PIED-PIPING AND QUESTION COMPOSITION
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1 Roadmap

The plan for today:

- Back to the question of how to compositionalize 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).

- The *wh*-triangle and pied-piping at LF (Baker 1968, Dayal 1996, Shan 2002).
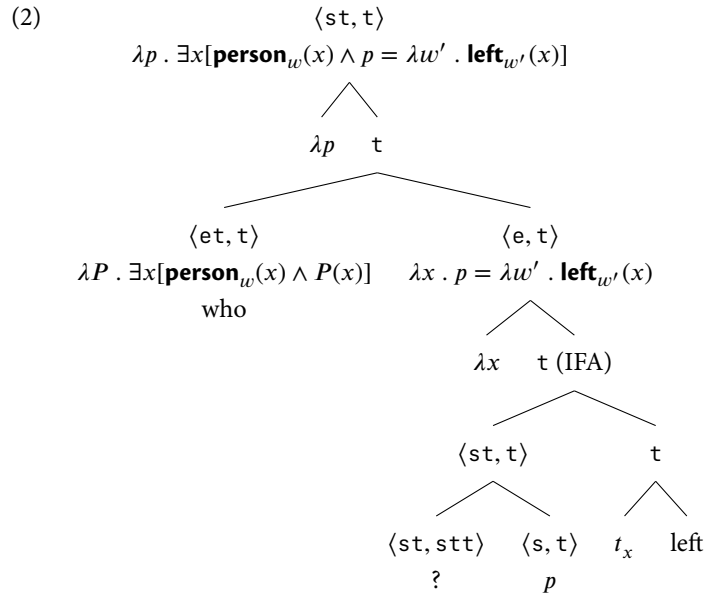
> **Optional reading**
>
> Much of today's discussion will cleave to chapters 2 and 3 of Demirok's 2019 MIT PhD thesis. If you have the inclination, I'd recommend reading chapter 2 up to §2.2.3, and chapter 3 up to §3.1.2, which cover the most important material from today's class.

2 An alternative compositionalization of Karttunen

Danny/Kai: *wh*-expressions are existential quantifiers; null operator movement from the complement of ? creates an abstraction over propositions.[1]
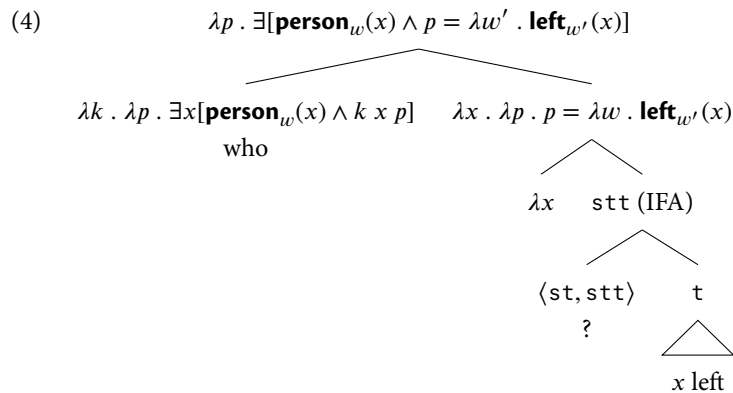
(1) Who left?

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[1] A potential refinement — abstraction is triggered by movement of the *answerhood* operator from the complement of ?.

(2)
$$\langle \mathtt{st}, \mathtt{t}\rangle$$
$$\lambda p \, . \, \exists x[\mathbf{person}_w(x) \wedge p = \lambda w' \, . \, \mathbf{left}_{w'}(x)]$$

$\lambda p \qquad \mathtt{t}$

$\langle \mathtt{et}, \mathtt{t}\rangle$
$\lambda P \, . \, \exists x[\mathbf{person}_w(x) \wedge P(x)]$
who

$\langle \mathtt{e}, \mathtt{t}\rangle$
$\lambda x \, . \, p = \lambda w' \, . \, \mathbf{left}_{w'}(x)$

$\lambda x \qquad \mathtt{t}$ (IFA)

$\langle \mathtt{st}, \mathtt{t}\rangle \qquad \mathtt{t}$

$\langle \mathtt{st}, \mathtt{stt}\rangle \quad \langle \mathtt{s}, \mathtt{t}\rangle \quad t_x \quad \text{left}$
$? \qquad\qquad p$

An alternative semantics for *wh*-expressions, after Heim 1994, Cresti 1995 —
wh-expressions as *selective scope-takers*.[2]

(3) $[\![\text{who}]\!]^w := \lambda k_{\langle \mathtt{e}, \mathtt{stt}\rangle} \, . \, \lambda p \, . \, \exists x[\mathbf{person}_w(x) \wedge k(x)(p)] \qquad \langle\langle \mathtt{e}, \mathtt{stt}\rangle, \mathtt{stt}\rangle$

Wh-expressions as scope-takers that expect something of type stt, and return
something of type stt.[3]

(4) $\lambda p \, . \, \exists[\mathbf{person}_w(x) \wedge p = \lambda w' \, . \, \mathbf{left}_{w'}(x)]$

$\lambda k \, . \, \lambda p \, . \, \exists x[\mathbf{person}_w(x) \wedge k \, x \, p]$
who

