Compositional semantics of questions and wh-movement

Two broad issues in the semantics of interrogative clauses:

1. "external semantics":
   What do interrogative clauses denote?
   How does their denotation enter (a) into the pragmatics of asking questions, and (b) into the compositional semantics of interrogative-embedding constructions?
2. "internal semantics":
   How is the denotation of interrogative clauses computed from the clause-internal lexical and functional material and the syntactic structure?

Main topic of my lectures will be internal semantics. The two issues interact in various ways.

external semantics

two major approaches:

"Hamblin/Karttunen" approach: sets of instantial positive answers

e.g. *who left?* denotes {that John left, that Mary left, ...}

"partition semantics" (Groenendijk-Stokhof approach): sets of mutually incompatible complete answers

e.g. *who left?* denotes {that nobody left, that only John left, that only Mary left, that only John and Mary left, ...}

I will assume that H/K denotations are needed for at least some purposes, and that partitions can be constructed from them and referred to where needed. This suggests that the clause-internal compositional semantics computes H/K denotations.

internal semantics

syntactic ingredients of a (constituent) question include

(a) interrogative wh-phrase,

(b) some Q-operator (on most views)

some common views on interrogative wh-phrases:

– assimilated to relative pronouns, interpreted as predicate modifiers
– assimilated to indefinites, interpreted as existential quantifiers
– assimilated to focused names, interpreted as sets of alternatives

various Q-operators that have been proposed:
- identity-predicate (ident type-shifter) for propositions (modified Karttunen)
- version that mentions truth (original Karttunen)
- versions that incorporate existential closure
- operator that constructs equivalence relations among worlds (Groenendijk & Stokhof)
- operator that absorbs alternatives (Hamblin-style alternative semantics)

1. Karttunen's approach to internal semantics

(after Karttunen 1977, with various modifications[1])

(1) Who left?
LF: λ_p[**who** λ_x[**Q**(**p**) **t**$_x$ **left**]]

syntax: Q-morpheme **Q** in C
covert argument (**p**) of **Q**, bound from edge of CP

semantics:

(2) **Q** shifts type <s,t> to <st,t> (cf. Partee's IDENT shifter from e to <e,t>).
$[\![\mathbf{Q}]\!] = \lambda p_{st}. \lambda q_{st}. p = q$

(3) wh-phrase is an existential quantifier
$[\![\mathbf{who}]\!]^w = \lambda P_{et}. \exists x_e$ [x is a person in w & P(x) = 1]
i.e., $[\![\mathbf{who}]\!]^w = [\![\mathbf{somebody}]\!]^w$

more syntax: distribution of **who** vs. **somebody**

(4) **who** has a feature **WH** (which **somebody** lacks)

(5) A phrase bears **WH** iff it is a Specifier of **Q**.

Wh-movement:
forced by principle (5);
not forced by interpretability,
but does have semantic consequences

another variant of Karttunen's theory: wh-movement forced by interpretability

(6) **WH** is semantically contentful (unlike above), as a type-shifter:
$[\![\mathbf{WH}]\!] = \lambda \mathcal{P}_{<et,t>}. \lambda \mathcal{Q}_{<e,<st,t>>}. \lambda p_{st}. \mathcal{P}(\lambda x. \mathcal{Q}(x)(p))$

concomitant assumptions:
no option of covertly saturating an argument of **Q** (as in (1) above);
LFs are simpler:

[1] sources: von Stechow, Dayal, and others

(7) Who left?

LF: **WH who** λ_x**[Q** t_x **left]**

consequence of this semantics: **who** and **somebody** are interpretable in different configurations

overt vs. covert movement:

The syntactic requirement (5) is assumed to hold at LF.

Interpretability obviously is only relevant at LF.

On either approach, distribution of overt vs. covert wh-movement needs to be regulated by additional assumptions.

some putative cases of covert (LF) wh-movement:

- multiple wh-questions (in English)
- all wh-questions in wh-in-situ languages (Japanese etc.)
- cases of pied-piping (see below)

2. Pied-piping

standard terminology:

wh-movement is "pied piping" if the moving phrase properly includes the wh-word

We want to distinguish two cases:

"minor" pied-piping (e.g. *which boy*):

moving phrase (*which boy*) larger than wh-word (*which*),

but coincides with wh-marked DP

(8) structure: **WH** [**which boy**]

interpretation: ⟦**which**⟧ = ⟦**some**⟧

"major" pied-piping (e.g. *whose cat*, *which boy's cat*, *how tall*, *how many cats*):

moving phrase is larger than the wh-marked DP

(9) structures:

whose cat: [[**WH who**]**'s cat**]

which boy's cat: [[**WH** [**which boy**]]**'s cat**]

how tall: [[**WH how**] **tall**]

how many cats: [[[**WH how**] **many**] **cats**]

Minor pied-piping creates no problems for the present theory. (In fact, its absence would.)

Major pied-piping raises issues (von Stechow 1996):

(10) Whose cat did you pet?

(11) first candidate for an LF:
$\lambda_{\mathbf{p}}$. **[WH who]'s cat** $\lambda_{\mathbf{x}}$. **Q(p) you petted** $\mathbf{t_x}$
– not interpretable
– also not in compliance with feature-licensing rule (5)

Further (covert) movement of **who** solves the interpretability problem.

(11) second candidate for an LF:
$\lambda_{\mathbf{p}}$. **WH who** $\lambda_{\mathbf{y}}$. $\mathbf{t_y}$**'s cat** $\lambda_{\mathbf{x}}$. **Q(p) you petted** $\mathbf{t_x}$
– denotes (12) below
– still not in full compliance with feature-licensing rule (5)

(12) denotation of (11) in the actual world @:
$\lambda p_{st}.\ \exists x_e\ [\text{person}_@(x)\ \&$
$p = \lambda w.\ \text{petted}_w(\text{you}, \iota y_e[\text{owns}_@(x,y)\ \&\ \text{cat}_@(y)])\ ]$

A scenario: You petted Tonya. Tonya is Irene's cat. John knows that you petted Tonya, but he doesn't know who Tonya belongs to.

(13) John knows whose cat you petted.
false in the scenario!

von Stechow's diagnosis (Stechow 1996): The correct LF involves not only covert movement of *who*, but also reconstruction below **Q** of the remnant t_y*'s cat*.

(14) third candidate for an LF:
$\lambda_{\mathbf{p}}$. **WH who** $\lambda_{\mathbf{y}}$. **Q(p) you petted** $\mathbf{t_y}$**'s cat**
– denotes (15) below
– fully complies with feature-licensing rule (5)

(15) $\lambda p_{st}.\ \exists x_e\ [\text{person}_@(x)\ \&$
$p = \lambda w.\ \text{petted}_w(\text{you}, \iota y_e[\text{owns}_{\mathbf{w}}(x,y)\ \&\ \text{cat}_{\mathbf{w}}(y)])\ ]$

An especially clear case:

(16) Whose cat is this?

(17) John knows whose cat this is.

The argument based on these examples with *whose cat* will be somewhat called into question when we get to *de dicto* readings of *which*-DPs. Therefore let's have another case.

(18) How many cats did you pet?

(19) $[\![\textbf{how}]\!] = \lambda P_{dt}.\ \exists d_d\ .\ P(d)$ ('to some degree')
$[\![\textbf{n-many cats}]\!]^w = \lambda P_{et}.\ \exists x_e\ [\text{cats}_w(x)\ \&\ |x| = n\ \&\ P(x)]$ (e.g. Hackl 2000)

(20) first candidate LF (after overt movement only):
$\lambda_{\mathbf{p}}$. **[[wh how] many cats]** $\lambda_{\mathbf{x}}$. **Q(p) you petted** $\mathbf{t_x}$
uninterpretable and doubly violates feature licensing

(21) second candidate LF (after additional covert movement):
λ_p. wh how λ_d. t_d-many cats λ_x. Q(p) you petted t_x
interpretable with denotation (22), one violation of feature licensing

(22) λp_{st}. $\exists n$. $\exists x$. [$cats_{@}(x)$ & $|x| = n$ & $p = \lambda w. petted_w(you, x)$]
equivalent to *Which cats did you pet?* !

(23) third candidate LF (after additional reconstruction):
λ_p. wh how λ_d. Q(p) t_d-many cats λ_x. you petted t_x
interpretable with denotation (23), complies with feature licensing

(24) λp_{st}. $\exists n$. $p = \lambda w$. $\exists x$. [$cats_w(x)$ & $|x| = n$ & $petted_w(you, x)$]
conforms to attested meaning

We must allow reconstruction to get the attested meanings, and we must block the derivations without reconstruction to avoid generating unattested meanings.
The chosen version of the feature licensing rule (5) is supported by its role in filtering out the non-reconstruction option.

The alternative approach with a type-shifting **WH** may work equally well, depending on the account of *de re-de dicto* ambiguities (see more later).

Preview of 2nd lecture: Our main goal is to assess Shimoyama's (2006) arguments for a Hamblin approach to the internal semantics of (Japanese) interrogative clauses. We begin with an introduction of Hamblin semantics, then present Shimoyama's analyses of island effects in Japanese interrogatives and of universal 'mo' constructions, and finally consider an intermediate theory which combines features of Shimoyama's proposal with those of a Karttunen semantics.

3. Hamblin semantics (aka "alternative semantics")

(25) redefinition of all semantic types as sets
my notation: underlined type-labels to distinguish from the standard ones
$D_{\underline{\sigma}} := \wp(D_\sigma)$ ($\wp$ = power set)

The redefinition of lexical denotations as sets will in most cases be trivial: the new denotation will be the singleton of the standard one, e.g.:

(26) $[\![\textbf{John}]\!] = \{\text{John}\}$ (type $\underline{e}$)

But non-singleton sets are crucially employed for interrogative words.[2]

(27) $[\![\textbf{who}]\!] = D_e$ (type $\underline{e}$)
or more precisely:
$[\![\textbf{who}]\!]^w = \{x \in D_e\text{: x is a person in w}\}$

(28) $[\![\textbf{which}]\!] = \{f \in D_{<et,e>}: \forall P_{et}.\ P(f(P)) = 1\}$ (type $\underline{<et,e>}$)
(i.e., the set of all choice functions[3])

Composition rules accordingly need to be adjusted to manipulate sets, e.g.:

(29) set-level Functional Application:
A node α with daughters β of type $\underline{<\sigma,\tau>}$ and γ of type $\underline{\sigma}$ is interpreted as follows:
for all w and g: $[\![\alpha]\!]^{w,g} = \{f(x): f \in [\![\beta]\!]^{w,g}\ \&\ x \in [\![\gamma]\!]^{w,g}\}$

syntactic assumptions:
wh-phrases are *in situ* at LF.
A Q-morpheme sits at the edge of the clause (say in C).

(30) LF for *who left?*
Q [**who left**]

(31) semantics of **Q** (syncategorematic):
$[\![\textbf{Q}\ \phi]\!]^{w,g} = \{[\lambda p_{st}.\ p \in [\![\phi]\!]^{w,g}]\}$
(i.e., form singleton of denotation of ϕ, redone as a characteristic function[4])

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[2] I must stress here that Shimoyama makes no claim about languages other than Japanese, particularly not about overt-wh-movement languages like English. I apply the framework to English here just for illustrative purposes.

[3] Curiously, I have never seen a (non-syncategorematic) entry for *which* in the Hamblin-semantics literature. I made this one up, but please let me know if it (or a different one) already exists.

