

PIED-PIPING & QUESTION COMPOSITION II

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1 Roadmap

The plan for today:

- ✓ Back to the question of how to compositionize Karttunen: an alternative approach based on selective scope-takers (Heim 1994, Cresti 1995).
- ✓ An examination of how to compose pied-piped material, starting with a simple example; the problem that our assumptions give rise to: the *total de re* interpretation (von Stechow's 1996 problem).
- ✓ Developing an analysis of pied-piping via cyclic scope (Charlow 2019, Demirok 2019).
- Recap of Tuesday's class, addressing some additional remarks.
- How is the *ban* on totally *de re* readings derived?
- Logical properties of \star and $?$.
- *Wh-in-situ* and island pied-piping.
- Nested questions, the limits of pied-piping, and Sudo's puzzle.
- De-dicto readings of *wh*-expressions.
- Baker's ambiguity.

Further reading for today's class

- Yasutada Sudo. 2017. De re readings of nested which-phrases in embedded questions. *Snippets* (31). 30–31. <http://www.ledonline.it/snippets/index.html> (30 September, 2019)
- Veneeta Dayal. 2017. *Questions* (Oxford Surveys in Semantics and Pragmatics). Oxford, New York: Oxford University Press. 352 pp.: chapter 7

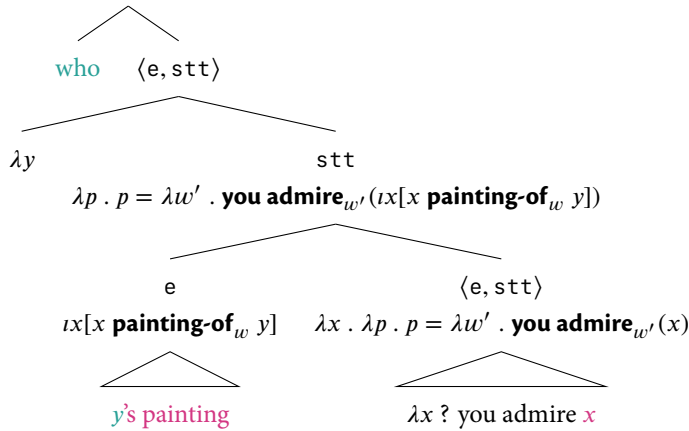
2 Recap

Focus: the interpretation of pied-piping configurations, such as (1).

- (1) Whose painting do you admire *t*?

First attempt: Scope the pied-piper *who* out of the pied-piped material at LF:

- (2) $\lambda p . \exists y [p = \lambda w' . \text{you admire}_{w'} (ix[x \text{ painting-of}_w y])]$



Important: This predicts that the pied-piped material is interpreted in the *evaluation world*.

von Stechow's problem: this amounts to a totally *de re* interpretation of the pied-piped material; the question “whose painting do you admire?” is predicted to be a question asking to identify *paintings*.

- (3) a. $\llbracket \text{whose painting do you admire?} \rrbracket^{\textcircled{a}} = \{ \lambda w' . \text{you admire}_{w'} (ix[x \text{ painting-of}_{@} y]) \mid y \in D \}$
 b. $\llbracket \text{which painting do you admire?} \rrbracket^{\textcircled{a}} = \{ \lambda w' . \text{you admire}_{w'} x \mid \text{painting}_{w'}(x) \}$

Illustration 1: The totally *de re* interpretation erroneously predicts equivalence in an embedding context.

- (4) a. Josie knows whose painting you admire.
 b. Josie knows which painting you admire.

Illustration 2: Applying Kai's adaptation of Stalnaker's third rule of assertion to pied-piping configurations predicts counter-intuitive results.

- (5) a. Which painting do you admire?
 Predicted: ✓ *it's common ground what the paintings are*
 b. Whose painting do you admire?
 Predicted: ✗ *it's common ground what the paintings are*

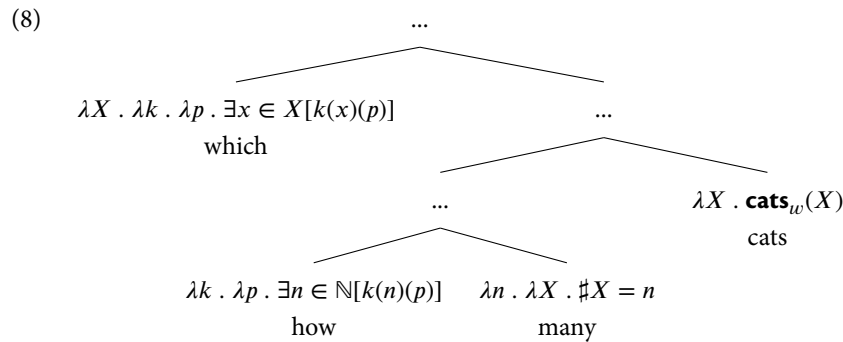
Illustration 3: *How many* questions, via Kai’s discussion of Irene’s notes (newly added to the textbook).

- (6) a. **How many cats** did you adopt?
- b. \neq **Which cats** did you adopt?

We predict equivalence based on the following LF:

- (7) How λn [*wh n-many cats*] λx ? you adopt x

Possible structure of a *how many* phrase on the selective scope-taker analysis (*how* needs to be scoped out of the pied-piped material in order for composition to proceed):



N.b., evidence for split scope analysis (Cresti 1995):

- (9) How many books do you want to read?
 - a. Three.
 - b. There are three books I want to read — Moby Dick, The White Guard, and Heart of Darkness.

Homework exercise

Work through this example; demonstrate how this particular instantiation of von Stechow’s problem arises for *how many* questions.

von Stechow’s analysis: sub-extract the *wh*-phrase at LF, and syntactically reconstruct the remnant pied-piped material.

- (10) **Who** λx do you admire [*x’s painting*].

Stan’s remark: Postal’s (1993) *Secondary Strong Crossover* (SSCO) configuration might be taken as evidence that von Stechow’s analysis is (in fact) on the right track.¹

¹ Thanks to Stan for sharing this paper with me.

(11) * [Whose sister] did they inform him that Joan would call *t*?

The suggestion: syntactically reconstructing the pied-piped remnant results in a SCO violation:

(12) *Who λx did they inform him that Joan would call [*x*'s sister]?
cf. *Who λx did they inform him that John would call *x*?

Modern approaches to weak crossover however recognize that *leftness* is a crucial component to any analysis of crossover, since pronouns can be bound from non-c-commanding positions, as long as the binder is to the left of the pronoun (Barker & Shan 2014, Chierchia 2020).²

(13) [Whose valet] parked their car for them?