$\lambda x \, . \, \lambda p \, . \, p = \lambda w \, . \, \mathbf{left}_{w'}(x)$

$\lambda x \qquad \mathtt{stt}$ (IFA)

$\langle \mathtt{st}, \mathtt{stt}\rangle \qquad \mathtt{t}$
$?$

$x \text{ left}$

We might struggle to come up with a special composition rule to scope a *wh*-
expression over a clause in the absence of ?, but if we stick with the compo-
sitional regime outlined in, e.g., Heim & von Fintel (2011), this will not be
possible.[4]

[2] What do I mean by a selective scope-taker?
Generally scope takers are of type $\langle\langle \sigma\tau\rangle, \tau\rangle$.
τ determines possible scope-sites for the
scope-taker. For generalized quantifiers,
$\tau = \mathtt{t}$, but τ can be some other type, such as
stt. In fact, most scope-takers we encounter
are selective, but since stt is not a typical
scope-site, selectivity is worth emphasizing.

[3] One way of thinking about this — the
dependency between ? and *wh* is cashed out
syntactically (in the types).

[4] As an exercise, try to write this composition
rule.

(5)

$$\text{✗}$$

```
        ✗
       ╱ ╲
⟨⟨e,stt⟩,stt⟩   ⟨e,t⟩
    who        ╱ ╲
           λx x left
```
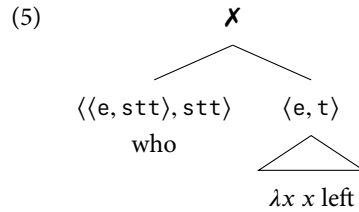
As usual, we can decompose further, and treat *which* as a function from a predicate to a selective scope taker.[5]

(6) $[\![\text{which}]\!]^w = \lambda P \,.\, \lambda k \,.\, \lambda p \,.\, \exists x[P(x) \wedge k(x)(p)]$ $\langle \text{et}, \langle \langle \text{e}, \text{stt}\rangle, \text{stt}\rangle\rangle$

It is of course possible to stack up relative advantages and disadvantages of treating *wh*-expressions as selective scope-takers, vs. existential quantifiers.

- For our purposes however, these two approaches are largely equivalent.

- The main difference is that the selective scope-taker approach allows the types to do some of the syntactic heavy lifting.

- I think it's worth knowing about this way of doing things!

I'll be using this approach in the following discussion of pied-piping.

3   Interpretability and pied-piping

3.1   A simple example

wh-movement frequently applies to constituents larger than mere *wh*-words.

(7)   a.   *Which does Mary like [*t* boy]?
        b.   Which boy does Mary like *t*?

In such an instance, we can ask whether or not there is a semantic motivation for moving the entire *which*-phrase as a unit.

The ban on sub-extracting *which* is typically subsumed under the *Left Branch Condition* (LBC; Ross 1967, Corver 1990).

Putting the LBC to one side, according to the account we've sketched, composition won't proceed — *which* is of the wrong type to compose with a question.

3.2   Possessors

What about the following kind of case:[6]

(8)   a.   Whose painting do you admire *t*?
       b.   *Who do you admire *t*'s painting?

Possessor extraction is classically ruled out by the LBC, but we may also ask whether there is a *semantic* motivation for pied-piping the container DP along with the *wh*-possessor.

Clearly, pied-piping must be syntactically motivated, since the following LF is perfectly interpretable according to the assumptions we've laid out thus far.

(9)   Who λx ? do you admire [x 's painting]

Let's consider the predictions we make for a more syntactically plausible LF:[7]

We can assume, therefore, that the syntax delivers the LF in (11) — we need a way of interpreting it!

(10) $\llbracket$'s$\rrbracket^{w} = \lambda P \, . \, \lambda x \, . \, \iota y[P(y) \wedge y \, \textbf{of}_{w} \, x]$
$\langle \text{et}, \langle \text{e}, \text{e} \rangle \rangle$

(11)   [Whose painting] λx ? do you admire x

Attempting to directly compose the *wh*-expression results in an immediate problem, so we're going to have to scope it.

(12)
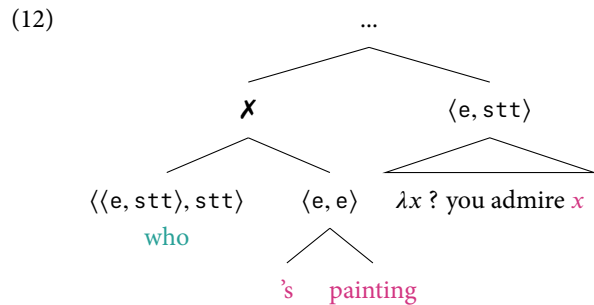
The only scope-site we have available to us which will resolve the type mismatch is above the matrix ? operator, as emphasized by von Stechow (1996).[8]
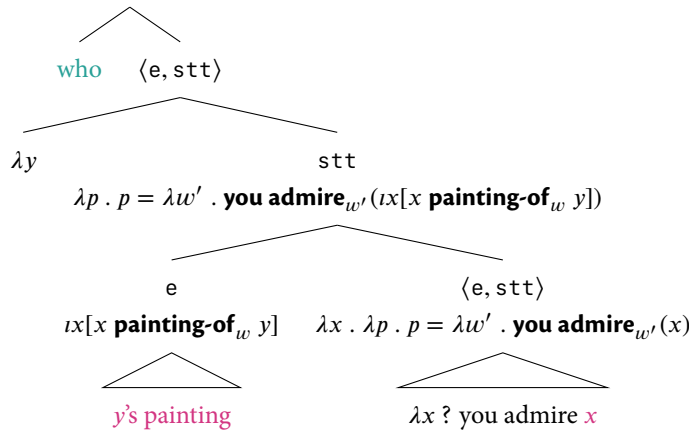
(13) $\lambda p . \exists y[p = \lambda w' . \text{\textbf{you admire}}_{w'}(\iota x[x \text{ \textbf{painting-of}}_w y])]$

The pied-piped material is interpreted in the position that it overtly moves to. You may think that this movement is semantically vacuous, but it is not.

