Nested *which*-phrases and the logic of pied-piping*

Patrick D. Elliott
Heinrich Heine University Düsseldorf

Filipe Hisao Kobayashi
University of Salzburg

Abstract Nested *which*-questions such as "Which album by which band do you like best?" lack the so-called 'pair-list' reading which is otherwise available for ordinary multiple questions (Higginbotham & May 1981, Elliott 2015, Fox & Sudo 2025). We show that the scopal theory of pied-piping (Charlow 2019, Demirok 2019) nevertheless derives such readings, even if the contained *which*-phrase is barred from subextracting: the contained *which*-phrase can pied-pipe its container, which then reconstructs and takes scope over a second question nucleus, yielding a family of questions. In order to address this, we propose that covert QP-movement is subject to Chomsky's (1964) *A-over-A* condition, which blocks exactly these derivations while preserving the theory's account of pied-piping. Our proposal makes novel predictions beyond strict nesting, e.g., in what we call quasi-nesting configurations and for Baker's ambiguity. We argue these predictions are borne out, and that they distinguish our account from Fox & Sudo's (2025). The result is a case study in how highly expressive, semantically motivated compositional machinery can be constrained by independently motivated syntactic principles.

Keywords: question semantics, scope, multiple questions, pied-piping, pair-list readings, A-over-A

1 The absence of pair-list readings of nested *wh*-questions

Multiple questions in English can be formed by fronting a *wh*-expression, and leaving the remaining *wh*-expression(s) *in situ*, as in (1). The syntactic and semantic properties of multiple questions have been studied extensively, and it is generally assumed that multiple questions formed from singular *which*-expressions allow for both a Single Pair (SP), and a Pair List (PL) reading, as reflected by possible answers in (1a) and (1b) respectively (see especially Dayal 2017: chapter 4 for an overview).

(1) Which man danced with which woman?

a. Mark danced with Helly.

b. Mark danced with Helly, Dylan with Gretchen, and Seth with Harmony.

* We are grateful to Danny Fox, Yasu Sudo and Stanislao Zompì.

Relatively little attention has been paid to a particular sub-species of multiple question, where the *in situ* *wh*-expression is contained inside of the fronted *wh*-expression, forming a *nested* which-*phrase* (Heim 1994). We refer to this configuration, illustrated in (2), as a *nested* which-*question*.[1]

(2) $\overbrace{\text{[Which album by [which English rock band]]}}^{\text{nested } \textit{which}\text{-phrase}}$ do you like best?

As first alluded to by Higginbotham & May (1981: pp. 49–50), nested *which*-phrases in English fail to give rise to PL readings.[2] There are a number of different ways of demonstrating this. Elliott (2015, 2019) observes that a nested question such as (3a) cannot be felicitously answered by listing *band-album* pairs.

(3) a. Which album by which English rock band do you like best?
b. #*Revolver* by *The Beatles*, *Wish You Were Here* by *Pink Floyd*, and *Physical Graffiti* by *Led Zeppelin*.

Elliott (2019) additionally diagnoses the availability of a PL reading using embeddability under predicates of listing, such as *list*, *enumerate*, and *rattle off*. The idea here is that predicates of listing are incompatible with simple *which*-questions due to their uniqueness presupposition (4a). Since multiple questions have a PL reading, they are however compatible with predicates of listing (4b). Tellingly, nested *wh*-questions involving singular *which*-phrases pattern with simple *which*-questions, indicating that they lack a PL reading.

(4) a. #Vinny listed/enumerated/rattled off which famous session musician worked on this album.
b. Vinny listed/enumerated/rattled off which famous session musician worked on which album.

(5) #Vinny listed/enumerated/rattled off which album by which English rock band he likes best.

Fox & Sudo (2025) add to this yet another diagnostic: embedded multiple questions with PL readings may be modified with an exceptive phrase targeting the fronted *wh*-expression, i.e., the 'sorting key' (Kuno 1982), as illustrated in (7). This is of course impossible with a simple singular *which*-question (6).

1 Richards (2004) evocatively dubs multiple questions formed from nested *wh*-phrases 'Russian doll questions'.

2 The judgments reported below robustly replicate for all of the native English speakers we have consulted. Fox & Sudo (2025) however report that there is a small class of speakers who are able to access a PL reading for nested *which*-questions. As yet, we do not have a good explanation for why such variation might exist, and we limit the scope of our claims to the grammars of the majority of speakers.

(6) #Except for *War and Peace*, the guest knows which book is on the table.