Barker & Shan (2014), for example, converge on roughly the following generalization: a binder *x*, may bind a pronoun *y*, iff the highest A-position occupied by *x* is to the left of *y*, and *x* takes scope over *y*.

Postal's SSCO configuration is therefore encompassed by recent statements of the WCO generalization, since the highest A-position occupied by *who* is *not* to the left of the pronoun *him*.

Towards an analysis: treat *which*-phrases as alternative sets; factor out the scopal part of the meaning into a polymorphic operator \star , which takes an alternative set and gives back a selective scope-taker.

(14) $\llbracket \text{which painting} \rrbracket^w = \{ x \mid \text{painting}_{iw}(x) \}$ $\langle e, t \rangle$

(15) $\star := \lambda X_{\sigma t} . \lambda k_{\langle \sigma, \tau t \rangle} . \lambda p_{\tau} . \exists x \in X[k(x)(p)]$ $\langle \sigma t, \langle \langle \sigma, \tau t \rangle, \tau t \rangle \rangle$

Give ? a more polymorphic type (but demand that it takes an intensional argument):

(16) $? := \lambda p . \{ p \}$ $\langle s\tau, \langle s\tau, t \rangle \rangle$

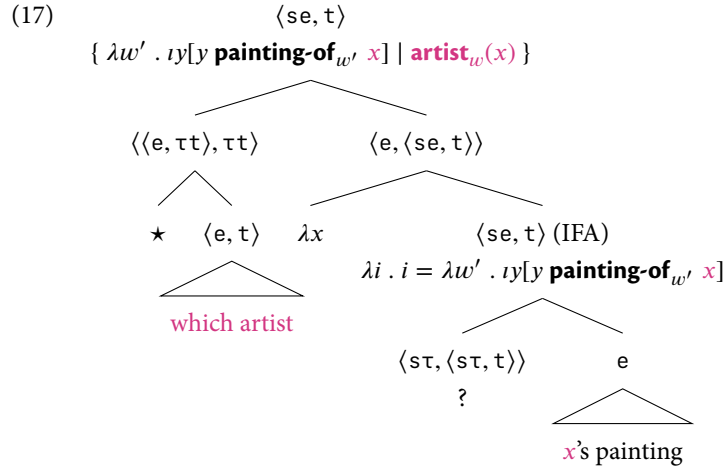
Crucial components: (i) both \star and ? are *polymorphic*, and (ii) ? is not as polymorphic as it might have been; it demands an intensional argument.³

Analysis i: in order to compose a pied-piping configuration, the pied-piper undergoes *internal wh-movement* to the edge of the pied-piped constituent (Heck 2008), mediated by \star and ?. Since ? demands an intensional argument, we compositionally construct a *set of individual concepts*.⁴

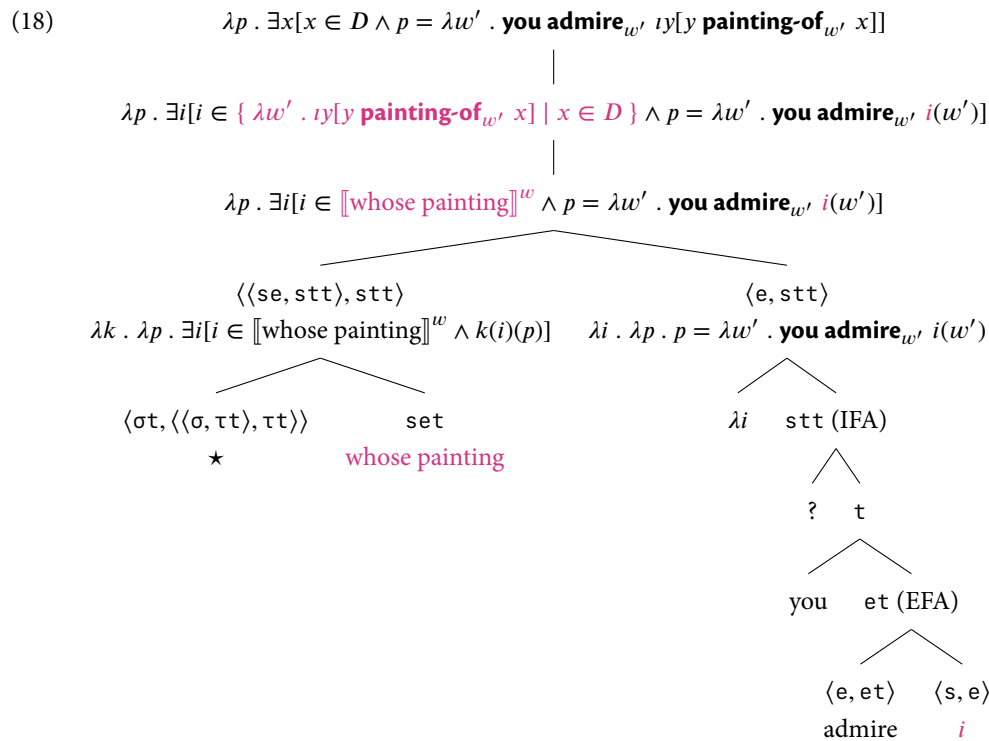
² The idea that *leftness* is part of the statement of the WCO generalization goes back to Chomsky 1976 in fact.

³ This will force pied-piped material to reconstruct for intensionality.

⁴ From this perspective, the fundamental semantic contribution of a *wh*-expression is to introduce a *set of alternatives*; internal *wh*-movement via \star and ? provides a way of compositionally constructing a *generalized wh-expression* about intensional objects compositionally.



Analysis ii: the generalized *wh*-expression created by internal *wh*-movement is scoped out, mediated by \star and $?$; the generalized *wh*-expression leaves behind an intensional trace, and therefore semantically reconstructs for intensionality.



The resulting meaning is in fact *equivalent* to if we had simply scoped out the contained *wh*-expression.

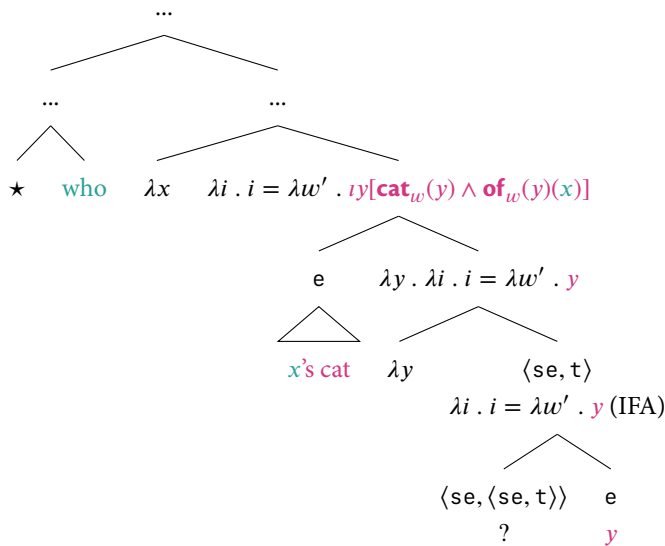
Deriving the *ban* on the totally *de re* reading: we showed that *de re* readings are not computed, based on conservative assumptions about what the syntax

delivers. The system is however powerful enough to derive total *de re* readings by remnant-moving the pied-piped material.

