, maintaining the independently motivated maximization approach to answers (Ans := $\lambda W[\iota q W(q)]$, section 3.5), and explaining the differential behavior of mono- and biclausal questions in relation to COV and UNI.

7. CONCLUSION

In a nutshell, the conclusion is in Appendix 2. The XLS theory presented there, together with the applications in Bittner 1994a,b, and in this work, constitute the beginning of an existence proof that it is indeed possible to formulate a universal semantic theory that applies to questions and declaratives alike (see Goldberg 1995 for some potential problems, and Bittner 1996a for possible solutions). According to this theory, the semantic component of the Universal Grammar (i.e., XLS) includes all of the compositional operations and semantic filters, as well as the possible meanings for "logical" vocabulary items. Thus, what a child needs to acquire in semantics are just the language-specific aspects of the Lexicon—primarily, "non-logical" lexical items and idioms. The following remarks are intended to clarify the relation between this universal framework and construction-specific semantic theories.

Since the pioneering work of Montague (1973) it has been standard practice to include construction-specific information in the semantic rules in order to generate the desired results or to block undesirable alternatives. In the XLS theory these two tasks are factored out and reassigned to two distinct components—roughly speaking, the translation component and the filtering component, respectively—both of which are universal.

As a solution to problems of overgeneration, semantic filters—supplemented with universal constraints on semantic transformations (see section 3)—seem to be empirically competitive to construction-specific stipulations in the semantic rules. Theoretically, of course, they are of greater interest because they seek to identify universal causes of semantic unacceptability, not just their construction-specific manifestations.

But it is in the generative domain that the strengths of the universal approach are clearest. Contrary to what one might expect, eliminating construction-specific information from the semantic rules need not result in a less accurate theory. Instead, the resulting theory may reveal very general semantic mechanisms which—freed of construction-specific restrictions—are more than capable of taking up the slack (see cross-references throughout this work). Thus, compared to construction-specific alternatives, the XLS analyses presented in this work are more accurate, not less. Furthermore, the analysis of complex constructions does not require any new semantic operations or meanings. Instead, we find new combinations of the same operations and meanings that are also attested in simpler structures. To reveal these semantic phenomena in their full generality, it is crucial that semantic rules ignore construction-specific details—that is, anything beyond the bare minimum of information that is relevant to compositionality. In formulating semantic rules, therefore, the decision what information to omit is as important as what to include.

As an undergraduate student of physics I learned that "Nature is stingy with fundamental physical principles and lavish with their manifestations" (lectures on Quantum Theory). The results of this inquiry suggest that She is just as stingy, and lavish, when it comes to linguistic phenomena.

APPENDIX 1:

LC, A TYPED VARIATION ON KAPLAN'S (1978) LD

Syntax:

I. Let $e \neq t$. The *set of types* is the smallest set T such that (a) $e, t \in T$, and (b) if $\tau,\tau' \in T$, then $\langle\tau,\tau'\rangle \in T$.

II. *Alphabet of symbols.* For each $\tau \in T$, there is a set of absolutely referring constants (Con_τ), a set of indexical constants ($\mathbf{Con}_\tau$), and a denumerably infinite set of variables (Var_τ)—including the following sets:

Type, τ	Con_τ	$\mathbf{Con}_\tau$	Var_τ
e	$\{a, b, c, \ldots\}$	$\{i, \ldots\}$	$\{v_{0,e}, v_{1,e}, v_{2,e}, \ldots\}$
$\langle e,t\rangle$	{exist′, speak′, …}	$\varnothing$	$\{v_{0,\langle e,t\rangle}, v_{1,\langle e,t\rangle}, v_{2,\langle e,t\rangle}, \ldots\}$
$\langle t,t\rangle$	$\{\neg, \Diamond, \Box, \ldots\}$	$\varnothing$	$\{v_{0,\langle t,t\rangle}, v_{1,\langle t,t\rangle}, v_{2,\langle t,t\rangle}, \ldots\}$

The syncategorematic symbols are: Dom, $\in$, $=$, $\leq$, $\times$, $+$, $\oplus$, $*$, **min**, **th**, ι, $\exists$, $\forall$, λ, ( ), [ ].

III. *Syntactic rules.*

CV: If $\tau \in$ T, then $\mathrm{Con}_\tau \cup \mathbf{Con}_\tau \cup \mathrm{Var}_\tau \subseteq \mathrm{ME}_\tau$.