(7) a. Except for *War and Peace*, the guest knows which book on the table is by which author.
b. Except for Tolstoy, the guest knows which author wrote which book. (Fox & Sudo 2025: p. 783)

Nested *which*-questions do not tolerate exceptive modification, targeting either the fronted *which*-phrase, or the *in situ which*-phrase.

(8) a. #Except for *War and Peace*, the guest knows which book by which author is on the table.
b. #Except for Tolstoy, the guest knows which book by which author is on the table.

(Fox & Sudo 2025: p. 783)

A closely related diagnostic is the possibility of *quantificational variability effects* in embedded questions (Lahiri 2002). Quantificational variability may arise with multiple questions, due to the possibility of the PL reading—the relevant reading of (9) can be paraphrased as *for most famous session musicians, Vinny knows (completely) which of these albums she worked on.* (10) on the other hand cannot receive a parallel reading, which would amount to: *for most English rock bands, I know (completely) which album by them Vinny likes best*. To the extent that (10) is acceptable, it can only mean that: my knowledge of Vinny's favorite album by an English rock band is incomplete.

(9) Vinny mostly knows which famous session musician worked on which of these albums.

(10) I mostly know which album by which English rock band Vinny likes best.

The unavailability of the PL interpretation notwithstanding, clearly nested *which*-questions are not infelicitous *per se*, given that they readily allow for an SP reading. The nested question in (11a) moreover *presupposes* that out of albums by English rock bands, the addressee has a single favorite one.

(11) a. Which album by which English rock band do you like best?
b. *Revolver* by *The Beatles*.

This set of facts poses a very general challenge for theories of multiple questions at the syntax-semantics interface. Concretely, a successful account should explain why the mechanisms responsible for deriving the PL reading of a multiple question do not generalize to nested questions, despite the fact that nested questions involve

multiple *wh*-expressions. Additionally, while the LF corresponding to the PL reading should be blocked for nested questions, the SP reading still needs to be accounted for.

Our goal is to demonstrate that a recent, influential approach to *pied-piping* in *wh*-questions in terms of scope-taking (Charlow 2019, Demirok 2019) surprisingly over-generates PL readings for nested *wh*-questions, even when the contained *which*-phrase is banned from scoping out of the containing *wh*-expression. We go on to suggest that, nevertheless, the scopal theory of pied-piping can be constrained syntactically—concretely, we propose that the scopal theory must be supplemented with a version of the *A-over-A* principle (Chomsky 1964). We later show that constraining the scopal theory syntactically makes novel (and correct) empirical predictions beyond strict nesting configurations.

The structure of the paper is as follows: we begin in section 2 by outlining our background assumptions concerning question composition, focusing in particular on the scopal theory of pied-piping. In section 3, we examine the predictions of the scopal theory of pied-piping for nested *which*-questions. Importantly, we show here that the scopal theory in fact *over-generates*, and allows PL readings to be derived for nested *which*-questions—on this basis, we propose that the scopal theory should be syntactically constrained via the *A-over-A* condition. In section 4 we observe that our syntactic constraint makes predictions beyond strict nesting configurations—specifically, in cases we dub 'quasi-nesting' configurations, as well as in the configuration known as the *wh*-triangle. We argue in this section that these predictions are correct. Finally, in section 5, we compare our analysis to a recent proposal due to Fox & Sudo (2025) regarding the absence of the PL reading, couched within a different approach to pied-piping. In section 6, we conclude with some open questions concerning the parallelism between *which*-phrases and indefinites.

2 Background: question composition & pied-piping

2.1 The scopal approach to question composition

The scopal theory of pied-piping is ultimately a generalization of Karttunen's (1977) scopal account of question composition. We take Heim's (1994) implementation of Karttunen's account as our starting point (see also Cresti 1995).

On this approach, questions are built from the two ingredients in (12). The first is the operator ?, which maps a proposition p to the singleton set containing p, i.e., the

question nucleus.[3] The second is a *wh*-phrase, analyzed as an existential quantifier that scopes over a question.[4]

(12) Scopal approach to question composition:

a. $[\![?]\!]^w = \lambda p_{st} \,.\, \{\, p \,\}$ $\quad : st, \{\, st \,\}$

b. $[\![\text{which boy}]\!]^w = \lambda k_{e,\{\, st \,\}} \,.\, \bigcup \{\, k(x) \mid \text{boy}_w(x) \,\}$ $\quad : (e, \{\, st \,\}), \{\, st \,\}$

These two ingredients interact as shown in (13), with the *wh*-phrase binding a variable across the ?-operator. After ? shifts its complement into a set of propositions, the *wh*-phrase feeds alternative boy-values into the nucleus pointwise, yielding a standard Hamblin denotation (Hamblin 1973):