We scope 's painting above the ? responsible for triggering internal *wh*-movement:

(19) Who's painting do you admire?

(20)



By covertly moving the pied-piped remnant above the internal ?, we can generate total *de re* readings.⁵

Demirok's suggestion: when ? composes with the extensional trace of remnant movement, it does so via IFA, and creates a *constant* function.

$$(21) \quad \llbracket ? t_1 \rrbracket^{g,w} = \lambda i . i = \lambda w' . g(1)$$

Derivations which compositionally create constant functions (i.e., vacuous binding configurations) are avoided.

2.1 Why does this work?

Let's consider an abstract representation of how pied-piped material composes:⁶

$$(22) \quad (\llbracket \text{which artist} \rrbracket^w \star (\lambda x . ? \llbracket x\text{'s painting} \rrbracket^w)) \star (\lambda i . ? \llbracket \text{you admire } i \rrbracket^w)$$

The following is a general fact about \star .⁷

⁵ We might have independent, syntactic reasons not to countenance this kind of extremely local movement (see, e.g., Abels 2003 on *antilocality*).

⁶ it's perspicuous to use infix notation for \star .

⁷ See Charlow 2019 for the proof; he calls \star , \gg .

The operators ? and \star , are an instantiation of a more general mathematical structure called a *monad*; associativity and left identity are two laws that are definitional of monads. In the computer science/category theory literature \star is called *bind*, and ? is called *return/unit* (Wadler 1995, Shan 2002b).

(Actually, this isn't *quite* correct — Demirok's ? isn't polymorphic enough to instantiate a monad, since it requires an intensional argument. The laws still hold, however.)

(23) **Associativity of \star :**

$$(m \star f) \star g = m \star (\lambda x . (f x) \star g)$$

Now let's consider the LF delivered by our method for composing pied-piping structures:

$$(24) \quad ([[\text{which artist}]^w \star (\lambda x . (? [x's painting]^w))] \star (\lambda i . ? [\text{you admire } i]^w))$$

By *associativity* we can rewrite our pied-piping LF:

$$(25) \quad [[\text{which artist}]^w \star (\lambda x . (? [x's painting]^w))] \star (\lambda i . ? [\text{you admire } i]^w))$$

The following is a general fact about \star and $?$ (again, see [Charlow 2019](#) for the proof):

$$(26) \quad \textbf{Left identity: } (? i) \star f = f i$$

Now by *left identity* we can rewrite (25):

$$(27) \quad [[\text{which artist}]^w \star (\lambda x . ? [\text{you admire } x's painting]^w))$$

Another way of thinking about this: our method for interpreting pied-piping automatically semantically reconstructs the pied-piped material.

2.2 *Wh-in-situ and locality*

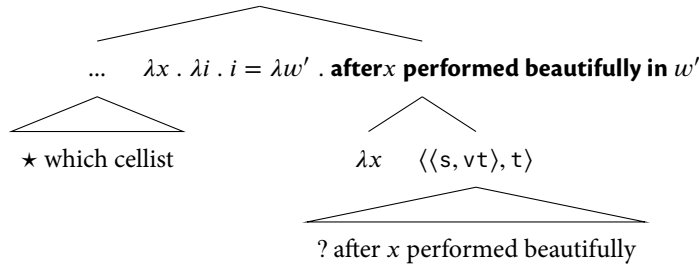
As is well known, the scope of *wh-in-situ* appears to be, in many languages, *island insensitive*

- (28) a. Which flautist cried [after which cellist performed beautifully]?
 b. Henk cried after Maria performed beautifully.

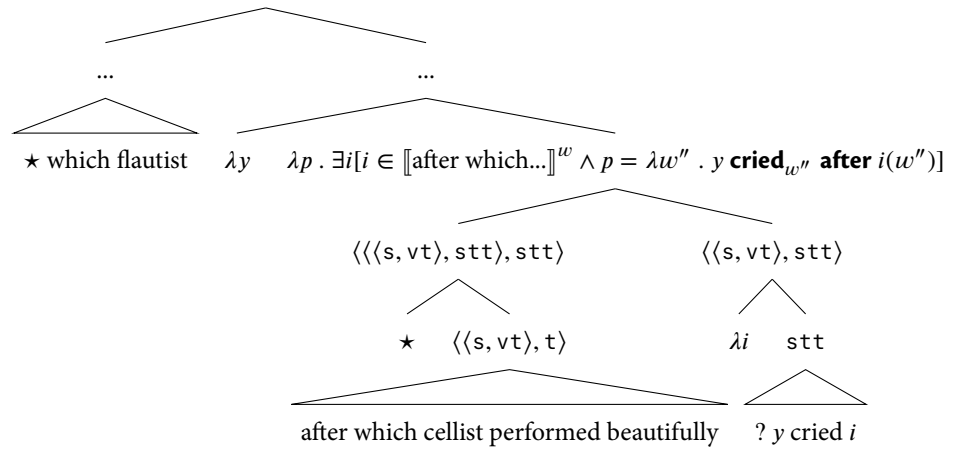
Putting the single-pair/pair-list distinction to one side, our pied-piping mechanism can be invoked to account for the observation that the scope of *in-situ wh-expressions* appears to be unbounded.

Let's assume that adverbial modifiers are of type vt .

(29) $\langle\langle s, vt \rangle, t \rangle$
 $\{ \lambda w' . \text{after } x \text{ performed beautifully in } w' \mid \text{cellist}_{w'}(x) \}$



(30) $\lambda p . \exists y, x [\text{flautist}_{w'}(y) \wedge \text{cellist}_{w'}(x) \wedge p = \lambda w'' . y \text{ cried}_{w''} \text{ after } x \text{ performed beautifully in } w'']$



Since this mechanism can apply cyclically, we can also account for cases like the following (compute the meaning as an exercise):

(31) Which flautist cried [after [which orchestra's first violin] performed beautifully].