[4] This is just to allow question-embedding verbs to have their accustomated semantic types (modulo only

working out the remaining details: a false start:

(32) $[\![\textbf{left}]\!]^w = \{[\lambda x_e.\ x \text{ left in } w]\}$ (type $\underline{<e,t>}$, singleton of standard denotation)

(33) computation for LF in (30), using lexical entries above and rule (29):
$[\![\textbf{who left}]\!]^w = \{[\lambda x.\ x \text{ left in } w](y): y \text{ is a person in } w\}$
oops! This is a set of truth-values, not what **Q** requires (a set propositions).

In standard frameworks, we could fix this by interpolating a step of Intensional Abstraction, either tied to a separate silent operator **^** or wrapped into the rule for the next-higher node (in this case the rule for **Q** ϕ).[5] Can we use the same strategy in the Hamblin-framework? Apparently not. We would need a recipe to get from a function from worlds to sets of truth values to a set of functions from worlds to truth-values. The desired such function seems hard to define. Here is a case that shows that it cannot be done.[6]

Suppose we have two wh-phrases *which of a and b* and *which of a, b, and a+b* (where *a*, *b* are names of people, and *a+b* names the plurality consisting of both of them). Let's consider the questions *which of a and b left?* and *which of a, b, and a+b left?*. Our desired result is that these denote different sets of propositions: a set of two propositions for one, a set of three propositions for the other. Now consider the sets of truth-values that we would compute for each given world w in the present system:

(34) $[\![\textbf{which of a, b left}]\!]^w = \{[\lambda x.\ x \text{ left in } w](y): y \in \{a,b\}\} =$
{0} if neither a nor b left in w
{0,1} if either a or b but not both left in w
{1} if both a and b left in w

(35) $[\![\textbf{which of a, b, a+b left}]\!]^w = \{[\lambda x.\ x \text{ left in } w](y): y \in \{a, b, a+b\}\} =$
{0} if neither a nor b left in w (and therefore not a+b either[7])
{0,1} if either a or b but not both left in w (and therefore also not a+b)
{1} if both a and b left in w (and therefore also a+b)

These are exactly the same! So whatever rule we try to write, we could not possibly recover the desired distinct sets of propositions from them.

The solution (tacitly adopted by all practioners of Hamblin semantics) is to employ a version of intensional semantics where verbs don't have world-dependent denotations.

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the trivial change to a singleton). Other technical set-ups are possible. Here I work with a type-system that has underlined types like $\underline{<\sigma,\tau>}$ (where σ and τ are standard, non-set, types) but no types like $<\underline{\sigma},\underline{\tau}>$ that are functions from or to underlined types (sets).

[5] The interpretation of **^** in standard (non-Hamblin) semantics is: $[\![{}^\wedge\phi]\!]^{w,g} = \lambda w.\ [\![\phi]\!]^{w,g}$. For the option of wrapping intensional abstraction into the rule for the next-higher node, cf. e.g. the Intensional Functional Application rule in Heim & Kratzer ch. 12.

[6] See Shan (2004), Novel & Romero (2009) for more general discussion of the technical problem that is exemplified here.

[7] This assumes that *leave* is distributive.

(36) non-world-dependent verb denotation, standard version (for non-Hamblin semantics):
$[\![\textbf{left}]\!] = \lambda x.\lambda w.\ x \text{ left in } w$ (type <e,st>)

(37) non-world-dependent verb denotation, version for Hamblin semantics:
$[\![\textbf{left}]\!] = \{[\lambda x.\lambda w.\ x \text{ left in } w]\}$ (type <u><e,st></u>, singleton of above)

Now we can compute successfully:

(38) computation for LF in (30)[8]:
$[\![\textbf{who left}]\!]^w = \{[\lambda w'.\ x \text{ left in } w']: x \text{ is a person in } w\}$
$[\![\textbf{Q who left}]\!]^w = \lambda p.\ p \in \{[\lambda w'.\ x \text{ left in } w']: x \text{ is a person in } w\}$
$= \lambda p.\ \exists x\ [x \text{ is a person in } w\ \&\ p = \lambda w'.\ x \text{ left in } w']$

4. Shimoyama on the distribution of island effects in Japanese

summary of the relevant facts of Japanese:

(i) interrogative phrases are *in situ* on the surface (no visible wh-movement to Spec-CP)

(ii) available readings are not constrained by most syntactic islands (e.g. Complex-NP)

(iii) but they are constrained by wh-islands

illustrations of these facts[9]:

(39) Taro-Top what-Acc asked Q
'What did Taro ask?'

(40) Taro-Top [[who-Nom bought] rice-cake]-Acc ate Q
'for which person x did Taro eat the rice cakes that x bought?'

(41) Taro-Top [Yamada-Nom who-Dat what-Acc sent Q] asked Q
cannot mean: *'for which person x did Taro ask what Yamada sent to x?'
nor: *'for which thing x did Taro ask to whom Yamada sent x?'[10]

Shimoyama's analysis:
syntax: LF is essentially like surface structure: wh-phrases in situ, Q in Comp.
semantics: Hamblin-style, as introduced above

Why is (40) grammatical, despite the Complex-NP-island separating *who* from *Q*?
– because alternative sets are computed for all nodes above *who*;

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[8] Here I did not revise the semantics of the (implicit) restricting noun 'person' in *who* to a non-world-dependent type, parallel to the revision for the verb *left*. What if NPs also have type <u><e,st></u>? How will *which*-phrases then work?

[9] Consult Shimoyama 2006 for the real Japanese examples. Here I give only the morpheme-by-morpheme glosses. "Q" is Shimoyama's gloss for the morpheme *ka*, which appears at the right edge of interrogative clauses.

[10] I disregard two other potential readings for this sentence, one of which is grammatical. These readings turn on the additional possibility of interpreting clauses with 'ka' as yes-no ('whether') questions.

movement islands are irrelevant.

(42) sketch of computation for (40):

relative clause:[11] ⟦**who bought**⟧$^{@}$

$= \{[\lambda x.\ \lambda w.\ buy_w(y,x)]: person_@(y)\}$

(the set of properties 'bought by y' for each person y)

complex NP:[12] ⟦**who bought rice-cake**⟧$^{@}$

$= \{[\lambda x.\ \lambda w.\ buy_w(y,x)\ \&\ {*}ricecake_w(x)]: person_@(y)\}$

(the set of properties 'ricecakes y bought' for each person y)

DP:[13] ⟦**THE who bought rice-cakes**⟧$^{@}$

$= \{[\lambda w.\ \sigma x.\ buy_w(y,x)\ \&\ {*}ricecake_w(x)]: person_@(y)\}$

(the set of individual concepts 'the ricecakes y bought' for each person y)

matrix IP: ⟦**Taro THE who bought rice-cakes ate**⟧$^{@}$

$= \{[\lambda w.\ eat_w(Taro, \sigma x.\ buy_w(y,x)\ \&\ {*}ricecake_w(x))]: person_@(y)\}$

(the set of propositions 'that Taro ate the ricecakes y bought' for each person y)

Why does (41) lack the readings indicated, if movement islands are irrelevant?

– because the lower **Q** "eats up" the alternatives, i.e., creates a singleton

(43) sketch of computation for (41):

embedded IP: ⟦**Yamada who what sent**⟧$^{@}$

$= \{[\lambda w.\ send_w(Yamada,x,y)]: thing_@(x)\ \&\ person_@(y)\}$

(set of propositions [that Y. sent x to y] for each thing-person pair x, y)

embedded CP: ⟦**Yamada who what sent Q**⟧$^{@}$

$= \{\ \lambda p.\ \exists x \exists y[thing_@(x)\ \&\ person_@(y)\ \&\ p = [\lambda w.\ send_w(Yamada,x,y)]]\}$

(<u>singleton</u> of characteristic function of above set of propositions)

Once we have a singleton (and there are no further wh-phrases higher in the structure), we will always have singleton denotations for all the higher nodes. So there is no way we can get the higher IP in (41) to denote a non-trivial set with one proposition per person (or per thing).

Karttunen semantics (as presented in my previous lecture) is committed to LFs in which a

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[11] If the relative clause involves abstraction, there are non-trivial issues in computing this from scratch. For simplicity, pretend here that the relative clause is **bought by who** and **bought-by** denotes (the singleton of) λx. λy. λw. x bought y in w.

[12] Here we assume that **rice-cakes** denotes (the singleton of) a property (type <e,st>), and that we have a set-level Predicate Modification rule, as follows:

A node α with daughters β and γ, both of type <u><e,st></u>, is interpreted as follows:

for all w and g: $[\![\alpha]\!]^{w,g} = \{[\lambda x.\ \lambda w.\ f(x)(w) = g(x)(w) = 1]: f \in [\![\beta]\!]^{w,g}\ \&\ g \in [\![\gamma]\!]^{w,g}\}$

[13] As Shimoyama discusses, these determiner-less DPs in Japanese are unmarked for either number or definiteness. The definite-plural interpretation chosen here is just one option, selected for expository simplicity. This is assumed to involve a covert definite article which denotes (the singleton of) $\lambda P_{<e,st>}.\ \lambda w.\ \sigma x.\ P(x)(w)$, where $\sigma x.\ P(x)(w)$ abbreviates $\iota x.\ P(x)(w)\ \&\ \forall y[P(y)(w) \rightarrow y \leq x]$. I.e., the definite DP denotes the individual concept which maps each world to the maximal (most inclusive) plurality that has property P.

sentence that is to be interpreted as a constituent question has a wh-phrase in its (topmost) Spec-CP. So the LF for the Japanese example with the Complex-NP island must look like this:[14]

(44) **who λ_x. Q ... t_x ...**

For the structure of the question-nucleus (the dots), there are in principle various semantically equivalent options, as long as everything is below **Q**. One possibility is (45) (with only **who** in a moved position).

(45) **who λ_x. Q Taro [[t_x bought] rice-cake] ate**

To derive this, **who** must have moved across the island boundary, which should not be allowed.

(46) Principle of Minimal Compliance (PMC) (Richards 1997, ... , 2008):
Only the first movement to the Spec of each **Q** must obey island constraints.

application: (46) allows the following derivation:

(47) **Q Taro [[who bought] rice-cake] ate**
pied-piping movement to Spec of **Q** (no island boundaries crossed):
[who bought] rice-cake Q Taro [[who bought] rice-cake] ate
second movement to a Spec of the same **Q**, free to cross islands:
who λ_x. [t_x bought] rice-cake Q Taro [[t_x bought] rice-cake] ate
reconstruction:
who λ_x. Q Taro [[t_x bought] rice-cake] ate

Support for the PMC: "additional wh effects" (Watanabe 1992)

(48) (a) *John [Mary what bought whether] wants-to-know Q
(b) John [Mary what bought whether] who asked Q
'for which x, y did John ask x whether Mary bought y?'

see also the famous Baker ambiguity in English:

(49) Who remembers where we bought what?
(a) who remembers the answer to "where did we buy what?"?
(b) for which x, y does x remember where we bought y?

Can Shimoyama make sense of PMC effects? She can assume that wh-phrases <u>may</u> move (covertly), although they don't have to. This movement will typically not affect interpretation – except when it takes the wh-phrase out of the scope of a **Q**. Moreover, Shimoyama can assume that this optional movement is subject to island constraints modulo Minimal Compliance. She then predicts the contrast in (48): some (semantically inert) and local movement of the matrix **who** would enable the (semantically significant) non-local movement of the embedded **what**.