(13) a. which boy λx ? [t_x sneezed]

b. $[\![\text{which boy}]\!]^{@} \,(\lambda x \,.\, \{\, \lambda w \,.\, \text{sneezed}_w(x) \,\})$
$= \{\, \lambda w \,.\, \text{sneezed}_w(x) \mid \text{boy}_{@}(x) \,\}$

Moving on to multiple questions, assuming that *in situ wh*-expressions covertly move above ? is sufficient to account for the SP reading (Heim 1994). This is illustrated in (14)—the result is a standard Hamblin denotation, but one where answers in the Hamblin set differ relative to two sets of alternatives, provided by each *wh*-expression.

(14) a. which boy λx which girl λy ? [t_x danced with t_y]

b. $[\![\text{which boy}]\!]^{@} \,(\lambda x \,.\, \{\, \lambda w \,.\, x \text{ danced with}_w y \mid \text{girl}_{@}(y) \,\})$
$= \{\, \lambda w \,.\, x \text{ danced with}_w y \mid \text{girl}_{@}(y), \text{boy}_{@}(x) \,\}$

A very natural generalization of this approach can be used to derive a *family-of-questions* denotation, which may be exploited in order to account for the availability of the PL reading (see, e.g., Fox 2012). Concretely, we may instead assume type-flexible entries for the *which*-phrase and question operator, as below. This allows *which*-phrases to take scope over both questions and families of questions. The basic idea is that ? may either take a proposition, and return a question, or take a question, and return a family of questions. As before, the *which*-phrase provides a way of feeding *boy*-values pointwise into a set.

(15) Scopal approach to question composition (type-flexible version):

3 The definition of the ? operator is effectively equivalent to the IDENT shifter of Partee (1986).

4 A brief note on some notational conventions: if σ and τ are types, then (σ, τ) is the corresponding functional type (parentheses are dropped when not necessary for disambiguation). Following Charlow 2014, 2019, we also find it perspicuous to draw a type distinction between *alternative sets* (type $\{\, \sigma \,\}$), and boolean types (type σ, t). Nothing crucial in the discussion however hinges on this.

a. $[\![\text{which boy}]\!]^w = \lambda k_{e,\{\tau\}} . \bigcup \{ k(x) \mid \text{boy}_w(x) \}$
b. $[\![?]\!]^w = \lambda p_\tau . \{ p \}$ $\tau \in \{ st, \{ st \} \}$

(16) a. which boy λx ? which girl λy ? [t_x danced with t_y]
b. $[\![\text{which boy}]\!]^@ (\lambda x . \{ \{ \lambda w . x \text{ danced with}_w y \mid \text{girl}_@(y) \} \})$
$= \{ \{ \lambda w . x \text{ danced with}_w y \mid \text{girl}_@(y) \} \mid \text{boy}_@(x) \}$

We now turn to how these denotations relate to answerhood conditions. Following much existing work, we adopt Dayal's (1996) influential conjecture that a question presupposes the existence of a unique, maximally informative true answer. Formally, Max_{inf} can be defined as an operator that takes a question denotation Q, and a world w, and returns the set of maximally informative true answers to Q at w. Applied to (14), this returns true propositions of the form 'b danced with g', where b and g are an actual boy and girl. Dayal's answerhood operator, defined in (17b) introduces the presupposition that there is only *one* such proposition. This correctly predicts that in a given world, a legitimate answer to (14) consists of a *single* boy-girl pair.

(17) Answerhood operator:

a. $Max_{inf}(Q)(w) = \{ p \in Q \mid p(w) = 1, \forall q \in Q[q(w) = 1 \rightarrow p \subseteq q] \}$
b. $Ans(Q) = \lambda w : \exists! p \in Max_{inf}(Q)(w) . \iota p[p \in Max_{inf}(Q)(w)]$

Following Fox (2012), we assume that *Ans* applies *pointwise* to a family of questions. Concretely, (16b) denotes a set of questions of the form 'which girl did x dance with?', where x is an actual boy. Applying *Ans* pointwise to each question in the set gives rise to a *universal* presupposition that, for each boy b, there is only one true proposition of the form 'b danced with g'. This predicts that in a given world, a legitimate answer to (16b) consists of a set of boy-girl pairings.