2.3 Overt island pied-piping

Overt island pied-piping of the kind that we've suggested happens covertly is cross-linguistically rare, it seems.⁸

Finnish is one language where this phenomenon has been extensively demonstrated. All Finnish data in the following it taken from [Huhmarniemi 2012](#):

(32) a. **kenelle* Pekka luki *t* kirjoitetun kirjeen?
 who.ALL Pekka read *t* written.PTCP letter.ACC
 "Which person *x* is such that Pekka read the letter written to *x*?"
 (intended)

⁸ At least, it has been reported in a small number of languages, including Basque, Haida, and Tlingit.

- b. [*kenelle kirjoitetun kirjeen*] Pekka luki *t*?
 who.ALL written.PTCP letter.ACC Pekka read *t*
 “Which person *x* is such that Pekka read the letter written to *x*?”

Huhmarniemi argues that the *wh*-expression which triggers pied-piping should always be at the *left edge* of the pied-piped constituent.

- (33) a. **pojan kenelle kirjoittaman kirjeen* Pekka luki
 boy.GEN who.ALL written.PTCP.ACC letter.ACC Pekka read
 “Which person *x* is s.t. Pekka read the letter written by the boy to *x*?”
 b. *kenen äidilleen kirjoittaman kirjeen* Pekka luki?
 who.GEN to.3SG.mother written.PTCP letter.ACC Pekka read
 “Which person *x* is s.t. Pekka read the letter written by *x* to *x*’s mother?”
 c. *kenelle kirjoitetun kirjeen* Pekka luki?
 who.ALL written.PTCP letter.ACC Pekka read
 “Which person *x* is such that Pekka read the letter written to *x*?”

As Demirok observes, this seems to be a special case of Heck’s (2008) *Edge generalization*:

- (34) *Edge generalization*
 If α pied-pipes β , then α must be at the edge of β .

(Recall David’s remarks on *picture of whom* pied-piping on Tuesday.)

- (35) a. I wonder [whose portrait] you’re admiring.
 b. *I wonder [portraits of whom] you’re admiring.

picture of whom pied-piping (“massive” pied-piping) seems to be limited in English at least to local matrix questions.

- (36) a. ??Pictures of *whom* did John like?

The edge generalization is clearly a nice fit for the picture of pied-piping we’ve laid out so far.

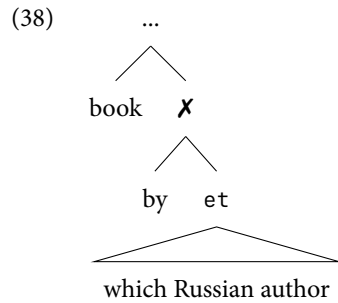
2.4 Nested questions: the limits of pied-piping

As we learned from Danny, *which*-phrases can *contained* other *wh*-expression; creating a configuration which we’ve been calling a *nested which-phrase*.⁹

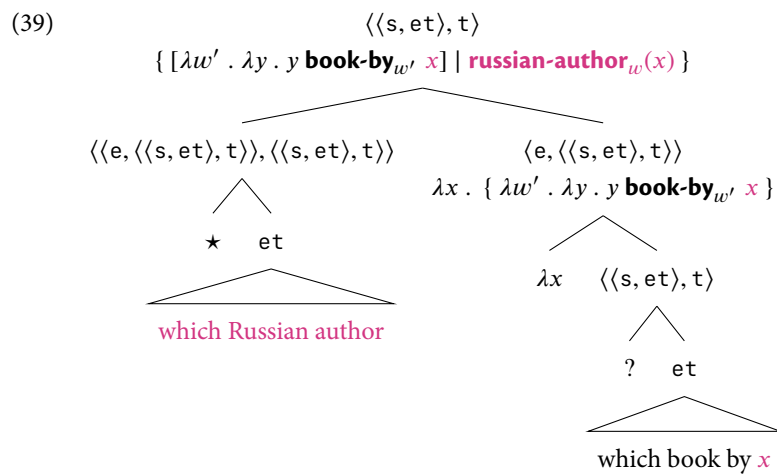
- (37) Which book by which Russian author did you read?

⁹ Richards (2004) evocatively calls these *Russian-doll questions*.

Let's consider what the machinery we've assembled delivers.



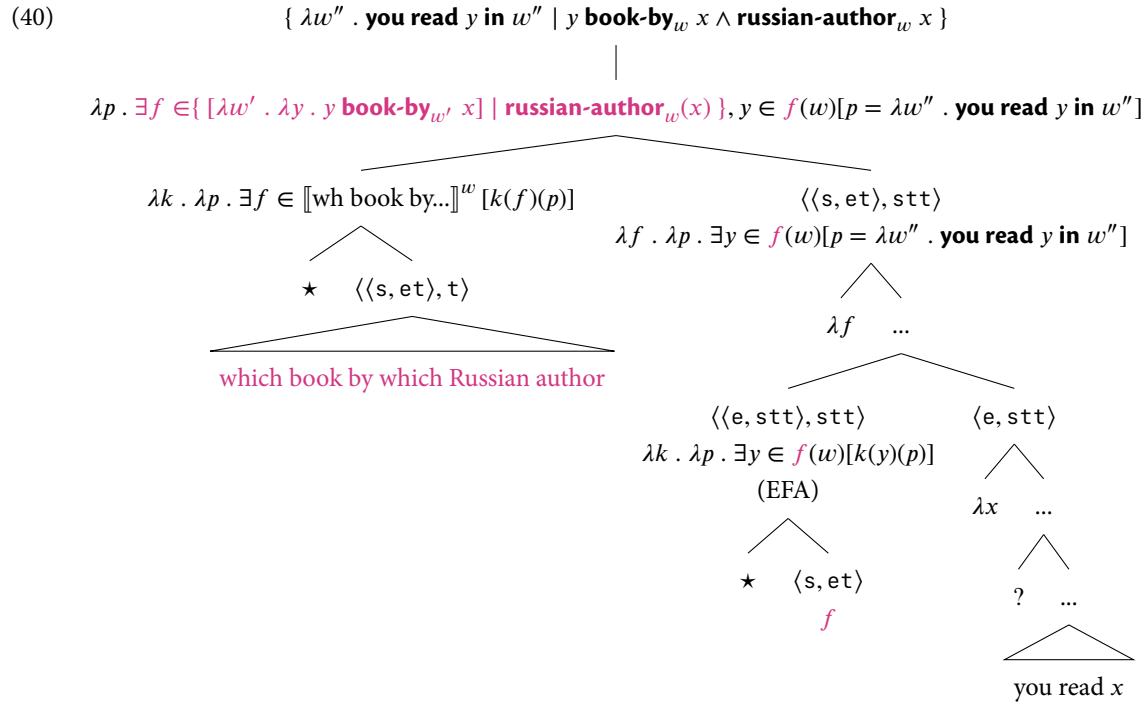
The most conversative option would seem to be to scope the *in-situ wh-expression* (via ★) to the edge of the containing *which*-phrase, with the help of a mediating ?.