This is because we're assuming a version of the *scope theory of intensionality*, in line with, e.g., Heim & von Fintel 2011.[9]

Because the pied-piped material moves to, and is interpreted in, a position above ?, it is interpreted relative to the world of evaluation, rather than caught within the skein of ?.

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

This may seem fairly innocent, but von Stechow (1996) showed in detail that this leads to somewhat unfortunate predictions.[10]

3.3   *Against the complete de re interpretation*

Let's consider the predictions our analysis of pied-piping makes in a concrete context:

Context: *There are only two paintings in @: Francis's painting "Triptych", and Lucian's painting "Reflection".*

(14)   a.   ① $[\![\text{whose painting do you admire?}]\!]^@ = \{ \lambda w' . \text{\textbf{you admire}}_{w'}(\iota x[x \text{ \textbf{painting-of}}_@ y]) \mid y \in D \}$

    b.   ② $[\![\text{which painting do you admire?}]\!]^@ = \{ \lambda w' . \text{\textbf{you admire}}_{w'} x \mid \text{\textbf{painting}}_w(x) \}$

$$① = ② = \left\{ \begin{array}{l} \lambda w' . \text{\textbf{you admire}}_{w'} \text{ \textbf{Triptych}} \\ \lambda w' . \text{\textbf{you admire}}_{w'} \text{ \textbf{Reflection}} \end{array} \right\}$$

[9] Important references for the scope theory include Keshet 2011 and Romoli & Sudo 2009. The scope theory is ordinarily contrasted with the *binding theory* of intensionality (Percus 2000). There's an important relationship between the semantics of pied-piping and the scope theory of intensionality, as explored in, e.g., Demirok 2019 and Elliott 2020.

[10] von Stechow (1996) is primarily focused on theories that invoked LF pied-piping for *wh-in-situ* (such as Nishigauchi's (1990) analysis of *wh-in-situ* in Japanese), but his points apply equally forcefully to overt pied-piping configurations.

The questions pick out the same set of propositions in @; the *wh*-expression, including the pied-piped material is interpreted *de re*.

von Stechow's observation — a theory which necessarily predicts equivalence is incorrect, based on evidence from embedding contexts.

Context: *There are only two paintings in @: Francis's painting "Triptych", and Lucian's painting "Reflection"; you admire Triptych, and Josie believes this, but she incorrectly believes that Triptych is by Lucian Freud.*

- "Josie knows whose painting you admire" is *false*.

- "Josie knows which painting you admire" is *true*.

Another way of seeing that the *complete de re* interpretation cannot be the (only) interpretation of the question: recall Kai's application of Stalnaker's *third rule of assertion* to questions.

(15)   **Stalnaker's third rule of assertion: Kai's formulation for questions**
Asking a question by uttering an interrogative ϕ if felicitous in a context C iff $[\![\phi]\!]^w = [\![\phi]\!]^{w'}$, $\forall w, w' \in C$

Applied to an utterance of a simple *which*-question, such as "which painting do you admire?", (15) predicts a felicity condition to the fact that what the paintings are is common ground.

Now let's try to apply (15) to our complete *de re* analysis of pied-piping:

(16) $[\![\text{whose painting do you admire?}]\!]^w = \{\ \lambda w'\ .\ \textbf{you admire}_{w'}\,(\iota x[x\ \textbf{painting-of}_w\ y])\ |\ y \in D\ \}$

The prediction is that the question should carry a felicity condition that it's common ground what the paintings are.

To illustrate, imagine that C contains at least w_1 and w_2 (we aren't certain what Lucian painted).

- w_1: Francis painted "Triptych", Lucian painted "Double Portrait".

- w_2: Francis painted "Triptych", Lucian painted "Reflection".

(17)   a. $[\![\text{whose painting do you admire?}]\!]^{w_1} = \left\{ \begin{array}{c} \text{that you admire "Triptych"} \\ \text{that you admire "Double Portrait"} \end{array} \right\}$

b. $[\![\text{whose painting do you admire?}]\!]^{w_2} = \left\{ \begin{array}{c} \text{that you admire "Triptych"} \\ \text{that you admire "Reflection"} \end{array} \right\}$

The felicity condition isn't met, but (I think) an utterance of "whose painting do you admire" is still felicitous, even if we don't know what Lucian painted.

- We can conclude that (15) is incorrect (and I think it's very likely that it isn't), or that there's something wrong the our question denotation.

von Stechow's proposal: pied-piping is obligatorily accompanied by subextraction of the contained *wh*-expression at LF + reconstruction of the remnant material.