Main problem for Richards' account: Why should a pied-piping derivation analogous to (47) not

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[14] I suppress the silent **p**-argument of **Q** and its binder, but they are meant to be there. The **WH** features aren't made explicit either, but I assume that each Japanese "indeterminate" has one, just like English wh-phrases. Moreover, for ease of reading, I put **Q** to the left, even though it's on the right in Japanese.

be able to circumvent a wh-island?[15]

5. Shimoyama on universal *mo* constructions

(50) which student-mo danced
‘every student danced’

(51) which student-NOM invited teacher-mo danced
‘for every student x, the teacher(s) x invited danced’

(52) which student-NOM submitted which TA-to assignment-mo A-was
‘for every student x and every TA y, the assignment(s) x submitted to y received an A’

summary of relevant facts:

– universal *mo* associates with one or more wh-phrases in its scope
– islands such as Complex NP are okay between *mo* and the associated wh
– each wh must associate with the closest *mo* or *ka*

Shimoyama’s analysis:

(53) semantics of **mo**:
$[\![\mathbf{mo}\ \phi]\!]^{w,g} = \{[\lambda P_{et}.\ \forall x \in [\![\phi]\!]^{w,g}\text{: } P(x) = 1]\}$

illustration: ...

Shimoyama’s criticism of previous analyses of *mo* (including von Stechow’s) is persuasive.

6. An intermediate theory between Hamblin and Karttunen?

Karttunen semantics generates sets only at the CP level and only at the point where there is a **Q**-morpheme, and they are always sets of propositions. Hamblin semantics generates sets at every node, independently of a triggering morpheme, and they can be sets of entities of any semantic type.

An intermediate theory might hold (with Karttunen) that set-denotations are constructed only at specific locations triggered by specific morphemes, but might assume (with Shimoyama) that this is not limited to interrogative clauses.

Recall Karttunen’s **Q**:

(54) $[\![\mathbf{Q}]\!] = \lambda p_{st}.\ \lambda q_{st}.\ p = q$

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[15] Richards (2000, 2008) sketches a multi-part answer that seems somewhat in conflict with the Minimal Compliance approach: (i) Pied-piping requires that a wh-phrase be at the left edge of the pied-piped phrase. (ii) Further movement out of the pied-piped phrase is only possible from the left edge. (iii) The left edge of a wh-clause cannot be extracted from. These constraints must hold even for second movements that are freed from subjacency by Minimal Compliance. (Assumption (iii) is independently useful to prevent the Baker-sentence from having an additional reading *‘for which person x and place y does x remember what we bought in y?’.)

Maybe there are similar ones for other semantic types, e.g.:

(55) ⟦**q**⟧ = $\lambda x_e. \lambda y_e. x = y$

This allows us to replicate Shimoyama's semantics for *mo*-constructions.

(56) **mo = [q EVERY]**

(57) ⟦**EVERY**⟧ = $\lambda P_{et}. \lambda Q_{et}. \forall x_e [P(x) \rightarrow Q(x)]$

derivation for example (51) (subject DP only)[16], [17]:

(58) **[q EVERY] [THE [λ_z. which student invited t_z] teacher]**
move **EVERY**:
EVERY λ_x. [q t_x] [THE [λ_z. which student invited t_z] teacher]
move wh-phrase to Spec of **q**:
EVERY λ_x. which student λ_y. [q t_x] [THE [λ_z. t_y invited t_z] teacher]

interpretation:

(59) ⟦**THE [λ_z. t_y invited t_z] teacher**⟧^{g} = the teacher that g(**y**) invited
⟦**λ_y. q t_x THE [λ_z. t_x invited t_z] teacher**⟧^{g} = 1 iff
λy. g(**x**) = the teacher that y invited

⟦**λ_x. which student λ_y. [q t_x] [THE [λ_z. t_y invited t_z] teacher**⟧^{g} =
λx. $\exists$y[student(y) & x = the teacher that y invited]

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[16] Again for readability, I put **mo** on the left of the phrase it attaches to instead of on the right where it actually appears.

[17] Recall that **t_x invited** is a relative clause (modifying **teacher**). **t_z** is the trtace of relativization.

De dicto readings of *which*-phrases

Preview of third lecture: The Karttunen semantics employed so far follows Karttunen 1977 in generating only so-called *de re* readings.[18] We start by recalling Groenendijk & Stokhof's criticism of this aspect of Karttunen's theory. Then we look at their proposal, and at another one essentially due to Rullmann & Beck (1998), and try to adjudicate between these. In the process, I will work out some specifics of the R&B approach that are left open in their paper.

1. Groenendijk & Stokhof (1982) on Karttunen (1977)

(1) Karttunen's semantics for interrogative-embedding *know* (simplified):
$[\![\textbf{know}]\!]^w = \lambda q_{<st,t>}.\ \lambda x.\ \forall p\ [\ q(p) = 1\ \&\ p(w) = 1 \rightarrow \text{know}_w(x,p)\ ]$
i.e., x believes every true proposition in the question-extension

two problematic consequences noted by G&S:

<u>Lack of "strong" exhaustivity</u>

The inference in (2) is intuitively valid, but not validated by Karttunen's analysis.

(2) (pointing at Mary, Bill, and Sue)
John knows which of these three passed the test.
Mary did not pass the test.
∴ John knows that Mary didn't pass the test.

<u>Undergeneration of *de dicto* readings</u>

There is a reading of the conclusion on which the inference in (3) is invalid, but Karttunen predicts it unambiguously valid.

(3) John knows which people passed the test.
∴ John knows which first-graders passed the test.

G&S's factual claims are generally accepted, but their diagnosis of the problems has been debated. Important questions include: Are these problems with Karttunen's semantics for interrogative clauses or rather with his semantics for the embedding verb *know* (or perhaps with both)? Do the two problems call for separate, independent, remedies, or are they connected?

G&S effectively diagnose both problems as mistakes in Karttunen's choice of question-denotations (not his analysis of *know*), and they effectively view them as independent. This

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[18] The same is true for the Hamblin semantics, at least as I have worked it out (adhering to Shimoyama 2006). Most authors who have advocated or employed a Hamblin semantics are not concerned with this issue. Novel & Romero (2009) is the only place where I have seen *de dicto* readings treated in a Hamblin semantics. Their analysis, like the one I will develop below in the Karttunen framework, is based directly on Rullmann & Beck.

maybe doesn't come out so clearly in their writings, but it will be relatively transparent in the following reformulation of their proposal.[19]

(4) Given a set of propositions S, PARTITION(S) := the set of propositions which are equivalence classes under the relation $\lambda w. \lambda w'. \forall p \in S$: $p(w) = p(w')$.

Karttunen's first mistake (according to G&S): failure to partition his denotations

repair: assume that interrogative clauses always contain another operator above **Q**, which denotes PARTITION as just defined.

(5) new LF for *which NP left?*
PART λ_p. **which NP** λ_x. **Q(p)** t_x **left**

This solves the exhaustivity problem (without changing the meaning of **know**)[20]. It still leaves the *de dicto* problem.

Karttunen's second mistake (according to G&S): wrong relative scopes of wh-phrase and **Q**

repair: switch to the predicate-modifier view of wh-phrases and redefine **Q** accordingly[21]

(6) new LF for *which NP left?*
Q' which NP λ_x. t_x **left**

(7) $[\![$**which**$]\!] = \lambda P_{et}. P$ (vacuous)

(8) $[\![$**Q'**$]\!] = \lambda P_{<s,et>}. \lambda p_{st}. \exists x. p = \lambda w. P(w)(x)$

This makes progress on the *de dicto* problem insofar that it now makes the inference in (3) invalid. But if we want to predict that it's invalid on one reading but valid on another, we need something else. E.g. adopt a (now standard) account of how *de re* readings come about by employing "extensionalized" LFs with world variables in them.

(9) extensionalized LFs for *which NP left?*[22]
(a) **Q'** λ_w. **which** $\textbf{NP}_w$ λ_x. t_x $\textbf{left}_w$
(b) **Q'** λ_w. **who** $\textbf{NP}_@$ λ_x. t_x $\textbf{left}_w$

This presupposes that denotations are no longer relativized to an evaluation world, but only a variable assignment (which includes assignments to world variables). Lexical entries then are like this:

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[19] I should credit a number of people for this formulation or ingredients thereof, certainly Danny Fox (MIT class handouts 2010) and the sources he cites, as well as Benjamin George's 2011 UCLA dissertation.

[20] Given that PARTITION creates sets of mutually contradictory propositions, only one member will be true in a given world. So the universal quantifier in the entry (1) for *know* might as well be existential or definite, but it works as it is.

[21] This would have to be generalized somewhat to accommodate multiple questions.

[22] World variables are written as subscripts to the predicates for better readability, but they should be thought of as occupying their own nodes in the syntactic tree, like traces or silent pronouns for individuals.

(10) $[\![\textbf{left}]\!] = \lambda w.\ \lambda x.\ x \text{ left in } w$
$[\![\textbf{student}]\!] = \lambda w.\ \lambda x.\ x \text{ is a student in } w$
etc.

The option of generating either the locally bound **w** or the free (or indexical) **@** as the argument of the *which*-NP gives rise to two readings, and the inference in (11) is valid on the latter and invalid on the former.

This now fixes the *de dicto* problem (again without changing the entry for *know*). It does nothing about the exhaustivity problem. To fix both problems, the two repairs need to be combined.[23]

(11) LF for *which NP left?*
$\textbf{PART Q' } \lambda_{\mathbf{w}}.\ \textbf{which NP}_{\mathbf{w/@}}\ \ \lambda_{\mathbf{x}}.\ \mathbf{t_x}\ \textbf{left}_{\mathbf{w}}$

2. Some possible concerns about G&S's proposal

1. Asymmetry judgements

A discomfort with the above solution to the *de dicto* problem: it appears to conflate (12a, b).

(12) (a) Which students are home-owners?
(b) Which home-owners are students?

On their *de dicto* construals,[24] they have the same denotation.

Is this problematic?

(13) (a) Which men are bachelors?
(b) #Which bachelors are men?

But we see this difference also in the relative clause constructions that the G&S-LFs are modeled after:

(14) (a) Which people here are men that are bachelors?
(b) # Which people here are bachelors that are men?

appropriateness at faculty meeting about student progress: ^{OK}(12a), #(12b)

Again, relative clause constructions show the same effect:

(15) (a) Which people are students who are home-owners?
(b) Which people are home-owners who are students?

generalization: relative clause can't be contextually entailed by its head noun.

A truth-conditional difference:

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[23] G&S's actual proposal wraps **PART** and **Q'** into one operation.

[24] They will not have the same *de re* readings, given Percus's (2000) constraint.

(16) (a) This algorithm decides which even numbers are multiples of three.
(b) This algorithm decides which multiples of three are even numbers.

unclear what to make of this?

2. A puzzle about question-answer pairs

(17) Q: Which students left?
A: Not John.

observation: The answer presupposes that John is a student.
What explains this?

question-denotation on *de dicto* reading:

PARTITION ({p: ∃x. p = that x is a student and left})

The proposition expressed by A, that John didn't leave, is incompatible with some cells of this partition – even if we don't restrict it the context set to worlds in which John is a student.