F: If $\alpha \in \mathrm{ME}_{\langle\tau,\tau'\rangle}$ and $\beta \in \mathrm{ME}_\tau$, then $\alpha(\beta) \in \mathrm{ME}_{\tau'}$.

D: If $\alpha \in \mathrm{ME}_{\langle\tau,\tau'\rangle}$ and $\beta \in \mathrm{ME}_\tau$, then $(\beta \in \mathrm{Dom}[\alpha]) \in \mathrm{ME}_t$.

R: If $\alpha, \beta \in \mathrm{ME}_\tau$, then $[\alpha = \beta]$, $[\alpha \leq \beta] \in \mathrm{ME}_t$.

O: If $\alpha, \beta \in \mathrm{ME}_\tau$, then $[\alpha \times \beta]$, $[\alpha + \beta] \in \mathrm{ME}_\tau$.

$\oplus$: If $\alpha \in \mathrm{ME}_{\langle\tau,\tau\rangle}$, then $\oplus[\alpha] \in \mathrm{ME}_\tau$.

P: If $\alpha \in \mathrm{ME}_{\langle\tau,t\rangle}$, then $*[\alpha]$, $\mathbf{min}[\alpha]$, $\mathbf{th}[\alpha] \in \mathrm{ME}_{\langle\tau,t\rangle}$.

I: If $u \in \mathrm{Var}_\tau$ and $\varphi \in \mathrm{ME}_t$, then $\iota u\varphi \in \mathrm{ME}_\tau$.

Q: If $u \in \mathrm{Var}_\tau$, and $\varphi \in \mathrm{ME}_t$, then $\exists u\varphi$, $\forall u\varphi \in \mathrm{ME}_t$.

λ: If $u \in \mathrm{Var}_\tau$ and $\alpha \in \mathrm{ME}_{\tau'}$, then $\lambda u[\alpha] \in \mathrm{ME}_{\langle\tau,\tau'\rangle}$.

<u>Semantics:</u>

I. *Denotation spaces.* Let E and W be non-empty sets (set of entities and set of worlds, respectively), $\dagger \notin E \cup W$.

For every $\tau \in T$, we define $\Delta_{\tau,E,W,\dagger}$ (set of possible intensions), $\Delta^\circ_{\tau,E,W,\dagger}$ (set of normal intensions), and $\dagger_{\tau,E,W,\dagger}$ (the †-intension), as follows:

a. $\Delta_{e,E,W,\dagger} = E \cup \{\dagger\}$

$\Delta^\circ_{e,E,W,\dagger} = E$

$\dagger_{e,E,W,\dagger} = \dagger$

b. $\Delta_{t,E,W,\dagger} = \mathcal{P}(W)$

$\Delta^\circ_{t,E,W,\dagger} = \mathcal{P}(W)$

$\dagger_{t,E,W,\dagger} = \varnothing$

c. $\Delta_{\langle\tau,\tau'\rangle,E,W,\dagger} = (\Delta_{\tau',E,W,\dagger})^{\Delta_{\tau,E,W,\dagger}}$

$\Delta^\circ_{\langle\tau,\tau'\rangle,E,W,\dagger} = \{f \in \Delta_{\langle\tau,\tau'\rangle,E,W,\dagger} : \text{if } \delta \in \Delta^\circ_{\tau,E,W,\dagger}, \text{ then } f(\delta) \in \Delta^\circ_{\tau',E,W,\dagger}\}$

$\dagger_{\langle\tau,\tau'\rangle,E,W,\dagger}$ = the unique element of $(\{\dagger_{\tau',E,W,\dagger}\})^{\Delta_{\tau,E,W,\dagger}}$

II. A *model* for LC is a 6-tuple $M = \langle\{\leq_\tau : \tau \in T\}, \dagger, E, W, K, F\rangle$ such that E and W are non-empty disjoint sets, $\dagger \notin E \cup W$, and (a)–(c) hold.

a. $\langle\Delta_{\tau,E,W,\dagger}, \leq_\tau\rangle$ and $\langle\Delta^\circ_{\tau,E,W,\dagger}, \leq_\tau\rangle$ are complete join semi-lattices for all $\tau \in$ T. Furthermore (i)–(iii) hold:

i. for any $a, b \in E$, $\sup_{\leq e}\{a, b\} \leq_e \dagger$

ii. for any $\pi, \pi' \in \Delta_{t,E,W,\dagger}$, $\pi \leq_t \pi'$ iff $\pi' \subseteq \pi$

iii. for any $f, f' \in \Delta_{\langle\upsilon,\tau\rangle,E,W,\dagger}$, $f \leq_{\langle\upsilon,\tau\rangle} f'$ iff