The result is of course equivalent to just scoping out the *wh*-expression.

(18) a. [Whose painting] do you admire *t*?   *surface structure*
     b. Who λx ? do you admire [$x's$ painting]   *LF*

Note that sub-extracting the pied-pipee from the pied-piped material *subverts* the (presumably) syntactic motivation for pied-piping in the first place.[11]

Questions:

- How can pied-piped material be interpreted in a way which doesn't violate syntactic locality?

- How can the ban on *complete de re* interpretations of *wh*-expressions be derived?

In the next section, we'll consider a version of Demirok's (2019) analysis of pied-piping, which aims to address von Stechow's objection.

4   Demirok's analysis

4.1   Going polymorphic

Starting point: instead of existential quantifiers, or selective scope takers, let's assume that *wh*-expressions just denote *sets of alternatives*.[12]

(20) $[\![\text{which painting}]\!]^w = \lambda x . \textbf{painting}_w(x)$ $\langle e, t \rangle$

Equivalently:

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[11] The ban on possessor extraction might be plausibly be taken to have a PF explanation, but this is less plausible in other cases:

(19)   whose painting pleased you?

Subextraction in this instance would involve violating the subject island condition. There are of course some people who have argued that all island conditions should receive a PF explanation, on the basis of alleged island repair under sluicing (Merchant 2008, Barros, Elliott & Thoms 2014 for a dissenting view). If so, all bets are off.

[12] The idea that *wh*-expressions simply introduce sets of alternatives has an obvious precedent in the focus-semantic approach to *wh* composition. See Beck 2006 and especially Kotek 2014. In recent work, Uegaki (2018) develops an account of how indefinites are built out of *wh*-expressions in Japanese which takes the alternative-set view as a starting point. This is prima facie a better fit for the typological picture (pointed out by Sabine), than an analysis which takes *wh*-expressions to be existential quantifiers.

(21) $= \{\, x \mid \textbf{painting}_w(x) \,\}$

Now, let's define an operator which takes an *alternative set*, and gives back a *selective scope-taker* (i.e., a Heim/Cresti *wh*-expression).[13]

N.b., σ and τ are *variables over types*.

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

We can rewrite this equivalently using set notation:

(23) $\star := \lambda X \,.\, \lambda k \,.\, \bigcup_{x \in X} k(x)(p)$

Let's also give ? a more polymorphic type (τ here is a variable over types):

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

We can now refactor our analysis of simple questions using our new, polymorphic machinery; nothing much changes, except we've factored out part of the Heim/Cresti meaning of *which* into an independent operator.[14]
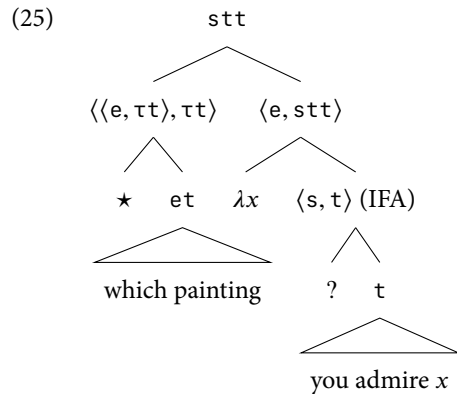
(25)

We'll find out why polymorphism is useful once we return to the question of how to compose pied-piped material.

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[13] Note that this is a polymorphic variant of Heim's (1994) lexical entry for *which* (where σ = e, and τ = st).

I've called this same operator Q in previous work (Elliott 2015); Charlow (2019), calls it ⋙. Charlow characterizes it as the *bind* operation associated with the set monad; see that work for details.

[14] Since ⋆ is responsible for scoping the alternatives introduced by the *wh*-expression, we might call it *the pied-piper of Hamblin*.

4.2   Pied-piping via cyclic scope

Thanks to the polymorphism of ? and $\star$, we can develop a compositional account of pied-piping by scoping the *wh*-expression to the *edge* of the pied-piped material.

We'll go through how this works step by step for *which artist's painting*.[15]
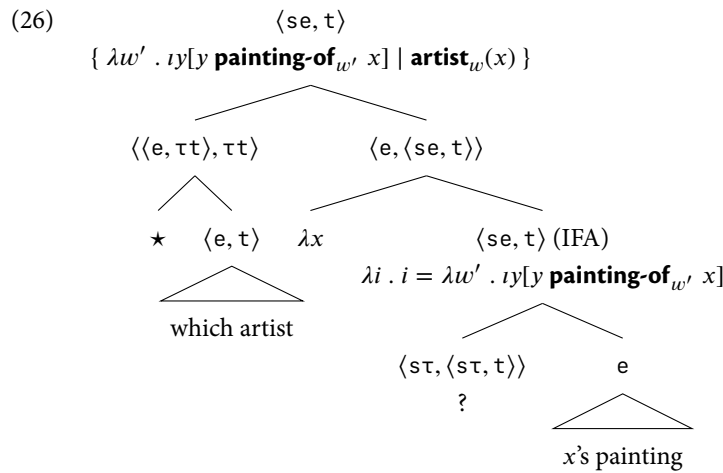
(26) $\langle \mathsf{se}, \mathsf{t} \rangle$
    $\{\ \lambda w' \ .\ \iota y[y \ \textbf{painting-of}_{w'}\ x]\ |\ \textbf{artist}_w(x)\ \}$