The proposition expressed by A2 is also not in either set. It IS incompatible with most cells of the partition (namely those where more than one student left), but is still compatible with two different cells, hence not a complete answer.

question-denotation on *de re* reading, dependent an utterance world @:

({p: ∃x. x is a student in @ & p = that x left} ∪ {∅})

or: PARTITION ({p: ∃x. x is a student in @ & p = that x left})

If John is a student, the proposition expressed by A1 is in the first of these sets, and incompatible with many cells of the partition.

3. Narrower scope *de dicto* readings (see R&B)

G&S scope the *which*-DP below their Q and the intensional abstraction that comes with it. But they still scope it above everything else in the question nucleus (have to for type reasons).

(18) John thinks he saw two unicorns, a blue one and a green one.
Which unicorn does he want to catch? (the green one or the blue one?)

G&S only generate readings which imply that there exist unicorns. *unicorn* cannot be in the scope of *want*.

I will argue later that this should be analyzed as a kind of functional reading.

3. A reconstruction account of *de dicto* readings

I employ a version of Chomsky's (1993) "copy theory of movement" which has been worked out by semanticists (notably Fox, but see also Sauerland 2000, Elbourne 2000, Kratzer 2009). In its original form sketched by Chomsky, copy theory provided for the option of retaining a moved phrase at LF in either its pre-movement or post-movement position, or of retaining parts of it in one position and parts in the other. The option of retaining only the lower copy covered cases of total reconstruction (e.g. scope reconstruction in topicalization or raising, head movement of verbs), but the option of retaining the higher copy alone did not yield useful interpretable structures, and the simple operations of copying and deleting could not by themselves produce the operator-variable structures that semanticists need. It was necessary to develop a view of movement that combined copying and deleting with the generation of variables and binder indices. Fox's mechanism of "trace conversion" is the best known explicit proposal of this kind. While Chomsky broke movement into the two steps of creating a copy and deleting (some of the) duplicated material, Fox interpolates an operation between Copy and Delete, namely the insertion of a binder index (lambda operator with variable) in the immediate scope of the higher copy and a matching variable as a sister to the lower copy.[25] After this, an interpretable configuration is obtained by deleting suitable parts of either copy and by inserting the type-shifters IDENT and THE in suitable places. Let me illustrate with a Foxian derivation for an LF with QR.

(19) base-generated: **John read every book**
copy: **every book** [**John read every book**]
insert binder and variable: **every book** $\boldsymbol{\lambda_x}$. **John read** [**every book x**]
delete lower determiner: **every book** $\boldsymbol{\lambda_x}$. **John read** [**book x**]
insert type-shifters: **every book** $\boldsymbol{\lambda_x}$. **John read** [**THE book IDENT x**]

How is this interpreted? The type-shifter IDENT denotes [λx. λy. x=y] and thus turns the variable **x** of type e into a predicate of type <e,t>. This can combine with the NP **book** by Predicate Modification, yielding [λy. book(y) & y = g(**x**)] (for a given variable assignment g). The type-shifter THE is a silent version of the Fregean definite article. It triggers the presupposition that its argument is a singleton and maps it to its only element where defined. So **THE book IDENT x** denotes g(**x**) if g(**x**) is a book, and it has no denotation otherwise. The interpretation of the higher part of the structure proceeds as usual, except that we have to be explicit about the projection of the presupposition. I use the "pedantic" version of Heim & Kratzer's functional Predicate Abstraction rule[26], by which the lambda-abstract $\boldsymbol{\lambda_x}$. **John read THE book IDENT x** comes to denote the partial function [λx: x is a book. John read x]. I assume that the universal quantifier projects a universal presupposition from its nuclear scope[27], so the final result of the computation for the LF in the last line of (19) is the assertion in (20a) and the (tautological) presupposition in (20b).

(20) (a) $\forall x[\ x \text{ is a book} \rightarrow \text{John read } x]$
(b) $\forall x[\ x \text{ is a book} \rightarrow x \text{ is a book}]$

The derivation above assumes that both copies of the NP *book* are retained at LF, the

[25] These operations could also be seen as preceding the entire movement process (including the Copy step); see Kratzer (2009).

[26] $[\![\boldsymbol{\lambda_i}\ \alpha]\!]^g = \lambda x{:}\ \alpha \in \text{dom}([\![\ ]\!]^{g^{i/x}}).\ [\![\alpha]\!]^{g^{i/x}}$. The presuppositions of the abstracted clause become restrictions on the domain of the function.

[27] Presupposition projection under quantificational determiners:
$[\![\textbf{every}]\!] = \lambda P_{<e,t>}.\ \lambda Q_{<e,t>}{:}\ \underline{\forall x[P(x) = 1 \rightarrow x \in \text{dom}(Q)]}.\ \forall x[P(x) = 1 \rightarrow Q(x) = 1)]$

higher copy which restricts **every** in the moved phrase and the lower copy which is responsible for a (locally) non-trivial presupposition in the "trace". As discussed by Fox, this looks like a good assumption for QR. The determiner *every* is a restricted (two-place) quantifier and therefore the higher copy is required by its semantic type. When we turn to wh-movement, however, we are not necessarily forced to treat *which* as a two-place quantifier too (although this is what Karttunen did). We are free to explore an unrestricted existential quantifier instead,[28] and this will mean that the higher copy of the NP can (and must) delete, a consequence we will find helpful below. For a simple *which*-question, I thus propose the following derivation, which parallels (19) above except for the deletion of the higher NP.

(21) base-generated: $\lambda_{\mathbf{p}}$. **Q(p) John invited which student**
copy: $\lambda_{\mathbf{p}}$. **which book [Q(p) John invited which student]**
insert binder and variable: $\lambda_{\mathbf{p}}$. **which student** $\lambda_{\mathbf{x}}$. **Q(p) John invited [which student x]**
delete lower determiner and higher NP: $\lambda_{\mathbf{p}}$. **which** $\lambda_{\mathbf{x}}$. **Q(p) John invited [student x]**
insert type-shifters: $\lambda_{\mathbf{p}}$. **which** $\lambda_{\mathbf{x}}$. **Q(p) John invited [THE student IDENT x]**

Before taking a closer look at how this LF is interpreted, let me observe that treating *which* as an unrestricted existential quantifier comes very close to not treating it as as a quantifier at all and positing instead a separate existential closure operation at the edge of the question. Rullmann & Beck (1998) develop this approach. They put the entire *which*-DP *in situ* at LF and interpret it as a definite, bound by a Q-morpheme that acts as an unselective existential binder. This eliminates any semantic rationale for wh-movement, and therefore does not predict that wh-phrases and their associated Q-morpheme should have to stand in a relation which has the characteristics of movement.[29] But nothing hinges on this choice for now.

The new lexical entry we need for the interpretation of the LF in (21) is given below.

(22) unrestricted **which**: $[\![\mathbf{which}]\!] = \lambda P_{<e,t>}. \exists x. P(x)$

We thus compute the following set of propositions as the denotation for the LF in (21).

(24) $\{p : \exists x.\ p = [\lambda w\text{: student}_w(x).\ \text{invited}_w(\text{John}, x)]\}$
informally: $\{p : \exists x.\ p = \text{that John invited the student x}\}$

This set of propositions differs in a few respects from our previous Hamblin/Karttunen denotation. Notably, due to the unrestricted range of the existential quantifier, the set in (24) has many more members than just one proposition per student. On the other hand, each of the members is a partial proposition rather than a total one. The proliferation of unaccustomed members looks problematic at first, but it seems reasonable to hope that their partiality will render them innocuous.

Consider examples of these "unwelcome" members which are obtained by instantiating the existential quantifier in (24) by a non-student, say by Professor Halle or, for that matter, by

[28] Danny Fox suggested this alternative. Previously I used a covert restrictor for *which* instead, whose value was determined by the presuppositions projected from the copy-trace.

[29] like the Hamblin semantics of Shimoyama

the city of Boston:

(25) [λw: student$_w$(Halle). invited$_w$(John, Halle)]
[λw: student$_w$(Boston). invited$_w$(John, Boston)]

These propositions cannot be asserted without presupposition failure – at least not in the contexts we have in mind for the use of the question in (21), in which it is common knowledge that Halle is not a student and neither, of course, is Boston. In other words, this question semantics generates a set containing countless unassertable propositions, and general constraints on assertability should suffice to explain why these do not correspond to intuitively appropriate answers. On the other hand, those members of (24) which are obtained by instantiating with a person who is presupposed to be a student, e.g., the partial proposition [λw: student$_w$(Igor). invited$_w$(John, Igor)], can be asserted as answers and then will effectively convey the same new information as the corresponding total proposition (λw. invited$_w$(John, Igor)) that we are accustomed to see as a member of the Hamblin/Karttunen denotation. To be precise, the prediction here is not that (24) contains an assertable proposition for each individual who is in fact a student, but rather that it contains an assertable proposition for each individual who the speaker can presuppose to be a student (either because this information is already common ground or because it can be accommodated). From the discourse participants' perspective, this ought to come to the same thing. There are, however, some issues in making this informal story precise; see below.

So far we have generated only one reading, which I propose represents the *de dicto* reading that G&S aimed to capture. To get a *de re* reading as well, again we extensionalize the LFs and allow non-locally bound world variables. This means that (21) becomes (30).

(30) λ_p. which λ_x. Q(p) λ_w. John invited$_w$ THE student$_w$ IDENT x

A second possible LFs for the sentence differs minimally in the world-argument for the noun *student*.

(31) λ_p. which λ_x. Q(p) λ_w. John invited$_w$ THE student$_@$ IDENT x

Let's sketch how these LFs can be used to capture the ambiguity that G&S perceived in (28).

The *de dicto* LF in (30b) denotes the set of partial propositions that we have already computed for the implicit-worlds LF that it replaces. It contains, for each entity x, the partial proposition [λw: student$_w$(x). invited$_w$(John, x)]. The *de re* LF (31), by contrast, turns out to denote a set of propositions which are either total or defined for no world at all. It contains, for each entity x, the proposition [λw: student$_@$(x). invited$_w$(John, x)]]. For those x that are students in the actual world, this is the total proposition that John invited x. For those x that are not actual students, it is the empty function of type <s,t> with no world in its domain. The denotation of the *de re* LF comes very close to Karttunen's own denotation.[30] It contains a (total) proposition for each actual student, and then just one additional element, the empty function. The latter is never an assertable proposition, so its inclusion should have no detectable effect.

[30] I am disregarding that Karttunen also had a restriction to true propositions.

Do we thus capture G&S's two readings of *which*-questions embedded under *know*, e.g. in the sentences in (3) or (36) below?

(36) Mary knows which students John invited.

This can't be answered without at least a rough semantics for the embedding verb *know*, but let's again use the simplified Karttunen meaning (1). Plugging into this the denotation of the *de re* LF (31) for Q, we capture the "de re" reading of (36) as described by G&S easily. Mary just needs to know the true ones among the total propositions {that John invited Igor, that John invited Junya, ...}. This does not require her to know who is a student, and it validates the inference from *Mary knows which people John invited*. Accounting for the "de dicto" reading of (36) is a bit more involved and forces us to say what it takes to "know" a partial proposition. But we must clarify this anyway when we analyze *know* + that-clause and the that-clause has presuppositions. Arguably, to know a partial proposition, one must know both its presupposition and at-issue content. If so, then when we combine *know* in (36) with the "de dicto" LF (30) of the complement clause, we get a sentence that is not true unless Mary knows for every x who is in fact a student invited by John that x is a student and x was invited. There is then no valid inference from *Mary knows which people John invited*.