$\forall\delta \in \Delta_{\upsilon,E,W,\dagger}(f(\delta) \in \Delta^\circ_{\tau,E,W,\dagger} \rightarrow f'(\delta) \in \Delta^\circ_{\tau,E,W,\dagger} \;\&\; f(\delta) \leq_\dagger f'(\delta))$.

b. K is a set of pairs $k = \langle a_k, w_k\rangle$ such that $w_k \in F(\text{exist}')(k)(a_k)$.

c. F is a function that assigns to each $\alpha \in (\text{Con}_\tau \cup \mathbf{Con}_\tau)$ a normal character $F(\alpha) \in (\Delta^\circ_{\tau,E,W,\dagger})^K$ such that (i)–(ii) hold:

i. If $\alpha \in \text{Con}_\tau$ and $k, k' \in K$, then $F(\alpha)(k) = F(\alpha)(k')$.

ii. If $k = \langle a_k, w_k\rangle \in K$, $w \in W$, and $\pi \subseteq W$, then:

$w \in F(\neg)(k)(\pi)$, iff $w \notin \pi$

$w \in F(\Diamond)(k)(\pi)$, iff $\pi \neq \varnothing$

$w \in F(\Box)(k)(\pi)$, iff $\pi = W$

$F(i)(k) = a_k$

$\forall\delta \in \Delta_{e,E,W,\dagger}[F(\text{exist}')(k)(\delta) = \varnothing, \text{ iff } \delta = \dagger]$

<u>Denotation and truth in a context:</u>

I. Let $M = \langle\{\leq_\tau: \tau \in T\}, \dagger, E, W, K, F\rangle$ be a model for LC:

a. For any $\tau \in T$, $w \in W$, $k \in K$, we define $(\Delta^\circ_{\tau,E,W,\dagger}|\langle w, k\rangle)$ (set of *real intensions*) as follows:

$(\Delta^\circ_{e,E,W,\dagger}|\langle w, k\rangle) = \{a \in \Delta^\circ_{e,E,W,\dagger}: w \in F(\text{exist}')(k)(a)\}$

$(\Delta^\circ_{t,E,W,\dagger}|\langle w, k\rangle) = \{\pi \in \Delta^\circ_{t,E,W,\dagger}: w \in \pi\}$

$(\Delta^\circ_{\langle\tau,\tau'\rangle,E,W,\dagger}|\langle w, k\rangle) = \{f \in \Delta^\circ_{\langle\tau,\tau'\rangle,E,W,\dagger}$: if $\delta \in (\Delta^\circ_{\tau,E,W,\dagger}|\langle w, k\rangle)$, then $f(\delta) \in (\Delta^\circ_{\tau',E,W,\dagger}|\langle w, k\rangle)\}$

b. An *M-assignment* is a function g that assigns to each $u \in \text{Var}_\tau$ a normal intension $g(u) \in \Delta^\circ_{\tau,E,W,\dagger}$.

The set of M-assignments is denoted by G_M.

c. An *M-context* is a pair $\langle k, g\rangle \in K \times G_M$. The set of M-contexts (i.e. $K \times G_M$) is denoted by C_M.

d. For any $c = \langle k, g\rangle \in C_M$, $u \in \text{Var}_\tau$, and $\delta \in \Delta^\circ_{\tau,E,W,\dagger}$, (i) $g[u/\delta] := (g - \{\langle u, g(u)\rangle\}) \cup \{\langle u, \delta\rangle\}$, and

(ii) $c[u/\delta] := \langle k, g[u/\delta]\rangle$.

II. Let $M = \langle\{\leq_\tau: \tau \in T\}, \dagger, E, W, K, F\rangle$ be a model for LC; $c = \langle k_c, g_c\rangle \in C_M$; $k_c = \langle a_c, w_c\rangle$; $w \in W$. An $\langle M, c\rangle$-*valuation* is a function $[\![\ ]\!]^{M,c}$ that assigns to each $\alpha \in \text{ME}_\tau$ an intension $[\![\alpha]\!]^{M,c} \in \Delta_{\tau,E,W,\dagger}$. In what follows we abbreviate $\Delta_{\tau,E,W,\dagger}$ as Δ_τ, $\Delta^\circ_{\tau,E,W,\dagger}$ as Δ°_τ, $(\Delta^\circ_{\tau,E,W,\dagger}|\langle w, k\rangle)$ as $(\Delta^\circ_\tau|\langle w, k\rangle)$, and $\dagger_{\tau,E,W,\dagger}$ as $\dagger_\tau$:

CV: If $\alpha \in \text{Con}_\tau \cup \mathbf{Con}_\tau$, then $[\![\alpha]\!]^{M,c} = F(\alpha)(k_c)$. If $\alpha \in \text{Var}_\tau$, then $[\![\alpha]\!]^{M,c} = g_c(\alpha)$.