2.2 Pied-piping via cyclic scope

We now turn to the scopal theory of pied-piping, developed as a generalization of Karttunen's approach by Charlow (2019) and Demirok (2019). As is well-known (see, e.g., von Stechow 1996), the challenge posed by questions with pied-piping such as (18) is how to have the *wh*-phrase take scope over the question nucleus, without positing syntactically dubious movement from out of the subject. Charlow (2019) demonstrates that decomposing the Karttunen entry for *which*-phrases provides additional insight into how to interpret *pied-piping* configurations, as in (18) (see also Demirok 2019).

(18) [Which philosopher's book] was a success?

Charlow's central insight is as follows: assuming that NP restrictors are of type *et*, the Karttunen entry for *which* can be decomposed into two components: it accomplishes both (i) alternative-set introduction, and (ii) scope-taking. Charlow factors scope-taking out of the Karttunen entry for *which*, and into an independent operator Q which is responsible for converting a set of alternatives into a scope-taker (19b).[5][6] Applying 'which' to an NP-restrictor, and Q to the result, returns a (type-flexible) Karttunen *which*-phrase denotation, as shown in (20). Charlow also assumes a type-flexible generalization for the question operator (19c), for reasons that will shortly become apparent.

(19) a. $[\![\text{which}]\!] = \lambda P_{et} \,.\, \{\, x \mid P(x) \,\}$

b. $[\![\text{Q}]\!] = \lambda X_{\{\,\sigma\,\}} \,.\, \lambda k_{\sigma,\{\,\tau\,\}} \,.\, \bigcup \{\, k(x) \mid x \in X \,\}$ $\quad \forall \sigma, \tau \in Typ$

c. $[\![?]\!] = \lambda p_{\tau} \,.\, \{\, p \,\}$ $\quad \forall \tau \in Typ$

(20) $[\![\text{Q}]\!] \left([\![\text{which}]\!] \left([\![\text{boy}]\!]^{w} \right) \right) = [\![\text{Q}]\!] \left(\{\, x \mid \text{boy}_{w}(x) \,\} \right)$

$= \lambda k_{e,\{\,\tau\,\}} \,.\, \bigcup \{\, k(x) \mid \text{boy}_{w}(x) \,\}$

This regime for composing alternatives corresponds syntactically to moving a QP, rather than a *which*-phrase directly, but delivers results identical to Karttunen's. The resulting LF for a simple *wh*-question is illustrated in (21).

(21) $[_{\text{QP}}$ Q which boy$]$ λx $[?$ t_x sneezed$]$

This decomposition affords a straightforward account of pied-piping as a form of recursive scope-taking. Pied-piping proceeds by scoping the pied-piping *which*-phrase to the left edge of the pied-piped constituent via Q, over an instance of ?, as in (22). In a sense, free insertion of a type-neutral instance of ? creates an 'inner nucleus' within the pied-piped constituent. What results is a *which*-phrase denotation, i.e., a set of alternatives, which may in turn take scope via Q, as in (23). As exhaustively demonstrated by Charlow, this is equivalent to allowing the pied-piper to independently take scope (modulo the *de re* interpretation of the restrictor).

(22) $[_{①}$ $[_{\text{QP}_2}$ Q which philosopher $]$ λx ? t_x's book $]$

$= \{\, \iota z[\text{book.of}_{@}(z)(x)] \mid \text{philosopher}_{@}(x) \,\}$

(23) $[_{\text{QP}_1}$ Q ① $]$ λy ? t_y was a success

$= \{\, \lambda w \,.\, \text{success}_{w}(y) \mid y \in \{\, \iota z[\text{book.of}_{@}(z)(x)] \mid \text{philosopher}_{@}(x) \,\} \,\}$

$= \{\, \lambda w \,.\, \text{success}_{w}(\iota z[\text{book.of}_{@}(z)(x)]) \mid \text{philosopher}_{@}(x) \,\}$

5 We label it Q after Cable's (2010) Q-particle, though it should be noted that the distribution of this operator is not the same as the distribution of Q-particles discussed in Cable's work.

6 This is identical to Charlow's (2019) *monadic bind* operator.

The scopal account of pied-piping is still missing one final ingredient, however, as emphasized by Demirok (2019). The problem with the derivation above is that the pied-piped phrase gets a full *de re* interpretation. As first observed by von Stechow 1996, this reading is unavailable as it would predict (18) to have a reading akin to "Which book by a philosopher was a success?", i.e., the Hamblin set in (23) corresponds to the set of propositions of the form *x is a success*, where *x* is a book by a philosopher. We can also show that pied-piped material must be interpreted *de dicto* via the question-answer pairs in (24): an appropriate answer to this interrogative must identify the philosopher whose book was a success, rather than naming the book itself (see von Stechow 1996 and Demirok 2019 for further discussion and additional evidence in favor of this claim).[7]

(24) Which philosopher's book was a success?

a. Lewis's.