The result is a *set of world-sensitive sets of books*, which vary according to the Russian author they are by.

If we shift the resulting constituent via ★, we will end up with a selective scope taker which leaves behind a trace of type $\langle s, et \rangle$.

In order for composition to proceed, we must compose the *trace* with a ★ operator via EFA, and scope *it* over a ? operator.



We get back a set of propositions of the form *that you read* y , where y is a book by a Russian author in the world of evaluation.

(41) $\llbracket \text{which book by which Russian author did you read?} \rrbracket^w$
 $= \{ \lambda w'' . \text{you read } y \text{ in } w'' \mid y \text{ book-by}_{w'} x \wedge \text{russian-author}_{w'} x \}$

Note that the entire nested *which*-phrase is interpreted *de re*!

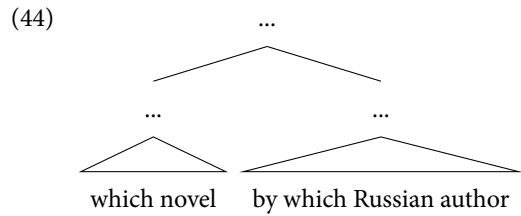
Sudo (2017) shows that nested *which*-phrases *cannot* have a totally *de re* reading — a striking instantiation of von Stechow’s problem.

- (42) *I reserve a part of my bookshelf for Russian novels, and my son doesn’t know what kind of book they are, or who wrote them, but knows which ones I haven’t opened (i.e.g, because they’re clean).*
- a. ✓ My son knows **which novels by Russian authors** I haven’t opened.
 - b. # My son knows **which novels by which Russian authors** I haven’t opened.

Sudo characterizes the problem as follows: the *in-situ* *which*-phrase has to contribute to the *wh*-question as *wh*-phrases normally do.

- (43) **Which novel by which Russian author** author did you read for this class?
- a. # The Master and Margarita.
 - b. ✓ The Master and Margarita by Bulgakov.

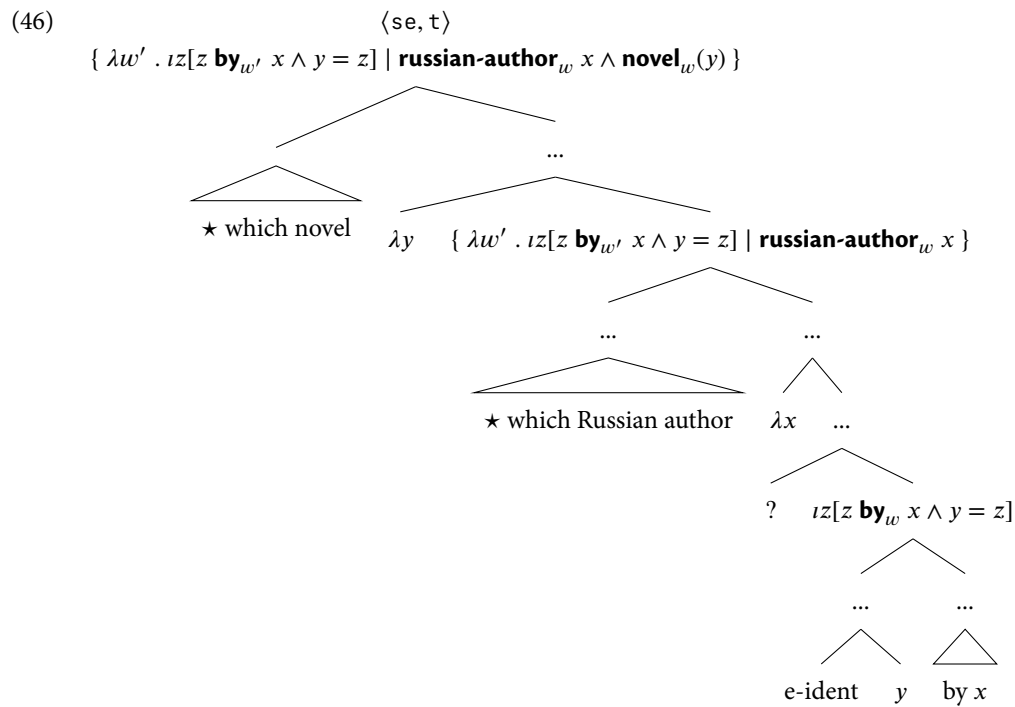
Sternefeld's (2001) and Demirok's (2019) solution: what appear to be nested *which*-phrases aren't really nested.



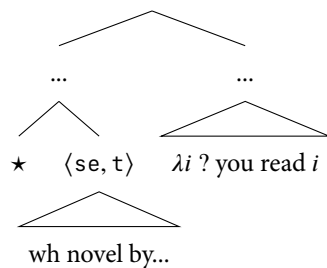
In order to compose this structure, Demirok posits a new type-shifter *e-ident*:

(45) $\llbracket e\text{-ident} \rrbracket^w = \lambda y . \lambda P . \iota z : P(z) \wedge y = z$

We can use this type shifter to independently scope both *wh*-expressions to the edge of the pied-piped constituent:



(47) $\{ \lambda w' . \text{you read}_{w'} \iota z [z \text{ by}_{w'} x \wedge y = z] \mid \text{russian-author}_w x \wedge \text{novel}_w(y) \}$



The result is a set of propositions which vary according to both authors and books.

As pointed out by Sauerland & Heck (2005), the Sternefeld/Demirok solution isn't going to be general enough. Their counterexample:

- (48) Which relative of which child attended the pot luck?
 a. #Heidi.
 b. Nick's mother.

Since *relative* is relational (type $\langle e, et \rangle$), the same trick isn't going to work.

Sauerland & Heck's solution to the current setting: *wh*-movement leaves behind a copy; the restrictor is interpreted *in-situ* as a bound definite description (Sauerland 1998, Fox 2002).

- (49) [which relative of which child] which relative of which child attended the pot luck?