F: $[\![\alpha(\beta)]\!]^{M,c} = [\![\alpha]\!]^{M,c}([\![\beta]\!]^{M,c})$

D: $[\![(\beta \in \text{Dom}[\alpha])]\!]^{M,c} = \{w \in W: [\![\alpha]\!]^{M,c}([\![\beta]\!]^{M,c}) \neq \dagger_{\tau'}\}$

R: $[\![[\alpha = \beta]]\!]^{M,c} = \{w \in W: [\![\alpha]\!]^{M,c}$ is $[\![\beta]\!]^{M,c}\}$

$[\![[\alpha \leq \beta]]\!]^{M,c} = \{w \in W: [\![\alpha]\!]^{M,c} \leq_\tau [\![\beta]\!]^{M,c}\}$

O: $[\![[\alpha \times \beta]]\!]^{M,c} = \inf_{\leq\tau}\{[\![\alpha]\!]^{M,c}, [\![\beta]\!]^{M,c}\}$, if there is such

$= \dagger_\tau$, otherwise

$[\![[\alpha + \beta]]\!]^{M,c} = \sup_{\leq\tau}\{[\![\alpha]\!]^{M,c}, [\![\beta]\!]^{M,c}\}$

$\oplus$: $[\![\oplus[\alpha]]\!]^{M,c} = \sup_{\leq\tau}\{\delta \in (\Delta^\circ_\tau|\langle w_c, k_c\rangle): [\![\alpha]\!]^{M,c}(\delta) \in (\Delta^\circ_\tau|\langle w_c, k_c\rangle)\}$, if there is such

$= \dagger_\tau$, otherwise

P: $[\![*[\alpha]]\!]^{M,c}(\delta) = \{w \in W: \delta \in \{\sup_{\leq\tau}X: \varnothing \subset X \subseteq \{\delta' \in \Delta^\circ_\tau: w \in [\![\alpha]\!]^{M,c}(\delta')\}\}\}$ for all $\delta \in \Delta_\tau$

$[\![\mathbf{min}[\alpha]]\!]^{M,c}(\delta) = \{w \in W: \delta$ is a $\leq_\tau$-minimal element of $\{\delta' \in \Delta^\circ_\tau|\langle w, k_c\rangle: w \in [\![\alpha]\!]^{M,c}(\delta')\}\}$ for all $\delta \in \Delta_\tau$

$[\![\mathbf{th}[\alpha]]\!]^{M,c}(\delta) = \{w \in W: \delta$ is a $\leq_\tau$-greatest element of $\{\delta' \in \Delta^\circ_\tau|\langle w, k_c\rangle: w \in [\![\alpha]\!]^{M,c}(\delta')\}\}$ for all $\delta \in \Delta_\tau$

I: $[\![\iota u\varphi]\!]^{M,c}$ = the $\leq_\tau$-greatest element of $\{\delta \in (\Delta^\circ_\tau|\langle w_c, k_c\rangle): w_c \in [\![\varphi]\!]^{M,c[u/\delta]}\}$, if there is such

= $\dagger_\tau$, otherwise

Q: $[\![\exists u\varphi]\!]^{M,c}$ = $\{w \in W: \{\delta \in \Delta^\circ_\tau: w \in [\![\varphi]\!]^{M,c[u/\delta]}\} \neq \emptyset\}$

$[\![\forall u\varphi]\!]^{M,c}$ = $\{w \in W: \{\delta \in \Delta^\circ_\tau: w \in [\![\varphi]\!]^{M,c[u/\delta]}\} = \Delta^\circ_\tau\}$

λ: $[\![\lambda u[\alpha]]\!]^{M,c}(\delta)$ = $[\![\alpha]\!]^{M,c[u/\delta]}$, if $\delta \in \Delta^\circ_\tau$

= $\dagger_{\tau'}$, if $\delta \in (\Delta_\tau - \Delta^\circ_\tau)$

III. Let $\varphi, \psi \in ME_t$, let $M = \langle\{\leq_\tau: \tau \in T\}, \dagger, E, W, K, F\rangle$ be a model for LC, c, an M-context, and $w \in W$.

a. φ-in-*c* is *true in w* relative to *M*, iff $w \in [\![\varphi]\!]^{M,c}$.

b. φ *logically entails* ψ in LC, iff $\forall M \forall c([\![\varphi]\!]^{M,c} \subseteq [\![\psi]\!]^{M,c})$

Defined expressions: (Note: The index 0 may be omitted, i.e., $p := p_0$, $x := x_0$, etc).