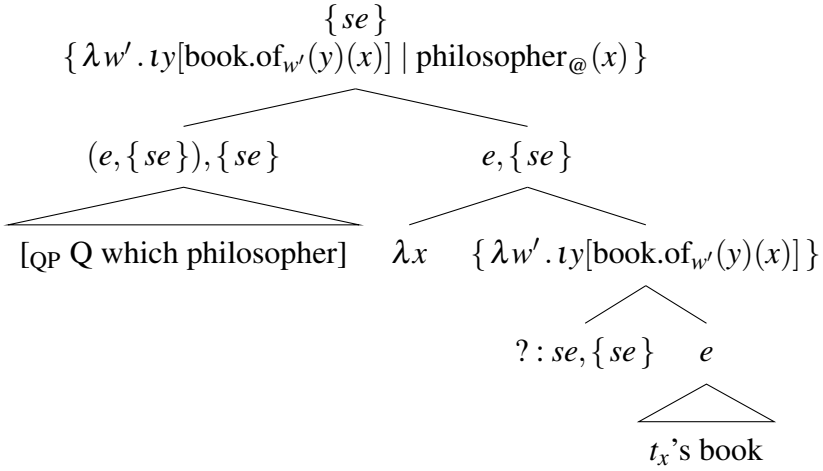
b. #*Counterfactuals*.

As discussed in Demirok 2019, only one small tweak is necessary to interpret the pied-piped material *de dicto*: namely, ? must be able to map an individual concept to a set of individual concepts. This is an option already afforded by the polymorphic typing of ?—concretely, it may be of type $se, \{se\}$, in which it composes with the *intension* of its argument and returns a set of concepts, rather than a set of individuals.[8] The derivation of 'which philosopher's book' is given below in (25). The ? essentially demarcates material that semantically reconstructs into the question nucleus, deriving the attested *de dicto* interpretation of the pied-piped material.

7 As Demirok (2019) emphasizes, it is not just that the pied-piped material may be interpreted *de dicto*, but rather that (at least some of) what is pied-piped *must* be interpreted *de dicto*. For now, we will demonstrate how the attested interpretation is derived, but we return to the question of how to block the fully *de re* interpretation in section 3.4.

8 Nothing in the dialectic here hinges on a particular approach to intensionality, but for concreteness we assume the free availability of *intensional functional application* (von Fintel & Heim 2023). That is to say, when $\alpha : s\sigma, \tau$ composes with $\beta : \sigma$, it takes the *intension* of β (of type $s\sigma$) as its argument.

(25)



The resulting *which*-phrase denotation ranges over *concepts of x's book*, where x is a philosopher in the actual world. The *which*-phrase leaves behind an intensional trace of type *se*, which is extensionalized within the scope of the sentential ?-operator—this just means that the intensional trace is evaluated relative to the local world of evaluation.[9] The pied-piped material thereby semantically reconstructs into the question nucleus.

(27) $[_{\text{QP}}$ Q which philosopher's book$]$ λi_{se} ? $t_i^{\downarrow}$ was a success
$= \{ \lambda w . \text{success}_w(\iota y[\text{book.of}_w(y)(x)]) \mid \text{philosopher}_{@}(x) \}$

3 Nested *which*-questions in the scopal theory of pied-piping

In this section, we show how nested *which*-questions are interpreted within the scopal theory of pied-piping presented in the previous section. First, we show how SP readings are derived. Then, we show that PL readings can be derived even if the contained *wh*-phrase never scopes out of the container *wh*-phrase. Finally, we show how such derivations can be blocked on syntactic grounds, as they all violate Chomsky's (1964) A-over-A principle.

9 For concreteness, we indicate extensionalization in the schematic LF via the operator $\downarrow$. For any $\alpha : s\sigma$:

(26) $[\![\alpha^{\downarrow}]\!]^w := [\![\alpha]\!]^w(w) : \sigma$

This corresponds to, e.g., von Fintel & Heim's (2023) composition principle *extensionalizing functional application*.