5. Partitions and answerhood in a semantics with partial propositions

(preliminary thoughts)

A Stalnakerian principle for question speech acts:[31]

(40) When an interrogative sentence is used as a question in a context c,
it must determine a unique partition of c.

one consequence:

Question denotations that depend on the evaluation world are usable only when they don't vary within the common ground.

Therefore, *de re* readings (of matrix *which*-phrases) require that the extension of the NP is common knowledge.

But what consequences are there for *de dicto* readings? This is clear for G&S's proposal, but for mine, I first must say how sets of partial propositions map to partitions.

option 1: Two worlds are in the same cell iff every p that is defined and true in one is defined and true in the other.

option 2: two partitioning steps: First, group together worlds in which the same propositions are defined. Then partition each cell so obtained into subcells in which the same ones of the defined propositions are true.

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[31] inspired by Stalnaker's principle that an assertion must determine a unique update of the context set, which he uses to derive pragmatic presuppositions from semantic presuppositions.

consequence?: the *de re-de dicto* distinction collapses for matrix questions.

6. A puzzling constraint on *de re* construals

recall from initial discussion of pied-piping:

(41) Whose son did you see?
okay meaning: $\{p : \exists y\ [\ \text{person}_@(y)\ \&\ p = \lambda w.\ \text{see}_w(\text{you}, \iota x.\ \text{son-of}_w(x,y))\ ]\ \}$
wrong meaning: $\{p : \exists y\ [\ \text{person}_@(y)\ \&\ p = \lambda w.\ \text{see}_w(\text{you}, \iota x.\ \text{son-of}_@(x,y))\ ]\ \}$
$= \{p : \exists z\ [\ \exists y[\text{person}_@(y)\ \&\ z = \iota x.\ \text{son-of}_@(x,y)]\ \&\ p = \lambda w.\ \text{see}_w(\text{you}, z)\ ]\ \}$

Wrong meaning is equivalent to 'which son did you see?', in the sense of 'which person who is somebody's son did you see?'

In the initial Karttunen-theory, forcing reconstruction of the **t's son** into the question nucleus was sufficient to force the *de dicto* construal. In the extensionalized theory, with world variables in LF and the option of non-local binding, the wrong meaning can be generated despite reconstruction. So forcing reconstruction no longer suffices to rule it out.

Scope of the problem:

first remark: It arises equally in other theories of the internal semantics of questions, in particular alternative semantics (Hamblin, Shimoyama) and set-ups based on wh-abstracts – as long as they treat *de re-de dicto* in the same standard way, with extensionalized LFs.

second remark: Nested *which*-phrases pose what seems to be the same problem.

(42) Which son of which neighbor did you see?
– I saw John, the son of Bill.
– # I saw John. (not perceived as a direct answer)

(43) okay meaning: $\{p : \exists x \exists y\ [\ \text{neighbor}_@(y)\ \&\ p = \lambda w\!: \text{son-of}_w(x,y).\ \text{see}_w(\text{you}, x)\}$
wrong meaning: $\{p : \exists x \exists y\ [\text{neighbor}_@(y)\ \&\ p = \lambda w\!: \text{son-of}_@(x,y).\ \text{see}_w(\text{you}, x)\}$
$= \{p : \exists x\ [\ \exists y[\text{neighbor}_@(y)\ \&\ x = \iota x.\ \text{son-of}_@(x,y)]\ \&\ p = \lambda w.\ \text{see}_w(\text{you}, x)\ ]\ \}$
i.e., 'which son of a neighbor did you see?'

Descriptive generalization:

(44) roughly: A predicate that contains a wh-phrase must be read *de dicto*.

(45) more precisely: A predicate that contains a wh-phrase must depend (for its extension) on the intensional abstractor whose scope matches that of the wh-phrase.

What kind of theory of *de re-de dicto* ambiguity can predict this generalization?

1. Functional readings

(1) Which relative of his did no man invite?
– His mother-in-law.

(2) Which photo of herself did every girl submit?
– Her graduation picture.

challenge for syntacticians: How do such examples satisfy constraints like Weak Crossover and Condition A?

challenge for semanticists: How can the appropriate sets of propositions be computed which contain the expected answers.

2. Functional readings in a Hamblin semantics

Prima facie appeal: If wh-phrases are interpreted *in situ*, as they are in Hamblin semantics, we have LFs that answer the syntacticians' concerns. Let's see if these LFs also get the desired interpretations.

(3) LF: **Q no man $\lambda_{\mathbf{x}}$. $\mathbf{t_x}$ invited which relative of $\mathbf{his_x}$**

computation with Hamblin-semantics rules from previous handout gets us this far:

(4) $[\![\mathbf{t_x} \textbf{ invited which relative of } \mathbf{his_x}]\!]^{@,g}$
$= \{[\lambda w.\ \text{invite}_w(g(\mathbf{x}),y)]: \text{relative}_@(y, g(\mathbf{x}))\}$
$= \{\ p_{st} :\ \exists y\ [\ \text{relative}_@(y, g(\mathbf{x}))\ \&\ p = [\lambda w.\ \text{invite}_w(g(\mathbf{x}), y)]\ ]\ \}$
$= \{\ p_{st} :\ \exists y\ [\ \text{relative}_@(y, g(\mathbf{x}))\ \&\ p = \text{that } g(\mathbf{x}) \text{ invited } y\ ]\ \}$

We now need a Hamblin-semantics rule for lambda abstracts, which we find in Hagstrom (1998) and Kratzer & Shimoyama (2002).[32]

(5) $[\![\lambda_{\mathbf{x}}.\ \phi]\!]^{w,g} = \{\ f_{<e,st>} :\ \forall x.\ f(x) \in [\![\phi]\!]^{w,g^{\mathbf{x}/x}}\ \}$

This gives:

(6) $[\![\lambda_{\mathbf{x}}.\ \mathbf{t_x} \textbf{ invited which relative of } \mathbf{his_x}]\!]^{@}$
$= \{\ P_{<e,st>} :\ \forall x.\ \exists y\ [\ \text{relative}_@(y, g(\mathbf{x}))\ \&\ P(x) = \text{that } x \text{ invited } y\ ]\ \}$

Here is one example of a property that is in this set.

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[32] This formulation is from Kratzer & Shimoyama. Hagstrom's was a bit more round-about.

A similar rule might have been proposed for Hamblinesque intensional abstraction, cf. discussion on p. 7 (in handout for my 2nd lecture).

$[\![{}^\wedge\phi]\!]^{w,g} = \{p_{st}: \forall w.\ p(w) \in [\![\phi]\!]^{w,g}\ \}$

This rule generates a larger set of propositions than we want. (Cf. the example that I constructed to show that no possible rule can yield the desired set of propositions.) In parallel fashion, the K&S rule for abstraction over individuals generates a larger set of properties than we arguably want (see Shan's point, below.)

(7) $\text{IMIL} := \lambda x.\ \lambda w.\ \text{invite}_w(x, \iota y.\ \text{mother-in-law}_@(y,x))$
i.e., $\lambda x.\ \lambda w.$ x invites in w the person who is x's mother-in-law in @,
i.e., inviting one's actual mother-in-law

proof: Take any x. Then there is a y, namely x's mother-in-law in @, such that y is a relative of x in @, and $\text{IMIL}(x) = \lambda w.\ \text{invite}_w(x, \iota z.\ \text{mother-in-law}_@(z,x)) = \lambda w.\ \text{invite}_w(x, y)$

For the top-most node in LF (3)[33], we compute the set of propositions:

(8) $[\![\textbf{no man } \lambda_\mathbf{x}.\ \mathbf{t_x} \textbf{ invited which relative of his}_\mathbf{x}]\!]^@$
$= \{ p : \exists P_{<e,st>} \in [\![\lambda_\mathbf{x}.\ \mathbf{t_x} \textbf{ invited which relative of his}_\mathbf{x}]\!]^@$ & p = that no man has P }

This set contains, e.g., the proposition that no man has the property IMIL, which arguably is the proposition expressed by the answer in dialogue (1). So we have captured the desired functional reading.

Functional reading without bound pronoun

Engdahl observes that a bound pronoun in the *which*-phrase is not necessary to obtain a functional reading. In suitable contexts, the following dialogues are also possible.

(9) Which photo did every girl submit?
– Her graduation picture.

(10) Who did no man invite?
– His mother-in-law.

The Hamblin semantics with the Kratzer-Shimoyama abstraction rule predicts this.

(11) $[\![\mathbf{t_x} \textbf{ invited who}]\!]^{@,g}$
$= \{ p_{st} : \exists y\ [\ \text{person}_@(y)\ \&\ p = \text{that } g(\mathbf{x}) \text{ invited } y\ ]\ \}$
$[\![\lambda_\mathbf{x}.\ \mathbf{t_x} \textbf{ invited who}]\!]^@$
$= \{ P_{<e,st>} : \forall x.\ \exists y\ [\text{person}_@(y)\ \&\ P(x) = \text{that } x \text{ invited } y\ ]\ \}$

Our property IMIL is in this set too.

proof: Take any x. Then there is a y, namely x's mother-in-law in @, such that y is a person in @, and $\text{IMIL}(x) = \lambda w.\ \text{invite}_w(x, \iota z.\ \text{mother-in-law}_@(z,x)) = \lambda w.\ \text{invite}_w(x, y)$

A refinement: enable *de dicto* readings of functional answers

concern to be addressed: Functional answers like *his mother-in-law* in (1) express (or at least can express) propositions like (12a) rather than (12b) or (12c).

(12) (a) $\lambda w.\ \neg\exists x\ [\ \text{man}_\mathbf{w}(x)\ \&\ \text{invite}_w(x, \iota y.\ \text{mother-in-law}_\mathbf{w}(y,x))\ ]$
(b) $\lambda w.\ \neg\exists x\ [\ \text{man}_w(x)\ \&\ \text{invite}_w(x, \iota y.\ \text{mother-in-law}_\mathbf{@}(y,x))\ ]$
(c) $\lambda w.\ \neg\exists x\ [\ \text{man}_@(x)\ \&\ \text{invite}_w(x, \iota y.\ \text{mother-in-law}_\mathbf{@}(y,x))\ ]$

(12a) is a proposition that one can know without knowing e.g. that John didn't invite Mary, even when Mary is actually John's mother-in-law. The semantics we currently have yields question-

[33] I ignore the **Q** here.

denotations that contain (12b) (or perhaps (12c) depending on how we treat *no man*[34]), but it doesn't get (12a) to be included.

(13) John knows which of his relatives no man invited.

(13) can be judged true when John knows that no man invited his mother-in-law but doesn't know anything about who the men or their mothers-in-law are and which person invited which.

The remedy is to revise the rule for *which* so as to produce sets of individual concepts, and accordingly use a suitable variant of the the Hamblinesque Functional Application rule.[35]

(14) $[\![\textbf{which}]\!] = \{f \in D_{<est,se>}: \forall P_{est}.\ P(f(P)(w))(w) = 1\}$

(15) Functional Application 2:
A node α with daughters β of type <u><e,st></u> and γ of type <u><s,e></u> is interpreted as follows:
for all w and g: $[\![\alpha]\!]^{w,g} = \{[\lambda w.\ P_{<e,st>}(x_{se}(w))(w)]: P \in [\![\beta]\!]^{w,g} \ \&\ x \in [\![\gamma]\!]^{w,g}\}$

show that LF (3) now denotes a set that contains (12a) ...