$p_n := v_{n,t}$	$q := v_{1,t}$	$r := v_{2,t}$
$x_n := v_{n,e}$	$y := v_{1,e}$	$z := v_{2,e}$
$x_\tau := v_{0,\tau}$	$y_\tau := v_{1,\tau}$	$z_\tau := v_{2,\tau}$
$P_n := v_{n,\langle e,t\rangle}$	$Q := v_{1,\langle e,t\rangle}$	$W_n := v_{n,\langle t,t\rangle}$
$P_{n,\tau} := v_{n,\langle\tau,t\rangle}$	$Q_{n,\tau} := v_{n+1,\langle\tau,t\rangle}$	$\mathscr{P}_n := v_{n,\langle\langle e,t\rangle,t\rangle}$
$R_n := v_{n,\langle e,\langle e,t\rangle\rangle}$	$R_{n,\tau} := v_{n,\langle\tau,\langle\tau,t\rangle\rangle}$	$\mathscr{R}_n := v_{n,\langle\langle e,\langle e,t\rangle\rangle,t\rangle}$
$f_n := v_{n,\langle e,e\rangle}$	$g := v_{1,\langle e,e\rangle}$	$f_{n,\tau} := v_{n,\langle\tau,\tau\rangle}$
$F_n := v_{n,\langle\langle e,e\rangle,t\rangle}$	$G := v_{1,\langle\langle e,e\rangle,t\rangle}$	$F_{n,\tau} := v_{n,\langle\langle\tau,\tau\rangle,t\rangle}$
$\mathscr{F}_n := v_{n,\langle\langle\langle e,e\rangle,t\rangle,t)}$	$\Phi_n := v_{n,\langle\langle\langle\langle e,e\rangle,t\rangle,t\rangle,t\rangle}$	
$h_n := v_{n,\langle\langle e,t\rangle,e\rangle}$	$k := v_{1,\langle\langle e,t\rangle,e\rangle}$	$h_{n,\tau} := v_{n,\langle\langle\tau,t\rangle,\tau\rangle}$
$H_n := v_{n,\langle\langle\langle e,t\rangle,e\rangle,t\rangle}$	$K := v_{1,\langle\langle\langle e,t\rangle,e\rangle,t\rangle}$	$H_{n,\tau} := v_{n,\langle\langle\langle\tau,t\rangle,\tau\rangle,t\rangle}$
$A_n := v_{n,\langle t,\langle e,t\rangle\rangle}$	$A_{n,\tau} := v_{n,\langle\tau,\langle e,t\rangle\rangle}$	
$C_n := v_{n,\langle\langle e,t\rangle,\langle e,\langle e,t\rangle\rangle\rangle}$	$C_{n,\tau} := v_{n,\langle\langle\tau,t\rangle,\langle\tau,\langle e,t\rangle\rangle\rangle}$	

$(\varphi \wedge \psi) := [\varphi + \psi]$ $\qquad$ $(\varphi \rightarrow \psi) := (\neg(\varphi) \vee \psi)$

$(\varphi \vee \psi) := \neg(\neg(\varphi) \wedge \neg(\psi))$ $\qquad$ $(\varphi \leftrightarrow \psi) := ((\varphi \rightarrow \psi) \wedge (\psi \rightarrow \varphi))$

$DIS_{n,\tau} := \lambda Q_\tau \lambda x_\tau[x_\tau \leq \oplus[f_{n,\tau}] \wedge \forall y_\tau(y_\tau \in Dom[f_{n,\tau}] \wedge y_\tau \leq x_\tau \rightarrow Q_\tau(y_\tau))]$

$DIS^+_{n,\tau} := \lambda Q_\tau \lambda x_\tau[DIS_{n,\tau}(Q_\tau)(x_\tau) \wedge \forall y_\tau(y_\tau \in Dom[f_{n,\tau}] \rightarrow \mathbf{min}[P_{n,\tau}](y_\tau))]$

APPENDIX 2:

CROSS-LINGUISTIC SEMANTICS (XLS)

In what follows, ME is the set of meaningful expressions of LC (Appendix 1), and Var is the set of variables.