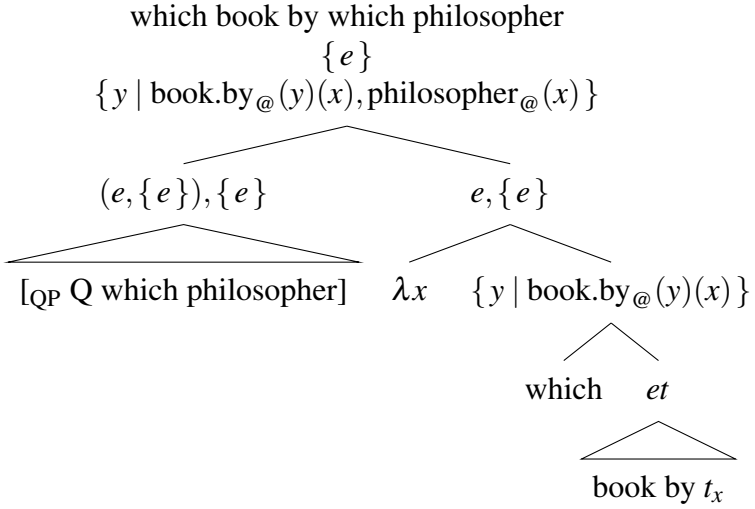
3.1 SP readings and *de dicto*

Nested *wh*-phrases pose the same general problem as pied-piping configurations: the contained *wh*-phrase must take scope over the matrix clause, but it is trapped within its container. In the case of a nested *wh*-question however, the container is itself a *wh*-phrase and must also take scope.

(28) $[_{\text{QP}}$ Q which book by which philosopher$]$ λx ? $[t_x$ was a success$]$

The scopal theory of pied-piping affords us all the tools we need to derive SP readings of nested *which*-questions, without scoping the contained *wh*-phrase out of its container. First, we assume that the contained *wh*-phrase scopes to the edge of its container, as shown in (29). Note that, because a *wh*-phrase is already an object of type $\{\tau\}$, unlike other cases of pied-piping, we do not need the contained *which*-phrase to take scope over an instance of the ?-operator.

(29)



A nested *wh*-phrase is thus interpreted as an object of the same type as a simple *wh*-phrase. Interpretation of the remainder of the sentence proceeds as expected:

(30) $[_{\text{QP}}$ Q which book by which philosopher$]$ λy ? $[t_y$ was a success$]$
$\rightsquigarrow \{\lambda w\,.\,\text{success}_w(y) \mid \text{book.by}_{@}(y)(x), \text{philosopher}_{@}(x)\}$

The above shows that Charlow's (2019) theory of pied-piping can naturally be extended to nested *wh*-phrases, allowing us to interpret these questions without having to resort to movement of the contained *wh*-phrase from its container into the matrix clause. However, the meaning in (30) is not quite correct yet. The issue is the same as the one observed by von Stechow 1996: (30) gives the containing *which*-phrase a fully *de re* interpretation, and, as Sudo (2017) observes, that reading

is not available. If it were, we would predict the nested question "Which book by which philosopher was a success?" to be semantically equivalent to "Which book by a philosopher was a success?". The answerhood conditions of the two questions are clearly different, however. Intuitively, the nested question in (31) requires an answer specifying a *book-author* pair, whereas the question in (32) does not. Sudo thus concludes that the outer *wh*-phrase must be interpreted *de dicto*.

(31) Which book by which philosopher was a success?

a. *Counterfactuals*, by Lewis.

b. #*Counterfactuals*.

(32) Which book by a philosopher was a success?

a. *Counterfactuals*, by Lewis.

b. *Counterfactuals*.

The analysis of pied-piping, however, does not need to be drastically modified. All we need is a way of interpreting the NP-restrictors of *wh*-phrases *de dicto*—a phenomenon that is independent of nested *wh*-phrases (e.g., Groenendijk & Stokhof 1982). For now, we introduce a *de dicto* counterpart to (19a) as an abbreviation.[10] A *de dicto which*-phrase denotes a set of partial, rigid individual concepts, one for each individual, each defined just in case that individual satisfies the restrictor; these reconstruct into the question nucleus:[11]