Shan's problem: overgeneration of functional (and pair-list) readings

It was attractive that the Kratzer-Shimoyama rule for Hamblinesque lambda-abstraction gave us functional readings apparently for free. But it will give such readings whenever a quantifier scopes over a wh-phrase, including cases where it does so covertly.

(16) example of the type discussed in Shan (2004):[36]
Which woman invited every man?
*Mary invited John, and Sue invited Bill.

(17) Who invited every man?
(a) *His mother-in-law.
(b) *Every man was invited by his mother-in-law.

(18) one LF for (17), when object scopes over subject:
Q every man λ_x. who invited t_x

---

[34] $[\![\textbf{man}]\!]^w$ could be $\{\lambda x.\ \lambda w'.\ man_{w'}(x)\}$ or $\{\lambda x.\ \lambda w'.\ man_w(x)\}$. Then, if $[\![\textbf{no}]\!] = \{\lambda P_{est}.\ \lambda Q_{est}.\ \lambda w.\ \neg\exists x(P(x)(w)\ \&\ Q(x)(w))\}$, we get $[\![\textbf{no man}]\!]^w$ to be either $\{\lambda Q_{est}.\ \lambda w'.\ \neg\exists x(man_{w'}(x)\ \&\ Q(x)(w'))\}$ or $\{\lambda Q_{est}.\ \lambda w'.\ \neg\exists x(man_w(x)\ \&\ Q(x)(w'))\}$.

[35] I tacitly used this version of Functional Application already when I computed the Japanese example with the Complex-NP island. In that case, I needed to avoid the problem that we discussed in connection with pied-piping in *whose cat did you see?* In order to predict answers of the form *I saw John's cat* rather than of the form *I saw Tonya*, we had to ensure that *cat* was not evaluated rigidly in the actual world. The same issue arises with the Japanese examples, where answers are of the form *Taro ate the ricecakes that Yamada bought* and not *Taro ate those* (pointing to a picture of the ricecakes Yamada bought). I handled this by computing a set of individual concepts for the complex definite description, but glossed over the fact that the FA rule as it was given wasn't compatible with this.

A way to avoid two coexisting variants of FA would be to lift definites (and wh-phrases) to a generalized quantifier type so they take properties as arguments.

[36] Shan uses examples with *no* rather than *every*, but one may question whether *no* in object position is ever allowed to scope over the subject. But *every*-objects generally can outscope subjects.

(19) $[\![\lambda_x.\ \textbf{who invited } \mathbf{t_x}]\!]^@ = \{ P_{<e,st>} : \forall x.\ \exists y\ [\text{person}_@(y)\ \&\ P(x) = \text{that } y \text{ invited } x\ ]\ \}$

This contains properties like BIMIL := $\lambda x.\ \lambda w.\ \text{invite}_w(\iota y.\ \text{mother-in-law}_@(y,x), x)$, i.e., being invited by one's actual mother-in-law. (proof as above)

Shan's conclusion: Kratzer-Shimoyama rule for abstraction must be abandoned.[37]

Another option? Introduce a syntactic constraint that disallows covert movement (QR) out of the scope (sister) of a wh-phrase.

Given this constraint, (18) would be impossible and the LF for (17) instead would have to be (20), with the quantifier scoped below the wh-phrase:

(20) **Q who** $\boldsymbol{\lambda_y}$. **every man** $\boldsymbol{\lambda_x}$. $\mathbf{t_y}$ **invited** $\mathbf{t_x}$

A diagnosis <u>not</u> available in the Hamblin theory: The absence of the functional reading in (17) falls under Weak Crossover, the constraint on bound pronouns that rules out **His mother-in-law invited every man*.

This is arguably a missed generalization – unless perhaps the new required constraint on QR across wh and the traditional Weak Crossover constraint can be naturally unified into one.

3. Engdahl's account[38]

This account is couched in a traditional Karttunen semantics: *which*-DPs are restricted existential quantifiers that scope over **Q**.

(21) LF for (1):

$\boldsymbol{\lambda_p}$. **which** [$\mathbf{E_{z,w}}$ **relative**$_\mathbf{w}$ **of his**$_\mathbf{z}$] $\boldsymbol{\lambda_f}$. **Q**(p) $\boldsymbol{\lambda_w}$. **no man**$_\mathbf{w}$ $\boldsymbol{\lambda_x}$. $\mathbf{t_x}$ **invited**$_\mathbf{w}$ [$\mathbf{t_f}$ **pro**$_\mathbf{x}$ **w**]

(22) suppressing world variables etc., underlining interesting parts:

which [$\underline{\mathbf{E_z}}$ **relative of his**$_\mathbf{z}$] $\underline{\boldsymbol{\lambda_f}}$. **Q no man** $\boldsymbol{\lambda_x}$. $\mathbf{t_x}$ **invited** $\underline{[\mathbf{t_f}\ \mathbf{pro_x}]}$

(23) interpretation:

for which function f that maps individuals to relatives of theirs did no man x invite f(x)?

Engdahl's three innovations:

(i) polymorphic *which*:

a type-flexible meaning for *which*, which allows it to quantify not only over individuals (type e) but also over functions to individuals (e.g. type <e,se>);

---

[37] What should take its place? For Shan, nothing at all, because he advocates a variable-free semantics in which there are no variables and binders in LFs, hence no need for any such rule. Another response is to adopt the version of alternative semantics developed in Rooth (1985), where all denotations are functions from assignments. As discussed by Novel & Romero (2009), it is then not obvious how to treat *which* phrases with free variables in them in the first place. They argue that this can be done, but only in such a way that the resulting version of alternative semantics no longer derives functional readings for free. (It does derive them when further enriched by counterparts of Engdahl's innovations, see their appendix.)

[38] also the account of von Stechow (1990), modulo specifics of implementation

(ii) complex traces:
the option of introducing covert pronominal arguments into traces, so that the trace as a whole can consist of one part that is bound in the usual way by the moved phrase, plus another part which is a pronoun bound from elsewhere;

(iii) pronoun binding within NP:
a covert operator at the edge of the NP restricting *which*, which shifts the type of the NP from a predicate of individuals to a predicate of functions and binds pronouns inside the NP.

(24) innovation (iii): semantics of the **E**-operator in ("**E**" for "Engdahl")[39]:
$[\![\mathbf{E_{x,w}}\ \zeta]\!]^g = \lambda f_{<e,se>}.\ \forall x.\forall w.\ [\![\zeta]\!]^{g^{\mathbf{x}/x,\mathbf{w}/w}}(f(x)(w)) = 1$

example:

(25) $[\![\mathbf{E_{z,w}\ relative_w\ of\ his_z}]\!]^g$
$= \lambda f_{<e,se>}.\ \forall z.\forall w.\ [\![\mathbf{relative_w\ of\ his_z}]\!]^{g^{\mathbf{z}/z,\mathbf{w}/w}}(f(z)(w)) = 1$
$= \lambda f_{<e,se>}.\ \forall z.\forall w.$ f(z)(w) is a relative of z in w
$= \lambda f_{<e,se>}.$ f maps each individual z and world w to a relative of z in w

functional readings without overt pronouns:

(26) Which woman did no man invite?
– His mother-in-law.

two assumptions needed:
– **E** operator is allowed to bind <u>vacuously</u>
– silent arguments in complex trace are <u>pronouns</u> for Weak Crossover

(27) $[\![\mathbf{E_{z,w}\ woman_w}]\!]^g$
$= \lambda f_{<e,se>}.\ \forall z.\forall w.\ [\![\mathbf{woman_w}]\!]^{g^{\mathbf{z}/z,\mathbf{w}/w}}(f(z)(w)) = 1$
$= \lambda f_{<e,se>}.\ \forall z.\forall w.$ f(z)(w) is a woman in w
$= \lambda f_{<e,se>}.$ f maps each individual z and world w to a woman in w

(28) Which woman invited no man?
* 'for which f was no man x invited by the woman f(x)?'

LF would have to be:

(29) **which [$\mathbf{E_z}$ woman] $\boldsymbol{\lambda_f}$. Q no man $\boldsymbol{\lambda_x}$. [$\mathbf{t_f}$ $\mathbf{pro_x}$] invited $\mathbf{t_x}$**
$\mathbf{pro_x}$ fails to be coindexed with a c-commanding A-position

<u>Misgivings about innovation (iii)</u>

Innovation (iii) amounts to denying that *his* in our example (1) is really bound by *no man*.

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[39] The job of **E** can be broken down into separate operations of lambda abstraction (binding the variables **x** and **w**) and shifting type <s,<e,et>> to type <<e,se>,t>. See von Stechow 1990, Jacobson (...) and others.

It claims that in reality *his* is bound by a covert and relatively near-by operator that bears no specific syntactic relation to *no man*. This creates puzzles. Before I elaborate on these puzzles, I hasten to acknowledge that, strictly speaking, a DP (such as *no man*) never binds variables. When we say that a pronoun is bound by a DP in a run-of-the-mill case of a bound-variable reading, this is always shorthand for the pronoun being bound by the lambda operator (binder index) which was created by the movement of that DP. Still, innovation (iii) denies that *his* is bound by *no man* even in this usual, not quite literal, sense. The operator that binds *his* according to innovation (iii) is not the operator created by moving *no man*. It stands in no syntactic relation with *no man*.

One puzzle that this creates concerns the phi-features (person, number, gender) that we see on the bound pronoun. *his* in (1) is 3rd person singular masculine, just as it would have to be if it were bound by *no man*. If we replace *no man* by a quantifier with different features, we see corresponding changes on the pronoun (always assuming a functional reading, of course).

(15) Which picture of <u>herself</u> did <u>no girl</u> submit?

(16) Which relative of <u>theirs</u> did <u>most people</u> complain about?

(17) Which mistake that <u>we</u> have made will <u>none of us</u> ever forgive ourselves?

So the question for a proponent of innovation (iii) is why the pronoun should agree in phi-features with a DP that doesn't bind it.

Whether this is a real problem depends on what feature agreement in bound-variable pronouns is all about in the first place. If it is all a consequence of the semantics of features (e.g., presuppositions associated with the features that will fail when they don't "agree"), then innovation (iii) seems not to hurt. The features on the pronoun will constrain the domain of the questioned function (e.g. to males in (1)). In the nucleus of the question, this function is applied to the individuals quantified over by the pronoun's apparent antecedent, and presupposition failure ensues at this point if the function's domain is too small. There is an extensive debate in the literature about whether the semantic approach to agreement can cover all the data or must be replaced or supplemented by syntactic mechanisms of feature agreement. Kratzer (1998, 2009), von Stechow (2003), and myself (2005) have taken the latter position, although the debate continues (see Spector, Spathas, Jacobson 2008) and I can certainly not do justice to it in this paper. But let me draw your attention to example (17) in the list above, which is modeled on cases that are especially challenging for the purely semantic approach (see Rullmann 200x). I will only conclude here that innovation (iii) entails a commitment to the semantic approach to feature agreement in bound variables. If there are cases that do require a syntactic agreement mechanism and these cases can be replicated in configurations of binding reconstruction (as example (17) suggests to me), then the absence of a real binding relation between the pronoun and its apparent antecedent will, at the very least, force complicated and unattractive revisions in the statement of the syntactic agreement mechanism.