<u>Inductive base</u>

D1. *Set of type lifting operators*, $\Omega := \bigcup_\tau\{[=]_\tau, [=]!_\tau, [+]_\tau, [+]!_\tau, [\exists]_\tau, [\exists]!_\tau, [\forall]_\tau, [\forall]!_\tau\}$

	From	*To*	*Definition*
$[=]_\tau$	τ	$\langle\tau,t\rangle$	$\lambda z_\tau \lambda y_\tau[y_\tau = z_\tau]$
$[=]!_\tau$	$\langle\tau,t\rangle$	$\langle\tau,\langle\tau,t\rangle\rangle$	$\lambda P_\tau \lambda y_\tau \lambda x_\tau[P_\tau(x_\tau) \wedge y_\tau = y_\tau]$
$[+]_\tau$	τ	$\langle\tau,\tau\rangle$	$\lambda z_\tau \lambda y_\tau[y_\tau + z_\tau]$
$[+]!_\tau$	$\langle\tau,t\rangle$	$\langle\langle\tau,\tau\rangle,t\rangle$	$\lambda P_\tau \lambda f_\tau[P_\tau(\oplus[f_\tau])]$
[˛]$_\tau$	$\langle\tau,t\rangle$	$\langle\langle\tau,t\rangle,t\rangle$	$\lambda P_\tau \lambda Q_\tau[\exists y_\tau(P_\tau(y_\tau) \wedge Q_\tau(y_\tau))]$
[˛]!$_\tau$	$\langle\tau,\langle e,t\rangle\rangle$	$\langle\langle\tau,t\rangle,\langle e,t\rangle\rangle$	$\lambda A_\tau \lambda Q_\tau \lambda x_e[\exists y_\tau(A_\tau(x_e, y_\tau) \wedge Q_\tau(y_\tau))]$
[Å]$_\tau$	$\langle\tau,\langle\tau,t\rangle\rangle$	$\langle\langle\tau,\tau\rangle,t\rangle$	$\lambda R_\tau \lambda f_\tau[\forall y_\tau(y_\tau \in \mathrm{Dom}[f_\tau] \rightarrow R_\tau(f_\tau(y_\tau), y_\tau))]$
[Å]!$_\tau$	$\langle\langle\tau,t\rangle,\langle\tau,\langle e,t\rangle\rangle\rangle$	$\langle\langle\langle\tau,t\rangle,\tau\rangle,\langle e,t\rangle\rangle$	$\lambda C_\tau \lambda h_\tau \lambda x_e[\forall P_\tau(P_\tau \in \mathrm{Dom}[h_\tau] \rightarrow C_\tau(x_e, h_\tau(P_\tau), P_\tau))]$

D2. Let Λ be an LF; L, the set of lexical items in Λ; N, the set of nodes in Λ; and $M \subseteq N$. An *interpretive base* $\mathbb{B}$ for Λ is a pair of functions $\langle\mathbb{L}, \mathbb{T}\rangle$ such that $\mathbb{L}: L \longrightarrow \{\varnothing\} \cup (\mathrm{ME} \times \{\sigma \subseteq \mathrm{Var}: |\sigma| \leq 1\})$ and $\mathbb{T}: M \longrightarrow \mathrm{Var} \cup \mathrm{Var}^2 \cup (\mathrm{Var}\times\Omega) \cup \Omega \cup \Omega^2$. We say that $\mathbb{L}$ is a *lexicon*, and $\mathbb{T}$, a *transformation plan*, for Λ.