    $\langle\langle \mathsf{e}, \tau\mathsf{t}\rangle, \tau\mathsf{t}\rangle$ $\langle \mathsf{e}, \langle \mathsf{se}, \mathsf{t}\rangle\rangle$

  $\star$ $\langle \mathsf{e}, \mathsf{t}\rangle$ λx $\langle \mathsf{se}, \mathsf{t}\rangle$ (IFA)
                   $\lambda i \ .\ i = \lambda w' \ .\ \iota y[y\ \textbf{painting-of}_{w'}\ x]$

which artist

            $\langle \mathsf{s}\tau, \langle \mathsf{s}\tau, \mathsf{t}\rangle\rangle$ e
               ?

                 x's painting

By scoping *who* to the edge of the pied-piped material, via ? and $\star$, we've created a *set of individual concepts*.[16]

Recall that $\star$ composes with a set of alternatives, and creates a *wh*-expression — namely, a selective scope-taker.

If we apply $\star$ to (26), we turn it into a selective scope-taker and can scope it into a question.

(27) $\lambda p\,.\,\exists x[x \in D \wedge p = \lambda w'\,.\,\textbf{you admire}_{w'}\ \iota y[y\ \textbf{painting-of}_{w'}\ x]]$

$\lambda p\,.\,\exists i[i \in \{\ \lambda w'\,.\,\iota y[y\ \textbf{painting-of}_{w'}\ x]\mid x \in D\ \} \wedge p = \lambda w'\,.\,\textbf{you admire}_{w'}\ i(w')]$

$\lambda p\,.\,\exists i[i \in [\![\text{whose painting}]\!]^{w} \wedge p = \lambda w'\,.\,\textbf{you admire}_{w'}\ i(w')]$

$\langle\langle se, stt\rangle, stt\rangle$
$\lambda k\,.\,\lambda p\,.\,\exists i[i \in [\![\text{whose painting}]\!]^{w} \wedge k(i)(p)]$

$\langle e, stt\rangle$
$\lambda i\,.\,\lambda p\,.\,p = \lambda w'\,.\,\textbf{you admire}_{w'}\ i(w')$

$\langle \sigma t, \langle\langle \sigma, \tau t\rangle, \tau t\rangle\rangle$
$\star$

set
whose painting

λi stt (IFA)

?   t

you   et (EFA)

$\langle e, et\rangle$ $\langle s, e\rangle$
admire i
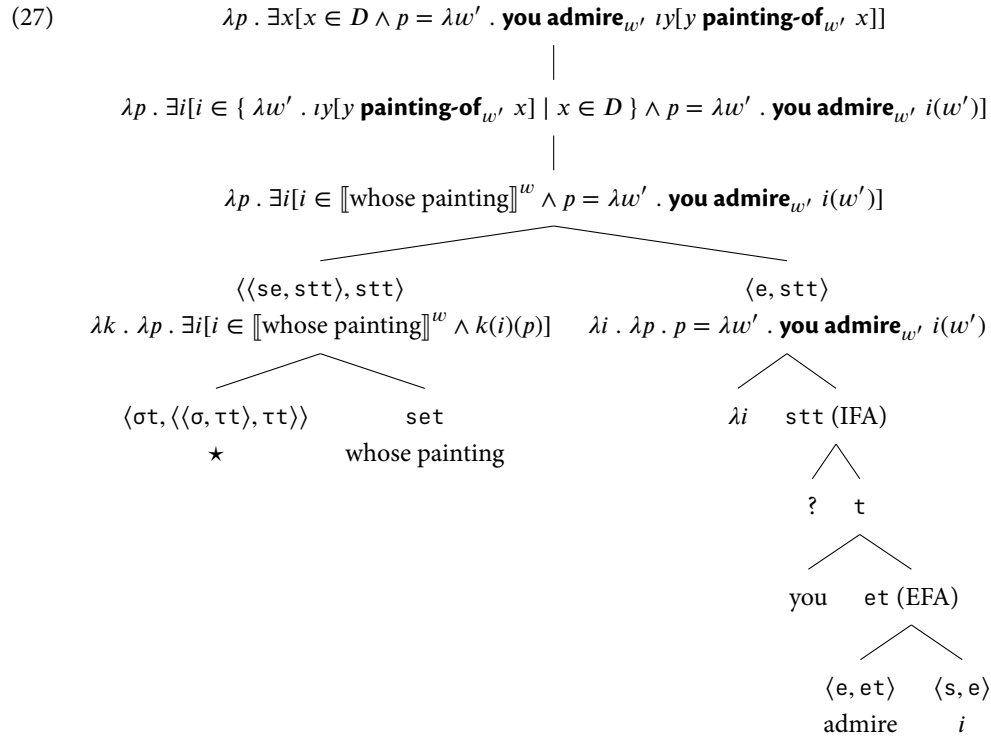
We've snuck in an extra composition rule here: Heim & von Fintel's *extensionalizing function application.*

(28)   **Extensionalizing Function Application (EFA)**

$$\left[\!\!\left[\begin{array}{c}\ldots\\ \langle\sigma,\tau\rangle\quad\langle s,\sigma\rangle\\ \alpha\qquad\beta\end{array}\right]\!\!\right]^{w} := [\![\alpha]\!]^{w}\,([\![\beta]\!]^{w}(w))$$

The resulting meaning is in fact *equivalent* to if we had simply scoped out the contained *wh*-expression.[17]

(29)   Which artist λx ? do you admire x's painting

4.3   Why does this work?

Let's consider an abstract representation of how pied-piped material composes:[18]

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

The following is a general fact about $\star$ (see Charlow 2019 for the proof; he calls

[17] Recall that this is essentially the LF that von Stechow's algorithm gives rise to.