A more familiar challenge for innovation (iii) is the distribution of reflexive vs. non-reflexive pronoun forms. As already observed by Engdahl (1986, p. ?), whether the pronoun inside the *which*-phrase is reflexive depends on the syntactic relation between the wh-trace and the apparent antecedent. E.g. we can have a reflexive *herself* in (15), where the wh-trace is the object of the same clause in which the "antecedent" *no girl* is the subject. But if, for example, we embed the "antecedent" within the subject so that it no longer c-commands the wh-trace, we need a non-reflexive pronoun.

(18) Which picture of *herself/her did every girl's father choose?

The licensing of the reflexive form depends on where the pronoun was in relation to the apparent antecedent before it moved out of its scope[40]. But if, as innovation (iii) would have it, the apparent antecedent is not the pronoun's binder, why is its position relevant at all?

Responses that a proponent of innovation (iii) might make to this could go in two directions. One is to define some notion of "syntactic binding" that is sufficiently different from semantic binding so that the apparent antecedent can be a syntactic binder without being a semantic one. (Binding Theory then looks at syntactic binding, of course.) Proposals in this general spirit were elaborated to some extent in the 1980s and 1990s (see in particular Barss, Higginbotham, Stowell, and von Stechow's refinement of Stowell's system in the 1990 paper), but are not currently seen to compete insightfully against the more ambitious enterprise (initiated by Reinhart 1983; see also Fox, Büring) of basing Binding Theory on an independently established notion of binding that also plays a role in semantics. A different and presumably more appealing stance for a contemporary proponent of innovation (iii) would be that there is no such thing at all as a syntactic binding theory, in the sense of a filter on syntactic representations of anaphoric relations. A step in this direction is the analysis of reflexive pronouns as detransitivizing operators on transitive predicates. This, of course, does not work for our example under consideration, as the meaning of (15) does not involve reflexivation of the 'picture-of'-relation. More sophisticated versions of this type of approach therefore usually distinguish between "real" reflexive pronouns, whose locality requirements follow from the semantic combinatorics, and a class of "exempt anaphora" (Büring's term) which supposedly have weaker constraints related to discourse structure and point of view. If it could be maintained that reflexive-"binding" into an NP is generally of the latter sort, this would (as far as I see) remove all examples in functional questions from the realm of true reflexives and absolve the proponent of innovation (iii) from worrying about them. I am very unclear about the details of this, however, and it seems doubtful that the line between real and exempt anaphora can be drawn in this way (see Büring 2005). At any rate, I haven't seen an explicit way to make principled sense of contrasts like (15) vs. (18) while denying that there is a binding relation between the reflexive and its apparent antecedent in (15).[41]

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[40] The reflexive is not necessarily licensed in its base position. At least in English, movement of a phrase containing a reflexive can create new binding possibilities, as in *Bill knows which picture of himself Mary saw*.

[41] If the reflexive in (7) is, after all, a detransitivizing operator, then it needs to apply to a relation composed of material from both the fronted phrase ('picture') and the question nucleus ('like'). But without reconstruction, there is no LF constituent that corresponds to this.

By the same logic, denying that there is a binding relation between the pronoun and its apparent antecedent poses a problem for the formulation of the constraint responsible for Weak Crossover, if that is another constraint on well-formedness of representations. If, for example, the relevant constraint is that bound variable pronouns must be c-commanded by a binder in an A-position (as maintained by Reinhart 1983 and defended against counterexamples by Büring 2005), we do not expect the implicit operator which supposedly binds the pronoun in (1) to be capable of licensing it. The formulation of the constraint will need to be revised, and it remains to be seen if this is possible without sacrificing simplicity, and without making it a mere accident that the apparent binder must c-command the trace of the wh-phrase that contains the pronoun.

These are the considerations that militate against innovation (iii) and favor instead an analysis that is able to let the pronoun in the fronted phrase of a functional question be really and literally bound by its apparent antecedent in the question nucleus. A necessary part of any such analysis is an LF in which the pronoun is in the apparent antecedent's scope.

4. Functional readings and unrestricted *which*

The unrestricted analysis of *which* combined with Fox's version of the copy-theory of movement is not by itself sufficient to capture functional readings. It helps us do away with Engdahl's innovation (iii) (the **E** operator), but we still need her innovations (i) and (ii). Without them, we could at best get an LF like (37).[42]

(36) Which picture of himself did no boy like?

(37) first attempt at LF:
λ_p. which λ_x. Q(p) λ_w. no boy$_w$ λ_y. t_y liked$_w$ THE [picture$_w$ of himself$_y$] IDENT x

(37) denotes the following set.[43]

(38) $\{p : \exists x[x \in C \ \&\ p = \text{that no boy y liked the [picture of y] x}]\}$

The propositions in this set are each about a particular individual, which is presupposed to be a picture of every boy. This does not capture the functional reading, which makes sense even when there is no such thing as a picture of more than one boy.

innovation (i): polymorphic *which*:

which remains an unrestricted existential quantifier, but can now quantify over any semantic type that "ends in" e. The types ending in e are the types of functions which (after applying to zero or more arguments of whatever types) map to an entity of type e. Type e itself is a special case.

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[42] I simplify by not applying copy-theory to the non-wh quantifier *no boy*.

[43] More precisely, the part after the equality sign is:

λw: $\forall y[\text{boy}_w(y) \rightarrow \text{pic-of}_w(x,y)]$. $\neg\exists y\ [\text{boy}_w(y)\ \&\ \text{likes}_w(y, x)]$.

I have projected a universal presupposition through the quantifier *no boy*.

(39) recursive definition:
e ends in e.
For any type σ that ends in e and any type τ, $<\tau, \sigma>$ ends in e.

(40) polymorphic *which*:
for each type σ that ends in e:
$[\![\textbf{which}^{\sigma}]\!] = \lambda P_{<\sigma,t>}.\ \exists v_{\sigma}.\ P(v)$

Our discussion above led us to conclude that the intended functional reading of (1) requests answers which specify functions of type <e,se>. So we expect to need an LF which employs the homonym **which**$^{\mathbf{<e,se>}}$ from the polymorphic *which*-family. Let's try to amend (37) accordingly.

(42) second attempt at LF:
λ_p. which$^{<e,se>}$ λ_f. Q(p) λ_w. no boy$_w$ λ_y. t$_y$ liked$_w$ THE [picture$_w$ of himself$_y$] IDENT f

Now the variable **f** bound by $\boldsymbol{\lambda_f}$ must be of type <e,se>. But this leads to a type-mismatch in **IDENT f**. **IDENT** requires an argument of type e. We could respond by redefining **IDENT** as polymorphic too, but that would only delay the trouble to the next node up, where we need a predicate of type <e,t> to combine intersectively with **picture of himself$_y$**. Better to fix the problem locally, by allowing the insertion of covert arguments for the function-variable **f** that will "fill it out" to the required type e.

innovation (ii): covert pronouns as arguments of trace

Think of the added arguments as some kind of covert pronouns of the appropriate types (here e and s). In the enriched LF below that this allows us to generate, the simple variable **f** after **IDENT** is now replaced by the complex structure [[**f pro$_y$**] **w**]. This can be interpreted by two applications of functional application and adds up to type e.

(46) third and final attempt at LF:
λ_p. which$^{<e,se>}$ λ_f. Q(p) λ_w. no boy$_w$ λ_y. t$_y$ liked$_w$ THE [pic$_w$ of himself$_y$] IDENT [[f pro$_y$] w]

interpretation:

(47) $[\![\textbf{picture}_\textbf{w}\ \textbf{of himself}_\textbf{y}]\!]^g$ = λx. x is a picture of g(**y**) in g(**w**)
$[\![\textbf{IDENT f y w}]\!]^g$ = λx. x = g(**f**)(g(**y**))(g(**w**))
$[\![\textbf{THE picture}_\textbf{w}\ \textbf{of himself}_\textbf{y}\ \textbf{IDENT f pro}_\textbf{y}\ \textbf{w}]\!]^g$
= g(**f**)(g(**y**))(g(**w**)), if g(**f**)(g(**y**))(g(**w**)) is a picture of g(**y**) in g(**w**), otherwise undefined
$[\![\lambda_\textbf{y}.\ \textbf{t}_\textbf{y}\ \textbf{liked}_\textbf{w}\ \textbf{THE [picture}_\textbf{w}\ \textbf{of himself}_\textbf{y}\textbf{] IDENT f pro}_\textbf{y}\ \textbf{w}]\!]^g$
= λy: g(**f**)(y)(g(**w**)) is a picture of y in g(**w**). likes$_w$(y, g(**f**)(y)(g(**w**)))]

The denotation of the question nucleus in (46) (projecting a universal presupposition through *no boy*) works out to the partial proposition (48).

(48) $[\![\lambda_\textbf{w}.\ \textbf{no boy}_\textbf{w}\ \lambda_\textbf{y}.\ \textbf{t}_\textbf{y}\ \textbf{liked}_\textbf{w}\ \textbf{THE [picture}_\textbf{w}\ \textbf{of himself}_\textbf{y}\textbf{] IDENT f pro}_\textbf{y}\ \textbf{w}]\!]^g$
= λw: $\forall$y[boy$_w$(y) $\rightarrow$ g(**f**)(y)(w) is a picture of y in w] .
$\neg\exists$y[boy$_w$(y) & likes$_w$(y, g(**f**)(y)(w))]

For a given function f as value for g(**f**), this proposition presupposes that every boy is in the domain of f and is mapped by f to a picture of him; and it asserts that no boy likes what f maps him to. We can see here how the projected presupposition effectively restricts the range of function variable to functions which map boys to pictures of them. Finally, the denotation of LF (46) is the following set of propositions.

(49) $\{p : \exists f_{ese}$.
$p = [\ \lambda w{:}\ \forall y[boy_w(y) \rightarrow \text{pic-of}_w(f(y)(w), y)]\ .\ \neg\exists y[boy_w(y)\ \&\ likes_w(y, f(y)(w))]\ ]\}$

This set contains partial propositions about functions of type <e,se>. Each such proposition presupposes about one such function that it maps all boys to pictures of them, and asserts about it that no boy liked what it maps him to. We can consider, for example, the graduation-picture function that is defined as follows:

(50) $f_0 := \lambda x.\ \lambda w{:}\ [boy_w(x)\ \&\ \exists!y.\ \text{graduation-picture-of}_w(y, x)].\ x\text{'s graduation-picture}_w$
i.e., the partial function which is defined for individuals x and worlds w where x is a boy in w and has a unique graduation picture in w, and which maps each such pair x, w to x's graduation-picture in w

This function satisfies the presupposition, and an answer to the question which identifies this function asserts that no boy liked his graduation picture.

<u>Comparison with Engdahl</u>

– simplification of semantic machinery:
no need to type-shift nouns (NPs) into anything other than type <e,t>

– simpler syntax of binding (Binding Theory, Weak Crossover, feature transmission):
apparent antecedent is real binder (of all copies of the pronoun)

We do, however, lose one potentially useful prediction of Engdahl. Consider again our first, rejected, attempt at generating an LF for the functional reading.

(51) which λ_x. Q no boy λ_y. t_y liked THE [picture of himself$_y$] IDENT x
'which x that is a picture of every boy did no boy like?'

We concentrated on the task of generating another LF which does capture the functional reading, but the system we developed still generates (51) too. Engdahl's proposal, by contrast, ensures that (52) is true.