L. Lexical constraints on *logical vocabulary*:

L_Q	If $Q_i \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}: Q_i \mapsto \langle p_i, \{p_i\}\rangle$	
L_{prn}	If $\alpha \in \{he_i, \ldots, pro_i\}$ and $\alpha \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}: \alpha \mapsto \langle x_i, \varnothing\rangle$	
L_{wh}	If $what_{i,\tau} \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}: what_{i,\tau} \mapsto \langle P_{i,\tau}, \varnothing\rangle$	
L_{which}	If $which_{i,\tau} \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}: which_{i,\tau} \mapsto \langle x_{i,\tau}, \{x_{i,\tau}\}\rangle$	
L_{each}	If $each_{i,\tau} \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}: each_{i,\tau} \mapsto \langle \lambda P_\tau[\mathrm{DIS}^+_{i,\tau}(P_\tau)(x_{i,\tau})], \{x_{i,\tau}\}\rangle$	
L_{TOP}	If $\mathrm{TOP}_\tau \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}: \mathrm{TOP}_\tau \mapsto \langle \lambda P_\tau[\iota x_\tau P_\tau(x_\tau)], \varnothing\rangle$	(Note: Ans := TOP_t)
$L_\leq$	If $of_\tau \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}: of_\tau \mapsto \langle \lambda z_\tau \lambda y_\tau[y_\tau \leq z_\tau], \varnothing\rangle$	
L_{POSS}	If $'s_{i,\tau} \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}: 's_{i,\tau} \mapsto \langle \lambda R_\tau \lambda z_\tau[\iota y_\tau[R_\tau + R_{i,\tau}](y_\tau, z_\tau)], \varnothing\rangle$	
L_{or}	If $or_\tau \in \mathrm{Dom}\mathbb{L}$ ($\tau \neq e$), then $\mathbb{L}: or_\tau \mapsto \langle \lambda z_\tau \lambda y_\tau[z_\tau \times y_\tau], \varnothing\rangle$	(*Boolean disjunction*)
L_{OR}	If $OR_\tau \in \mathrm{Dom}\mathbb{L}$, then $\mathbb{L}: OR_\tau \mapsto \langle \lambda z_\tau \lambda y_\tau \lambda x_\tau[[x_\tau = y_\tau] \times [x_\tau = z_\tau]], \varnothing\rangle$	(*identity disjunction*)

Initial and final translations. Relative to an interpretive base $\mathbb{B} = \langle \mathbb{L}, \mathbb{T} \rangle$, LF 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 functions by simultaneous recursion, following some auxiliary definitions (D3–5).

D3. *Type-driven application* is that operation $\mathbb{F}$ such that (i) $\mathrm{Dom}\mathbb{F} = \{\langle \varepsilon, \varepsilon' \rangle \in \mathrm{ME}^2 \text{: } \varepsilon(\varepsilon') \in \mathrm{ME} \text{ or } \varepsilon'(\varepsilon) \in \mathrm{ME}\}$, and (ii) $\mathbb{F}\text{: } \langle \varepsilon, \varepsilon' \rangle \mapsto$ the unique element of $\mathrm{ME} \cap \{\varepsilon(\varepsilon'), \varepsilon'(\varepsilon)\}$.

D4. To each type, the following functions **r** and **o** assign a *rank* and an *order*, respectively.

$\mathbf{r}(e) = \mathbf{r}(t) = 0$ $\qquad$ $\mathbf{o}(e) = \mathbf{o}(t) = 0$

$\mathbf{r}(\langle \tau,\upsilon \rangle) = \mathbf{r}(\upsilon) + 1$ $\qquad$ $\mathbf{o}(\langle \tau,\upsilon \rangle) = \max(\{\mathbf{o}(\tau) + 1, \mathbf{o}(\upsilon)\})$

D5. For any types τ, υ, $\tau \prec \upsilon$, iff either (i) $\mathbf{o}(\tau) < \mathbf{o}(\upsilon)$, or (ii) $\mathbf{o}(\tau) = \mathbf{o}(\upsilon)$ and $\mathbf{r}(\tau) < \mathbf{r}(\upsilon)$

LEXICAL (L). If $A \in \mathrm{Dom}\mathbb{L}$ and $\mathbb{L}(A) \neq \emptyset$, then $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \mathbb{L}(A)$.

EMPTY (E). Let A be an empty category with the index i. Then $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle v_{i,\tau}, \{v_{i,\tau}\} \rangle$, if either (a) or (b) holds:

a. A is in an ARG position and is sister to B, $B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_B, \sigma_B \rangle$, and $\varepsilon_B \in \mathrm{ME}_{\langle \tau,\upsilon \rangle}$ for some type υ;

b. A is not in an ARG position and the highest projection of A is sister to B, $B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_B, \sigma_B \rangle$, and $\varepsilon_B \in \mathrm{ME}_\tau$.

COPYING (K). If A is the mother of B, $B \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \beta$, and B has no sister C s.t. $\exists\gamma(C \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \gamma)$, 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 $\langle \varepsilon_B, \varepsilon_C \rangle \in \mathrm{Dom}\mathbb{F}$, then $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\varepsilon_B, \varepsilon_C), \sigma_B \cup \sigma_C \rangle$.