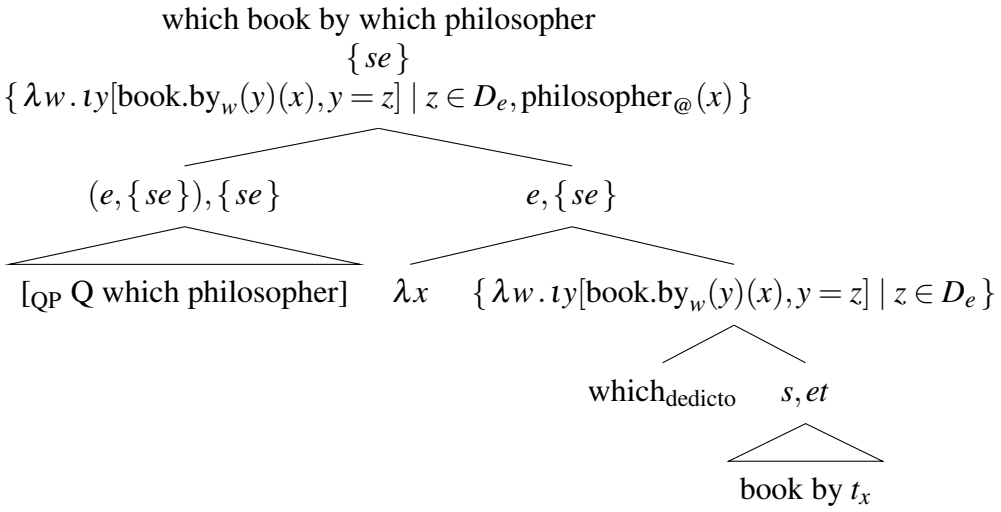
(33) $[\![\text{which}_{\text{dedicto}}]\!] := \lambda P_{s,et} \,.\, \{\, \lambda w \,.\, \iota y[P(w)(y), y = x] \mid x \in D_e \,\} \qquad (s,et), \{\, se \,\}$

We can derive the attested SP readings of nested *which*-phrases with the same structure as before, the only difference being that the container *which*-phrase is headed by $\text{which}_{\text{dedicto}}$ instead:

10 In section 3.4 we will show that (33) need not be stated as an independent lexical entry; it can be derived from the logic of pied-piping, once *which* is decomposed into a definite core and an alternative-introducing operator.

11 Our account of *de dicto* restrictors can be thought of as a semantic implementation of the syntactic approach of Rullmann & Beck 1998 (see also Heim 2012).

(34)



We then assume that the *wh*-phrase leaves behind a trace of type *se* and we get the attested *de dicto* reading of these questions:

(35) $[_{\text{QP}}$ Q which book by which philosopher] λi_{se} ? $t_i^{\downarrow}$ was a success
$\rightsquigarrow \{ \lambda w . \text{success}_w(\iota y[\text{book.by}_w(y)(x), y = z]) \mid z \in D_e, \text{philosopher}_{@}(x) \}$

An immediate virtue of this analysis is that the PL reading *cannot* be derived if nested *wh*-phrases are interpreted as (34), i.e., as objects of type $\{se\}$. It is easy to see why: to derive the desired family-of-questions denotation, we would need a second ? to take scope in between the two *wh*-phrases, but this is impossible when they are interpreted as a flat set of individual concepts:

(36) a. ? $[_{\text{QP}}$ Q which book by which philosopher] λi_{se} ? $[t_i^{\downarrow}$ was a success]
$\rightsquigarrow \{ \{ \lambda w . \text{success}_w(\iota y[\text{book.by}_w(y)(x), y = z]) \mid z \in D_e, \text{philosopher}_{@}(x) \} \}$

b. $[_{\text{QP}}$ Q which book by which philosopher] λi_{se} ? ? $[t_i^{\downarrow}$ was a success]
$\rightsquigarrow \{ \{ \lambda w . \text{success}_w(\iota y[\text{book.by}_w(y)(x), y = z]) \} \mid z \in D_e, \text{philosopher}_{@}(x) \}$

Thus it may appear that we already have an account of the ban on PL readings. Deriving a family-of-questions denotation requires the two *wh*-phrases to scope over distinct ?-operators, and the only apparent route to this is "unnesting", as in (37). Suppose such structures are blocked, plausibly because DP is a scope island (Charlow 2010, *pace* Sauerland 2005). Would it then follow that there is no way for the two *wh*-phrases to take scope relative to different question operators? In the next section we show that it would not.

(37) *[Which Russian author]$_x$? [which novel by t_x]$_y$? t_y was a success?

3.2 Over-generating PL readings

Having shown how the scopal theory of pied-piping allows us to derive SP readings of nested *which*-phrases, we now demonstrate that this approach is sufficiently expressive to also derive PL readings *without scoping out the contained wh-expression*. While such readings cannot be generated when nested *which*-phrases are interpreted as objects of type $\{se\}$, these unattested interpretations can be derived once such phrases are allowed to denote objects of more complex types. In this subsection, we show that PL readings can be derived via two different LFs.