- (50) a. = { **that the_x relative of the_y child attended** | $x, y \in D$ }
 b. = { $\lambda w' : \mathbf{child}_{w'}(y) \wedge x \mathbf{relative-of} y \mathbf{in} w' : \mathbf{attended}_{w'}(x)$ | $x, y \in D$ }

- (51) = $\left\{ \begin{array}{l} \textcircled{1} \lambda w' : \mathbf{Nick a child and Heidi relative of Nick in} w' . \mathbf{Heidi attended}_{w'} \\ \textcircled{2} \lambda w' : \mathbf{Joe a child and Heidi relative of Joe in} w' . \mathbf{Heidi attended}_{w'} \\ \dots \end{array} \right\}$

Remember that asserting a question in a context C amounts to a proposal that the question partition C (a simplified version of Kai's rule of assertion for questions):

- (52) $C[\phi] := \mathbf{PART}(\llbracket \phi \rrbracket^w, C)$ ϕ an interrogative; w an arbitrary world in c

Given a question Q the equivalence relation used to partition worlds in C was defined as follows:

- (53) $w \sim_{Q,C} w'$ iff $w, w' \in C \wedge \forall p \in Q[p(w) = p(w')]$

- w_{nh} : Heidi attended the pot luck; she is Nick's mother and unrelated to Joe.
- w_{jh} : Heidi attended the pot luck; she is Joe's mother and unrelated to Nick.

w_{nh} and w_{jh} are *not* equivalent relative to the question denotation in (51), since $\textcircled{1}(w_{nh}) = 1, \textcircled{1}(w_{jh}) = \#$, and $\textcircled{2}(w_{nh}) = \#, \textcircled{2}(w_{jh}) = 1$.

This means that the resulting partition is $\{ \{ w_{nh}, \dots \}, \{ w_{jh}, \dots \}, \dots \}$.

“Heidi attended the pot luck” will not count as a complete answer to the question, because at least two cells will survive.

2.5 *De dicto readings of wh-expressions*

So far, we’ve been focusing on *de re* readings of *wh*-expressions.

Under the *de re* reading of the *which*-phrase below, Josie knows which member of a particular set of entities I admire, and these entities happen to be self-portraits (but it isn’t necessary that Josie knows this).

(54) Josie knows **which self-portraits** I admire.

In embedded contexts, the more salient reading of *which*-phrases is the *de dicto* one, according to which Josie knows which member of a particular set I admire, and also knows that these entities are self-portraits.

According to the current approach, the *de dicto* reading falls out automatically; since the embedded question is interpreted in the intensional context created by *know*.

In order to derive the *de re* interpretation of (54), the *wh*-expression must take scope over *know*, pied-piping the embedded clause with it and leaving behind a higher-type trace.

(55) [**which self-portraits I admire**] Josie knows *t*

Extracting a *which*-phrase from out of an intensional context also gives rise to a *de re/de dicto* ambiguity.

(56) *Sam thought he saw two ghosts, a pale one, and an ethereal one.*

- a. Which ghost did Sam want to talk to?
- b. Which ghost did Sam think he saw?

Rullmann & Beck (1998) suggested that, in order to achieve the *de dicto* reading, *which*-phrases can be interpreted as definite descriptions *in situ*.

Their analysis gives rise to question denotations of the following kind:

(57) \llbracket which ghost did Sam want to talk to? \rrbracket
 $= \{ \lambda w' . \mathbf{Sam\ want}_{w'} (\lambda w'' . \mathbf{talk-to}_{w''} (\iota y[\mathbf{ghost}_{w''}(y) \wedge y = x])) \mid x \in D \}$

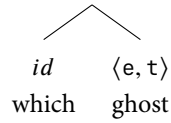
Demirok (2019) suggests a way of compositionally constructing a Rullmann & Beck-style Logical Form using the *e-ident* type-shifter from the discussion of

nested *which*-phrases.¹⁰

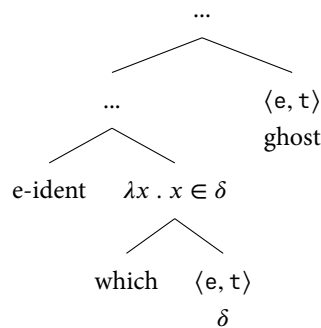
The idea is that *which*-phrases allow for two different representations:

¹⁰ The idea is based on mechanisms proposed in Heim (2012); Demirok's *e-ident* operator is just the composition of Heim's polymorphic THE and IDENT type-shifters.

(58) *Restricted which-phrases* $\lambda x . \mathbf{ghost}_w(x)$



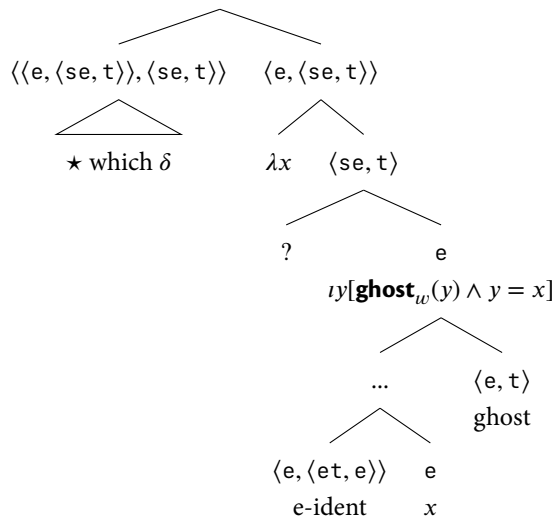
(59) *Unrestricted which-phrases*



Recall that *e-ident* is looking for a type *e* argument; in order to interpret structures like (59), *which* needs to take scope.

Just as in pied-piping configurations, *which* can undergo internal *wh*-movement to the edge of the *which*-phrase; here, the movement is string vacuous.

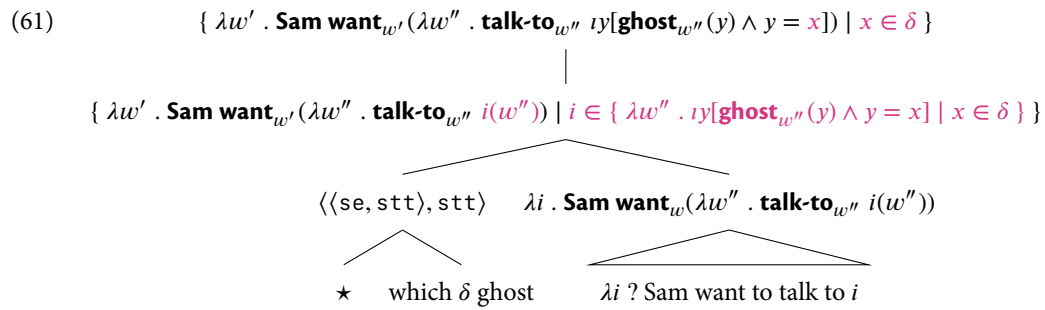
(60) $\langle se, t \rangle$
 $\{ \lambda w'' . \iota y [\mathbf{ghost}_{w''}(y) \wedge y = x] \mid x \in \delta \}$



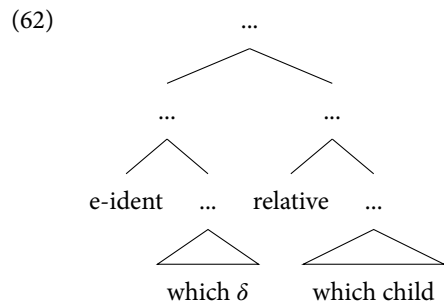
Note that the resulting meaning of the unrestricted *which*-phrase is a *set of*

individual concepts; the same type as a canonical case of pied-piping such as *whose painting*.