COPYING′ (K′). If $A \notin \mathrm{Dom}\mathbb{T}$ and $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \alpha$, then $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \alpha$.

BINDING (B). Let $\mathbb{T}(A) \in \{v_{i,\tau}, \langle v_{i,\tau}, \omega \rangle, \langle v_{i,\tau}, v_{j,\upsilon} \rangle\}$, $\omega \in \Omega$, $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_A, \sigma_A \rangle$, and $\tau = \min_{\prec}(\{\tau' \text{: } v_{i,\tau'} \in \sigma_A\})$. Moreover, let i be the index of A or A's sister. Then:

a. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \lambda v_{i,\tau} [\varepsilon_A], \sigma_A - \{v_{i,\tau}\} \rangle$, if $\mathbb{T}(A) = v_{i,\tau}$

b. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\omega, \lambda v_{i,\tau} [\varepsilon_A]), \sigma_A - \{v_{i,\tau}\} \rangle$, if $\mathbb{T}(A) = \langle v_{i,\tau}, \omega \rangle$ and $\omega(\lambda v_{i,\tau} [\varepsilon_A]) \in \mathrm{ME}$.

c. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\lambda v_{i,\tau} [\varepsilon_A], \mathbb{F}(v_{i,\langle \upsilon,\tau \rangle}, v_{j,\upsilon})), (\sigma_A - \{v_{i,\tau}\}) \cup \{v_{i,\langle \upsilon,\tau \rangle}, v_{j,\upsilon}\} \rangle$, if $\mathbb{T}(A) = \langle v_{i,\tau}, v_{j,\upsilon} \rangle$.

TYPE LIFTING (T). Let $\mathbb{T}(A) \in \{\omega_1, \langle \omega_1, \omega_2 \rangle\}$, $\omega_1, \omega_2 \in \Omega$, $A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_A, \sigma_A \rangle$, and $\omega_1(\varepsilon_A) \in \mathrm{ME}$. Moreover, let A have a sister B such that $B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle \varepsilon_B, \sigma_B \rangle$ and $\langle \varepsilon_A, \varepsilon_B \rangle \notin \mathrm{Dom}\mathbb{F}$. Then:

a. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\omega_1, \varepsilon_A), \sigma_A \rangle$, if $\mathbb{T}(A) = \omega_1$.

b. $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \mathbb{F}(\omega_2, \mathbb{F}(\omega_1, \varepsilon_A)), \sigma_A \rangle$, if $\mathbb{T}(A) = \langle \omega_1, \omega_2 \rangle$ and $\omega_2(\omega_1(\varepsilon_A)) \in \mathrm{ME}$.

Semantic Filters. A meaningful expression ε represents an intuitively available reading of a sentence *S*, only if ε is is a *proper translation* (defined in D6) of a syntactically well-formed LF representation of *S*. Furthermore, if *S* is a (direct or indirect) question, then ε must further satisfy the Answerability Filter (AF).

D6. Let Λ be an LF; $\mathbb{B} = \langle \mathbb{L}, \mathbb{T} \rangle$, an interpretive base for Λ; and $\varepsilon \in$ ME. Then ε is a *proper translation* of Λ based on $\mathbb{B}$, iff (i) **root**(Λ) $\rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle \varepsilon, \emptyset \rangle$, and (ii) the following filters are satisfied by all nodes *A* and *B* in Λ:

Initial Filter : If $\exists\alpha(A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \alpha)$ and *B* dominates *A*, then $\exists\beta(B \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \beta)$.

Final Filter : If $\exists\alpha_1(A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \alpha_1)$, then $\exists\alpha_2(A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \alpha_2)$.

Type Filter : If *A* is the root of Λ or of a small clause in Λ, then $\exists\langle\varepsilon_A, \sigma_A\rangle(A \rightsquigarrow_{1,\mathbb{L},\mathbb{T}} \langle\varepsilon_A, \sigma_A\rangle$ and $\varepsilon_A \in ME_t$).

AF. If *A* is the highest projection of 'Q_i' uttered in a context *c* and $A \rightsquigarrow_{2,\mathbb{L},\mathbb{T}} \langle\varepsilon, \emptyset\rangle$, then $\{w_c\} \subset [\![Ans(\varepsilon)]\!]^c$.

(Ans := TOP_t := λW[ιpW(p)])

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