(52) [*which* NP] quantifies over functions of at least as many arguments as there are bound pronouns in NP.

two questions:

(a) Are there empirical problems with not enforcing (52)?
(b) Does Engdahl predict (52) in a principled way?

Question (a) is discussed by Jeremy Kuhn[44]. He concludes that there are no obvious empirical

[44] Unpublished Brown University undergraduate thesis. (I have only seen a partial draft so far.)

problems as far as *which*-questions are concerned, but there are if the analysis is extended to definite descriptions.

(53) Which relative of his did no man invite?
– Mary.

(54) #The relative of his that no man invited showed up anyway.

(55) The relative of theirs that no man invited showed up anyway.

We (or Engdahl, for that matter) are not automatically committed to letting definite descriptions denote functions too. More on this later ...

Re question (b): One could have defined other operators in Engdahl's system and thereby removed prediction (52). E.g.:

(56) $[\![\mathbf{E}^{-}_{\mathbf{x,w}}\ \zeta]\!]^{g} = \lambda y_e.\ \forall x.\forall w.\ [\![\zeta]\!]^{g^{\mathbf{x}/x,\mathbf{w}/w}}(y) = 1$

By what criteria is $\mathbf{E}^{-}$ less natural than $\mathbf{E}$?[45] Once we elucidate these criteria, can we exploit them also in the reconstruction theory?

[45] I have yet to assess whether the implementation of Engdahl in variable-free semantics (Jacobson 1994, 200x) has a truly principled answer to this question.

Functional readings in relative clauses/definite descriptions

1. Specificational sentences

(1) The relative of his that no man invited was his mother-in-law.

– identity of functions accounts (Stechow 1990, Jacobson 1994, Sharvit 1999, 2009):

pre-copular and post-copular DP each denote a function (of type <e,e>)

– identity of propositions accounts (Schlenker 2003, Romero 2005, 2007, 2011):
pre-copular DP is a concealed question, postcopular DP an elided sentence

The accounts differ most dramatically regarding the post-copular DP.

identity-of-propositions account: postcopular phrase is a clause at LF:

(2) no man λ_x. t_x invited his_x mother-in-law
(denotes a proposition)

This raises questions for the syntactician (what licenses that ellipsis?), but the semantics is easy: *his* is an ordinary bound pronoun with a quantificational antecedent.

identity-of-functions account: postcopular phrase has (almost) no covert structure at LF:

(3) λ_x. his_x mother-in-law
(denotes the function $\lambda x_e.\ \iota y_e.$ mother-of(y,x))

How would this LF/meaning come about? – One would posit a freely available lambda-abstractor that can be inserted at the edge of the DP and coindexed with the pronoun.[46]

"Heycock's Problem":

(4) His mother is his greatest fan.
can mean: 'John's mother is John's greatest fan'. (referential pronouns)
cannot mean: '[λx. x's mother] = [λx. x's greatest fan]' (bound pronouns)

Free lambda-abstraction overgenerates this unattested reading.

This is an argument against the identity-of-functions analysis and in favor of the identity-of-propositions approach (alongside other arguments by Schlenker, Romero). So let's discard the identity-of-functions approach.

What about the pre-copular DP in the identity-of-propositions analysis?

target denotation: 'the answer to the question 'which relative of his did no man invite?''

How is this obtained compositionally? A natural proposal (Romero): first construct a definite

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[46] If the "Engdahl"operator **E** is decomposed into more elementary operations, this "generalized abstraction" (von Stechow's 1990 term) would be one of them.

description of a function (same as in the identity-of-functions approach), then apply an operation to convert it into a (concealed) question meaning. This implies we need definite descriptions to be able to denote functions.

(5) desired denotation for *the relative of his that no man invited*:
$\iota f_{<e,e>}. \forall x.\ \text{relative}(f(x), x)\ \&\ \neg\exists x[\text{man}(x)\ \&\ \text{invited}(x, f(x))]$

make **the** polymorphic:

(6) for each type σ that ends in e:
$[\![\mathbf{the}^{\sigma}]\!] = \lambda P_{<\sigma,t>}:\ \exists! v_{\sigma}.\ P(v) = 1.\ \ \iota v_{\sigma}.\ P(v) = 1$

This is not enough. Unless we want to reintroduce Engdahl's operator after all, we also need a raising analysis of the relative clause.

(7) derivation:
the [no man invited relative of his]
QR: **the [no man λ_x. t_x invited relative of his_x]**
relativization, copy-step: **the [relative of his_x [no man λ_x. t_x invited relative of his_x]]**
insert vbl and binder: **the [relative of his_x λ_f. no man λ_x. t_x invited [relative of his_x] f]**
deletion of upper copy: **the λ_f. no man λ_x. t_x invited [relative of his_x] f**
insert type-shifters and covert pronoun:
the λ_f. no man λ_x. t_x invited THE [[relative of his_x] IDENT f(pro_x)]

How do presuppositions project from complement of **the**? one option(?):

(8) $[\![\mathbf{the}^{\sigma}]\!] = \lambda P_{<\sigma,t>}:\ \exists! v_{\sigma}[v \in \text{dom}(P)\ \&\ P(v) = 1].\ \ \iota v_{\sigma}[v \in \text{dom}(P)\ \&\ P(v) = 1]$

interpretation of (7):
presupposed condition on f: $\forall x[\text{man}(x) \rightarrow \text{relative}(f(x), x)]$
asserted condition on f: $\neg\exists x[\text{man}(x)\ \&\ \text{invited}(x, f(x))]$

alternative (Schlenker 2003): construct question meaning directly from predicate, without detour through a definite description. (Definiteness might be contributed higher in the structure.)

Prediction (on both alternatives): Definite descriptions that denote concealed questions about functions always contain relatives with a head-raising structure.

2. Relative clauses in functional *which*-DPs

simple case:

(9) Which woman that he doesn't like did every man (nevertheless) invite?
– His mother-in-law.

This works the same as our original example *Which relative of his did no man invite?* The fact that the bound pronoun is in a relative clause makes no difference. A standard analysis of relative clauses (head external, abstraction over individuals) will do.

more involved:

(10) Which woman that no man likes did every man (nevertheless) invite?
– His mother-in-law.

This turns out to require head-raising relative and a covert polymorphic *THE*:

derivation for the sub-tree *woman that no man likes* (the complement of *which*):

(11) base-generated: **no man likes woman**
QR **no man**: **no man** λ_x. t_x **likes woman**
copy **woman**, insert binder and vbl:
woman λ_f. **no man** λ_x. t_x **likes** [**woman f**]
delete upper copy, insert type-shifters and covert pronoun:
λ_f. **no man** λ_x. t_x **likes THE woman IDENT f**(**pro**$_x$)

(12) denotes: λf: $\forall x[\text{man}(x) \rightarrow \text{woman}(f(x))]$. $\neg\exists x[\text{man}(x) \ \&\ \text{like}(x, f(x))]$

In the derivation for the matrix clause, I abbreviate the above sub-tree as α.

(13) base-generated: **Q every man invited which** α
QR **every man**: **Q every man** λ_y. t_y **invited which** α
copy which-phrase, insert binder and variable:
which α λ_g. **Q every man** λ_y. t_y **invited which** α **g**
delete higher α and lower **which**, insert type-shifters:
which λ_g. **Q every man** λ_y. t_y **invited THE** α **IDENT g**
insert covert pronoun:
which λ_g. **Q every man** λ_y. t_y **invited** [[**THE** α **IDENT g**] **pro**$_y$]

The covert pronoun here had to be merged as sister to the entire definite description, not as sister to **g**. This is because of the type of α, a predicate of functions. For the same reason, both **IDENT** and **THE** must be higher-type instances of a polymorphic meaning.

interpretation:

(14) presupposition about **g** triggered in object of *invite*:
α is true of g, i.e., g is such that
$\forall x[\text{man}(x) \rightarrow \text{woman}(g(x))]$ & $\neg\exists x[\text{man}(x) \ \&\ \text{like}(x, g(x))]$
i.e., g maps every man to a woman he doesn't like

(15) question nucleus:
presupposition (same as above): g maps every man to a woman he doesn't like
assertion: every man y invited g(y)

<u>Summary and conclusions</u>

my central working hypothesis:

(16) There are no mechanisms for binding a pronoun other than coindexing it with the trace of a moving DP.
(i.e., no operations like Engdahl's operator or free lambda abstraction)

This turned out to imply the following further commitments:

(17) *which* is unrestricted, its superficial restrictor is interpreted (only) as part of a complex Foxian wh-trace.

(18) Presupposition projection from the trace accounts for restriction of answer space.

(19) Specificational sentences must have postcopular elided clauses (following Schlenker).

(20) Certain relative clauses must have head-raising derivations and be headless at LF. (This includes relatives in the precopular part of specificational sentences, and some relatives that modify *which* in functional questions.)

(21) In addition to polymorphic *which* that quantifies over functions, we need polymorphic versions of *the* in its covert and probably also its overt version.

Alternative questions

an analysis based on Larson (1985) and Han & Romero (2004)

(1) ... whether John saw Mary or Sue.
   (a) yes/no reading 'is it true that he saw one of the two women?'
   (b) alternative reading: 'which of the two women did he see?'

(2) ... whether it rained or it snowed.
   (a) yes/no reading 'is it true that one of the two wheather conditions obtained?'
   (b) alternative reading: 'which of the two wheather conditions obtained?'

(disregard the yes/no readings)

Larson: *whether* originates at the edge of the disjunction and moves to Spec of CP

LFs:

(3) λ_p. whether λ_i. Q(p) John saw [t_i [Mary or Sue]]

(4) λ_p. whether λ_i. Q(p) [t_i [it rained or it snowed]]

What is the type of the trace, the meaning of *whether*, the meaning of *or*?

intuition to be implemented: *whether Mary or Sue* relates to *(either) Mary or Sue* in the same way as *which woman* to *some woman*.

With the Larsonian syntax above, *whether*-clauses have a wh-word moved and its restrictor "stranded" inside the question nucleus, analogous to what I have assumed for *which* – except that here the stranded restrictor is overt. To make these structures interpretable, we can use the same type-shifters as in Fox's trace conversion.

(3) λ_p. whether λ_i. Q(p) John saw THE [IDENT t_i] [IDENT Mary or IDENT Sue]
   $\{ p : \exists x.\ p = \lambda w{:}\ x = \text{Mary} \vee x = \text{Sue}.\ \text{John saw x in w} \}$
   $= \{ p : \exists x\ [[x = \text{Mary} \vee x = \text{Sue}]\ \&\ p = \lambda w.\ \text{John saw x in w}] \} \cup \{\varnothing\}$

Discussion: Do we really need this analysis? (1) may result by ellipsis from *whether John saw Mary or John saw Sue*, and Han & Romero in fact argue that it must. Then the analysis of (1) reduces to the analysis of (2). But (2) allows a simpler analysis[47], applying a set-union operation to the denotations of **Q it rained** and **Q it snowed**.

The simpler analysis does not suffice for those cases where *whether* moves non-locally and ellipsis is not an option (as shown by Schwarz 1999 and Romero & Han).

(4) ... whether John thought that it rained or snowed
   LF: λ_p. whether λ_i. Q(p) John thought [t_i [it rained or it snowed]]

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[47] spelled out in a handout by Benjamin Spector that he shared with me