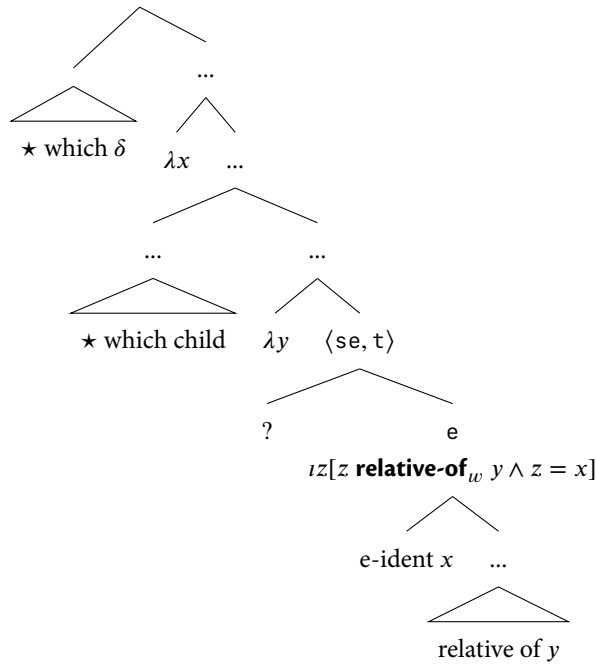
We can scope the unrestricted *which*-phrase via \star which leaves behind an *intensional* (se) trace in the embedded clause, which composes via EFA.



I think it's possible to adapt this solution to Sudo's puzzle for nested *which*-phrases while avoiding Sauerland & Heck's objection:



(63) $\{ \lambda w' . \iota z [z \text{ relative-of}_{w'} y \wedge z = x] \mid \text{child}_{w'}(y) \wedge x \in \delta \}$



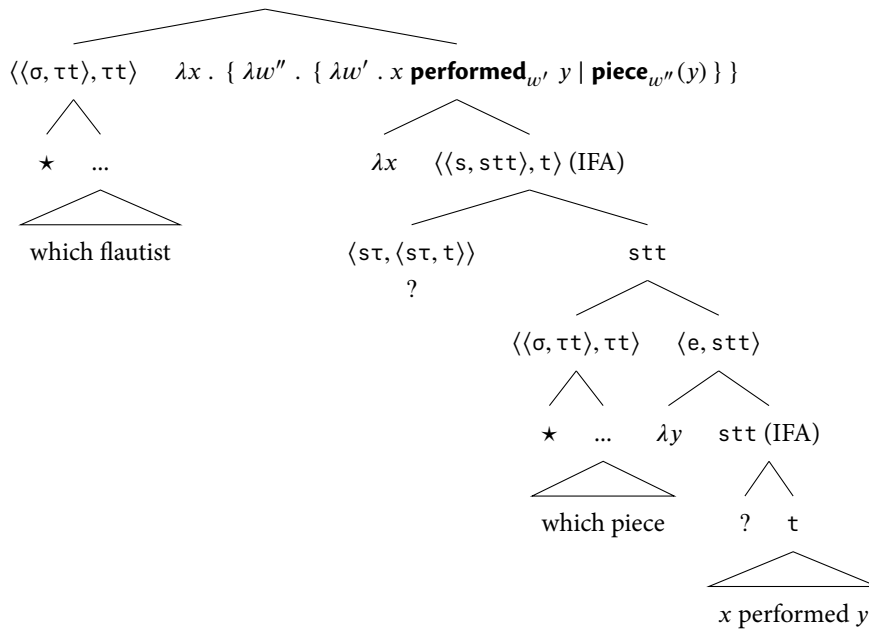
2.6 Pair-list

You may have noticed that the *polymorphism* of both ★ and ? allows us to compose higher-order denotations (which as we've seen, are useful for pair-list readings) without further ado.¹¹

(64) Which flautist performed which piece?

¹¹ There's a complication here - what Demirok's semantics actually delivers is a set of question *intensions* which piece did *x* play, for each flautist *x* in the world of evaluation.

(65) $\{ [\lambda w'' . \{ \lambda w' . x \text{ performed}_{w'} y \mid \text{piece}_{w''}(y) \}] \mid \text{flautist}_{w'}(x) \}$



In order to get facts concerning domain exhaustivity right (modulo empirical disagreements from last time), we must assume that covert movement of the *in-situ wh*-expression tucks in below the overtly moved *wh*-expression.

Another way of thinking about this: domain exhaustivity tells us that *wh*-expressions always take *surface scope*.¹²

¹² See Shan 2002a for a way of cashing out this intuition without making commitments regarding the syntax of covert movement.

3 Baker's ambiguity/the *wh*-triangle

Baker (1968) originally observed an ambiguity in questions like the following:¹³

- (66) Which one of our friends remembers where we bought which book?
 a. ① Alice remembers where we bought War and Peace.
 b. ② Alice does A.

¹³ Dayal (1996) evocatively calls this configuration the *wh-triangle*.

Putting the pair-list/single-pair distinction to one side,¹⁴ (66) is two-ways ambiguous, corresponding (Baker suggests) to two potential scope sites for the *in-situ wh*-expression.¹⁵

¹⁴ We'll come back to this.

(67) ① Which friend λx which book λy x remembers [where we bought y]

¹⁵ Something important to keep in mind: overtly moved *wh*-expressions take scope exactly over the clause they are overtly raised to, hence (66) is only two-way ambiguous, not four or eight.

(68) ② Which friend λx x remembers [where which book λy we bought y]

As pointed out by Dayal (1996), there's good reason to be skeptical of Baker's analysis.

First, note that although extraction of a *which*-phrase from a *wh*-island is marginally acceptable, extraction of a simplex *wh*-expression is much worse.¹⁶

¹⁶ *Wh*-islands are *weak*.

(69) a. ?Which book does Alice remember [where we bought t]?
b. *What does Alice remember [where we bought t]?

Baker's ambiguity persists with simplex *wh*-expressions:

(70) Who remembers where we bought what?
a. ① Alice remembers where we bought War and Peace.
b. ② Alice does Δ .