[18] it's perspicuous to use infix notation for $\star$.

$\star, \ggg$):

(31)   **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:

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

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

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

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

(34)   **Left identity:** $(? \ i) \star f = f \ i$

Now by *left identity* we can rewrite (33):

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

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

4.4   Cyclic scope

You may have noticed that the *polymorphism* of both $\star$ and ? allows us to compose higher-order denotations (which as we've seen, are useful for pair-list readings) without further ado.[19]

(36)   Which flautist performed which piece?

[19] 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.

(37)   { [$\lambda w''$. { $\lambda w'$. x **performed**$_{w'}$ y | **piece**$_{w''}(y)$ }] | **flautist**$_w(x)$ }

$\langle\langle\sigma,\tau t\rangle,\tau t\rangle$ λx . { $\lambda w''$. { $\lambda w'$. x **performed**$_{w'}$ y | **piece**$_{w''}(y)$ } }

★   … λx $\langle\langle s,stt\rangle,t\rangle$ (IFA)

which flautist $\langle s\tau,\langle s\tau,t\rangle\rangle$ stt
                                                    ?

                                          $\langle\langle\sigma,\tau t\rangle,\tau t\rangle$ $\langle e,stt\rangle$

                                          ★   … λy stt (IFA)

                                          which piece   ?   t

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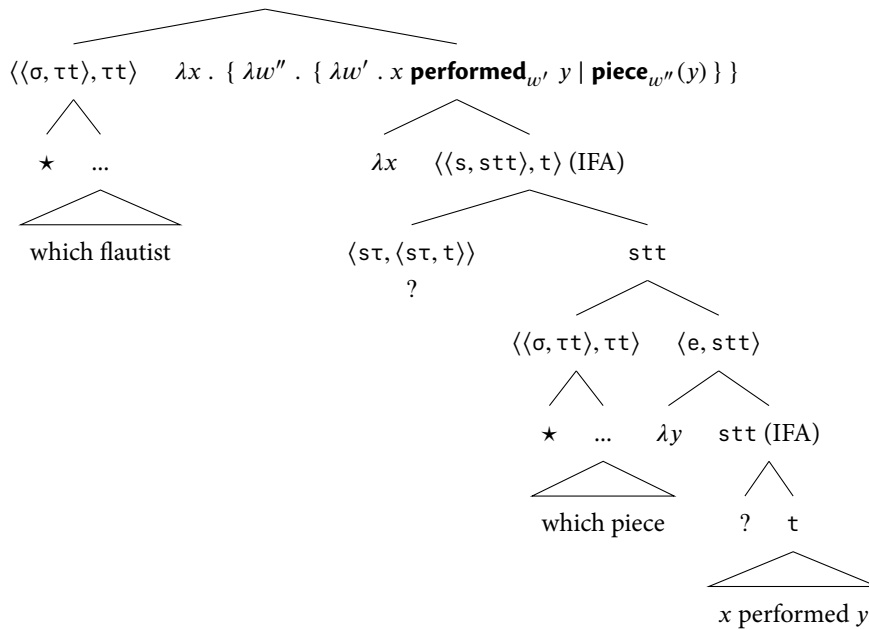
In order to get facts concerning domain exhaustivity right (modulo empirical disagreements from last time), we must assume that covert movement of the *in-situ wh*-expression tucks in below the overtly moved *wh*-expression.

Another way of thinking about this: domain exhaustivity tells us that *wh*-expressions always take *surface scope*.[20]

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.

(38)   Which flautist cried [after which cellist performed beautifully]?

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

(39) $\langle\langle s,vt\rangle,t\rangle$
        { $\lambda w'$. **after** x **performed beautifully in** w' | **cellist**$_w(x)$ }

                … λx . λi . $i = \lambda w'$. **after**x **performed beautifully in** w'

        ★ which cellist λx $\langle\langle s,vt\rangle,t\rangle$

                                        ? after x performed beautifully

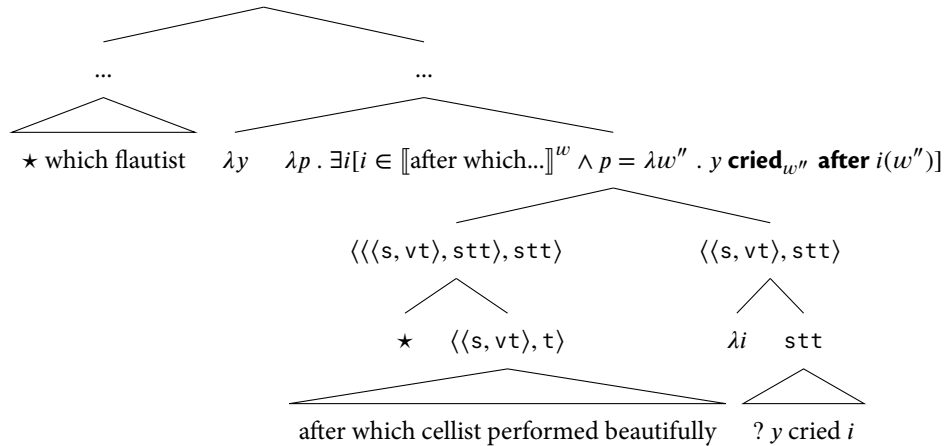[20] See Shan 2002 for a way of cashing out this intuition without making commitments regarding the syntax of covert movement.
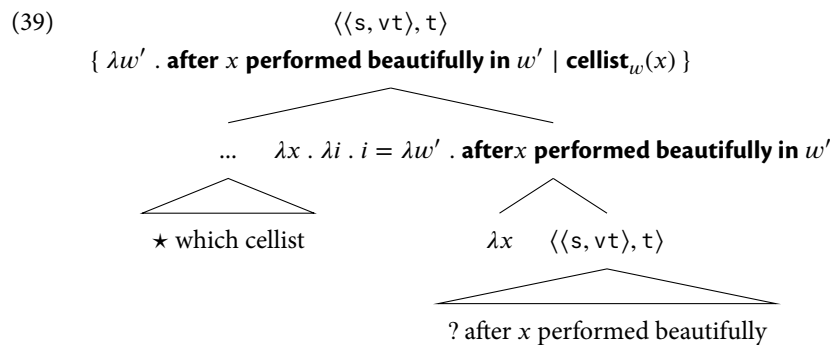
(40) $\lambda p \,.\, \exists y, x[\textbf{flautist}_w(y) \wedge \textbf{cellist}_w(x) \wedge p = \lambda w'' \,.\, y\ \textbf{cried}_{w''}\ \textbf{after}\ x\ \textbf{performed beautifully in}\ w'']$

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

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

5   Baker's ambiguity/the wh-triangle

Baker (1968) originally observed an ambiguity in questions like the following:[21]

(42)   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 Δ.

Putting the pair-list/single-pair distinction to one side,[22] (42) is two-ways ambiguous, corresponding (Baker suggests) to two potential scope sites for the in-situ *wh*-expression.[23]

(43)   ① Which friend λx which book λy x remembers [where we bought y]
(44)   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.[24]

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

[21] Dayal (1996) evocatively calls this configuration the *wh-triangle*.

[22] We'll come back to this.

[23] Something important to keep in mind: *overtly* moved *wh*-expressions take scope exactly over the clause they are overtly raised to, hence (42) is only two-way ambiguous, not four or eight.

[24] *Wh*-islands are *weak*.

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

(46)   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 (46) what amount to the claim that covert, unlike overt movement of simplex *wh* out of a *wh*-island is possible.[25]
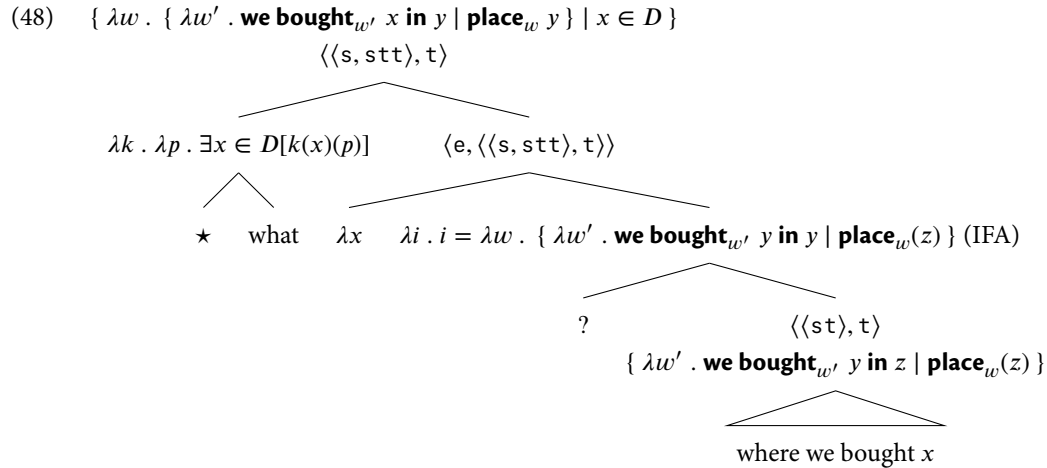
5.1   Deriving the ambiguity

The reading in (42b) is easy.[26]

(47) $(\star \text{ who}) \, \lambda x \, ? \, x \text{ remembers } ((\star \text{ where}) \, \lambda y \, (\star \text{ what}) \, \lambda z \, ? \text{ we bought } z \, y)$

The reading in (42a) is more challenging.