Applying Baker's analysis to (70) what amount to the claim that covert, unlike overt movement of simplex *wh* out of a *wh*-island is possible.¹⁷

¹⁷ Although this is a good reason to be cautious, I should note that one can find claims in the literature that locality constraints do not apply to movement at LF (e.g., Huang 1982).

3.1 Deriving the ambiguity

The reading in (66b) is easy.¹⁸

Dayal (1996, 2017) gives several more arguments against Baker's analysis, although I believe that many of them are problematic.

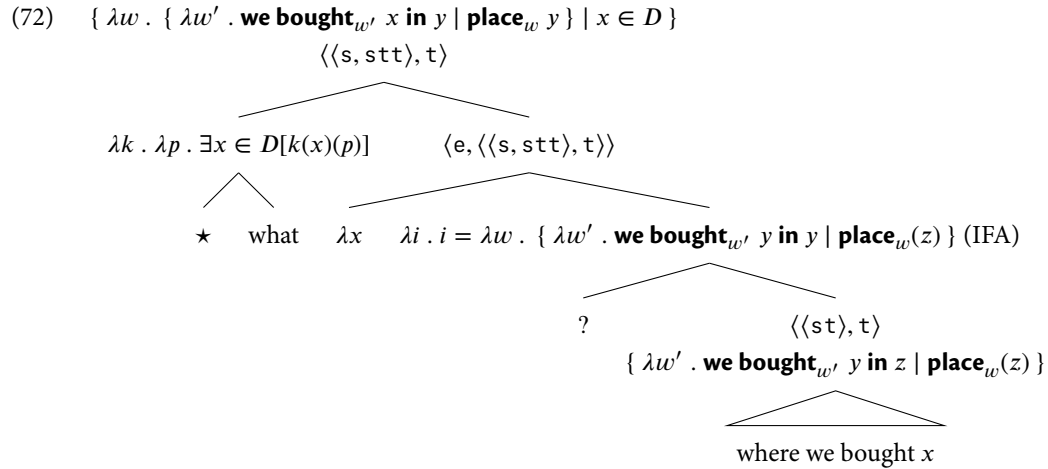
(71) (★ who) λx ? x remembers ((★ where) λy (★ what) λz ? we bought z y)

The reading in (66a) is more challenging.

¹⁸ I make the simplifying assumption that responsive predicates take questions as complements (Uegaki 2015).

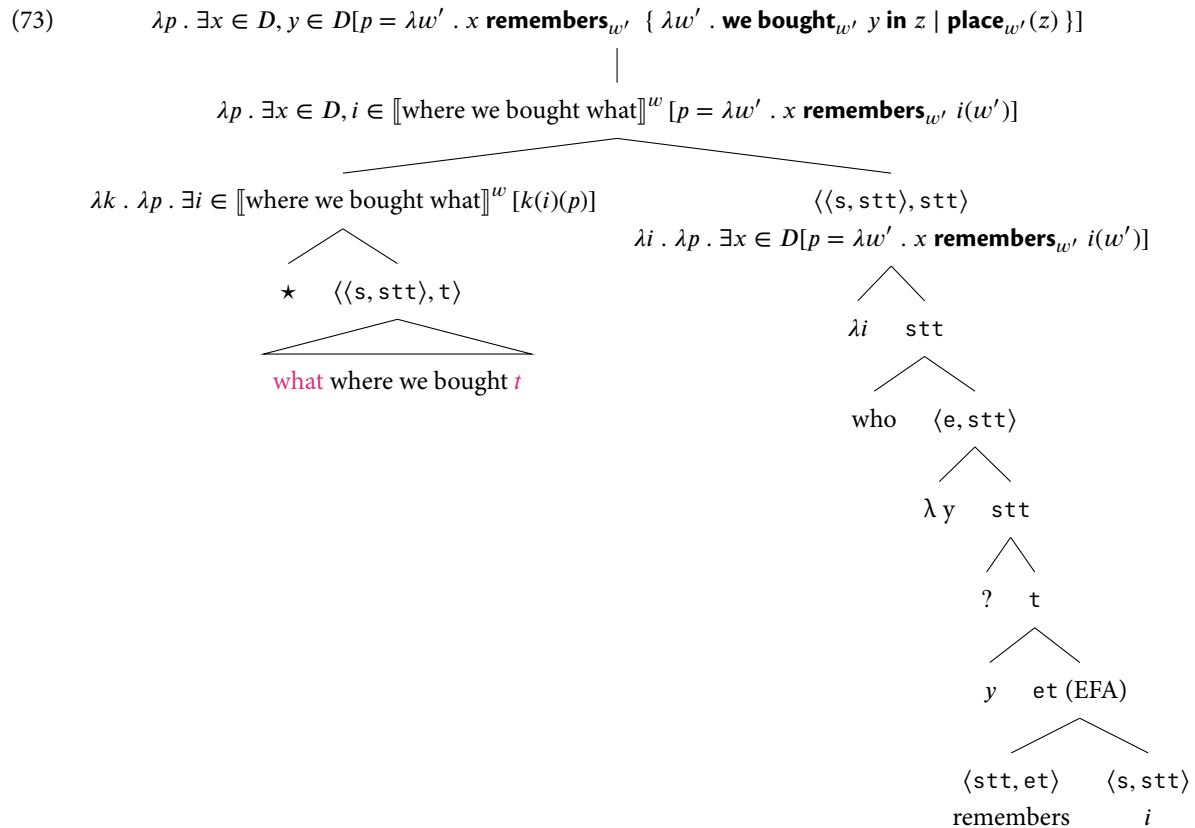
Recall that our algorithm for pied-piping says that we can convert any constituent into a kind of *generalized wh-expression* by scoping a contained *wh* to its edge.

Let's apply this algorithm, and turn the embedded interrogative clause into a generalized *wh-expression*.



The result is a *set of question intensions* which vary according to what is bought.

We can scope out the generalized *wh* via \star , leaving behind a trace which has the type of a question intension, which composes with *remember* via EFA.



Pesetsky's problem: (cited in Dayal 2017) Baker's ambiguity only arises if the

embedded multiple question is a complement of the matrix verb.

- (74) **Which student** believes that
 John knows where Mary bought **which book**?
 a. ??**Frank** believes that John knows where Mary bought **Moby Dick**,...
 cf. Frank believes that John knows where Mary bought which book.

The mechanism of *cyclic scope* is sufficiently powerful that this is derivable:

- (75) $Wh_x \lambda x [[wh_y \lambda y \text{ where } M \text{ bought } y] \lambda Q J \text{ knows } Q] \lambda p ? x \text{ believes } p$

Homework exercise

Go through the computation step by step.

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