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.
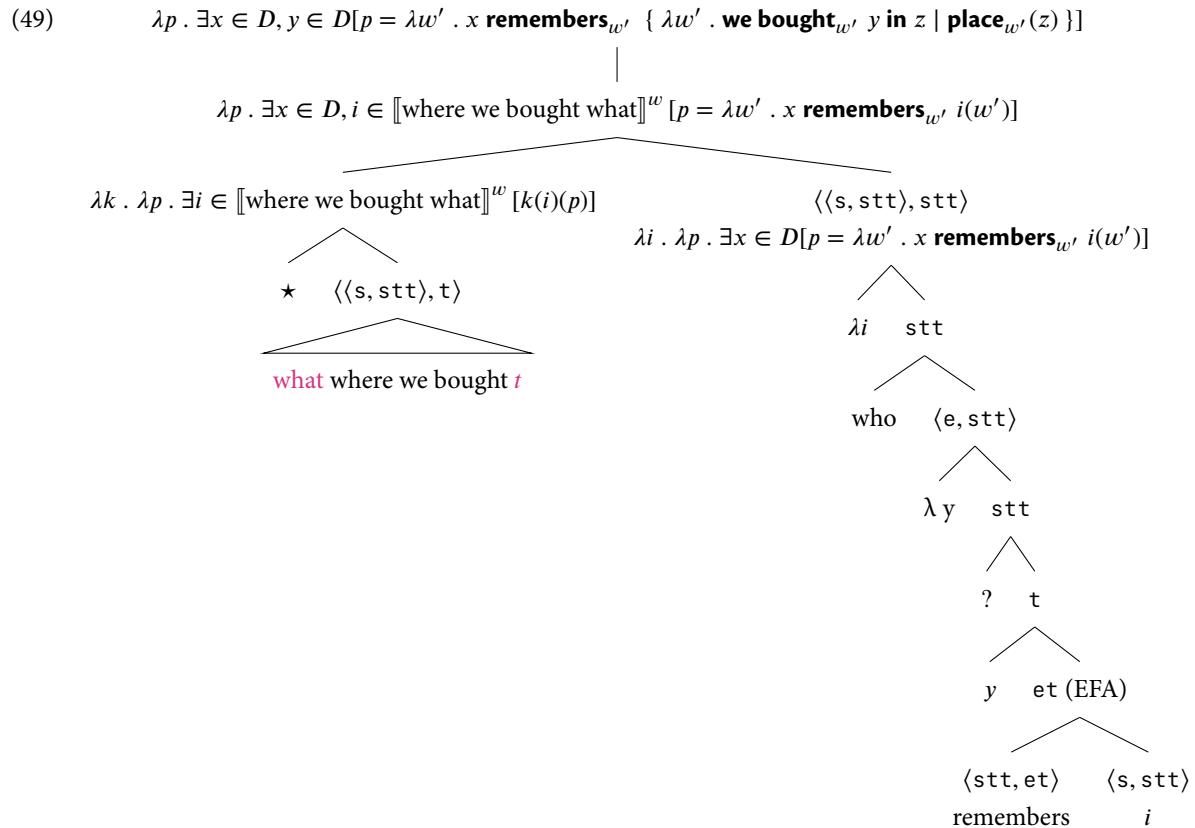
(48) $\{ \, \lambda w \, . \, \{ \, \lambda w' \, . \, \textbf{we bought}_{w'} \, x \textbf{ in } y \mid \textbf{place}_w \, y \, \} \mid x \in D \, \}$

$\langle\langle s, stt\rangle, t\rangle$

$\lambda k \, . \, \lambda p \, . \, \exists x \in D[k(x)(p)] \qquad \langle e, \langle\langle s, stt\rangle, t\rangle\rangle$

$\star \quad \text{what} \quad \lambda x \quad \lambda i \, . \, i = \lambda w \, . \, \{ \, \lambda w' \, . \, \textbf{we bought}_{w'} \, y \textbf{ in } y \mid \textbf{place}_w(z) \, \}$ (IFA)

$? \qquad\qquad \langle\langle st\rangle, t\rangle$
$\{ \, \lambda w' \, . \, \textbf{we bought}_{w'} \, y \textbf{ in } z \mid \textbf{place}_w(z) \, \}$

where we bought x

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.

[25] 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).

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

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

(49) $\lambda p \,.\, \exists x \in D, y \in D[p = \lambda w' \,.\, x \text{ \textbf{remembers}}_{w'} \;\{\; \lambda w' \,.\, \text{\textbf{we bought}}_{w'} \; y \text{ \textbf{in}} \; z \mid \text{\textbf{place}}_{w'}(z) \;\}]$

|

$\lambda p \,.\, \exists x \in D, i \in [\![\text{where we bought what}]\!]^{w} \, [p = \lambda w' \,.\, x \text{ \textbf{remembers}}_{w'} \; i(w')]$

$\lambda k \,.\, \lambda p \,.\, \exists i \in [\![\text{where we bought what}]\!]^{w} \, [k(i)(p)]$ $\langle \langle s, stt \rangle, stt \rangle$
$\lambda i \,.\, \lambda p \,.\, \exists x \in D[p = \lambda w' \,.\, x \text{ \textbf{remembers}}_{w'} \; i(w')]$

$\star$ $\langle \langle s, stt \rangle, t \rangle$ λi stt

what where we bought t who $\langle e, stt \rangle$

λy stt

? t

y et (EFA)

$\langle stt, et \rangle$ $\langle s, stt \rangle$
remembers i

Note that this derivation gives rise to a *single-pair* reading; both *who* and *what* take scope over the matrix question nucleus, and the remnant pied-piped material semantically reconstructs.

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