First, consider an LF in which the contained *which*-phrase scopes to the edge of the container as before, but now it does so over an instance of the ?-operator, as shown in (38). Thus, rather than composing with a function of type $e, \{ se \}$, *which philosopher* will compose with a function of type $e, \{ \{ se \} \}$. As illustrated in (39), the result is an object of type $\{\{se\}\}$: a *which*-phrase which itself ranges over ordinary *which*-phrase denotations. We refer to such objects as *higher-order which-phrases*.[12]

(38) $[_{\text{QP}_3}$ Q which philosopher] λx ? [which$_{\text{dedicto}}$ book by t_x]

(39) $[\![(38)]\!] = \{ \{ \lambda w \,.\, \iota y[\text{book.by}_w(y)(x), y = z] \mid z \in D_e \} \mid \text{philosopher}_@(x) \}$

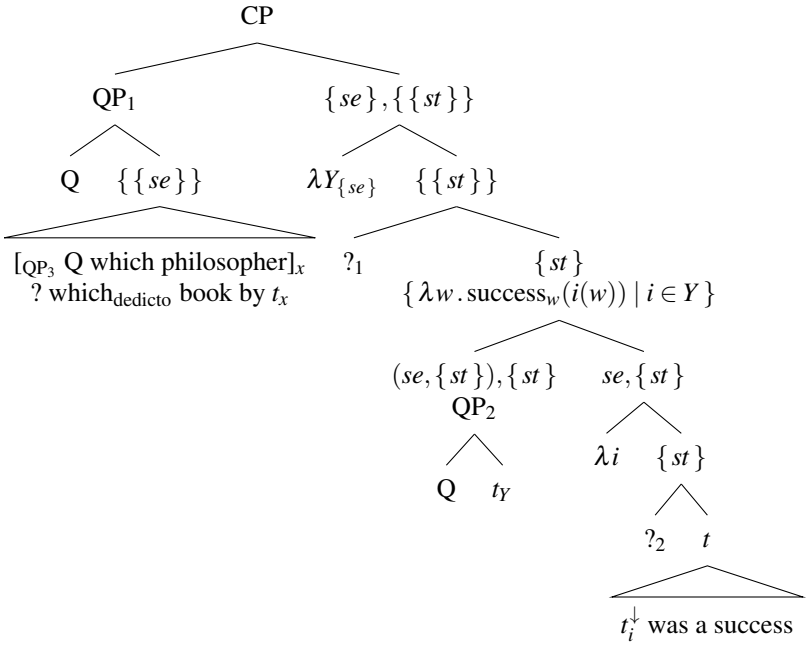
The resulting higher-order *which*-phrase may then take scope via Q. In other words, attaching Q to the *which*-phrase denotation in (39) gives rise to a scope-taker that ranges over *which*-phrases.

(40) $[\![\text{Q}]\!]^@ ([\![39]\!]^@)$
$= \lambda k_{\{se\},\{\tau\}} \,.\, \bigcup \{ k(X) \mid X \in [\![39]\!]^@ \}$
$= \lambda k_{\{se\},\{\tau\}} \,.\, \bigcup \{ k(\{ \lambda w . \iota y[\text{book.by}_w(y)(x), y = z] \mid z \in D_e \}) \mid \text{philosopher}_@(x) \}$

In order to derive the unattested PL reading, all that is necessary is to allow the higher-order *which*-phrase to leave behind a trace of type $\{ se \}$, which itself scopes via Q above a distinct question operator. The pied-piped material *which book by x* thereby semantically reconstructs. The LF that needs to be ruled out is schematized in (41).

12 In order to avoid confusion, note that we use this term in a different way to how it is sometimes used in the literature. Concretely, *wh*-expressions ranging over generalized quantifiers are often described as 'higher-order' (see, e.g., Elliott, Nicolae & Sauerland 2022). We use 'higher-order *which*-phrase' in a narrower sense here.

(41) $\{\{\lambda w.\text{success}_w(\iota y[\text{book.by}_w(y)(x), y = z]) \mid z \in D_e\} \mid \text{philosopher}_@(x)\}$



The resulting family-of-questions denotation is a set of questions of the form "which book by x was a success?", where x is a philosopher. In other words, *which philosopher* is the 'sorting key'. Applying *Ans* pointwise predicts that the nested question in (42a) should presuppose that for each philosopher x, x has exactly one successful book, and may be answerable with a list of *philosopher-book* pairings as in (42b). As we argued extensively in section 1, this PL reading is unavailable.

(42) a. Which book by which philosopher was a success?
b. #*Counterfactuals* by Lewis and *Inquiry* by Stalnaker.

The second LF to consider is one in which we scope the contained *which*-phrase to the edge of the container's QP (shifted by an instance of the ?-operator). This is illustrated schematically in (43). Whereas the strategy schematized in (38) derives a *higher-order wh-phrase* denotation, the strategy in (43) derives a *wh*-phrase denotation *ranging over QPs*—i.e., a set of QPs, type $\{(se, \{st\}), \{st\}\}$.

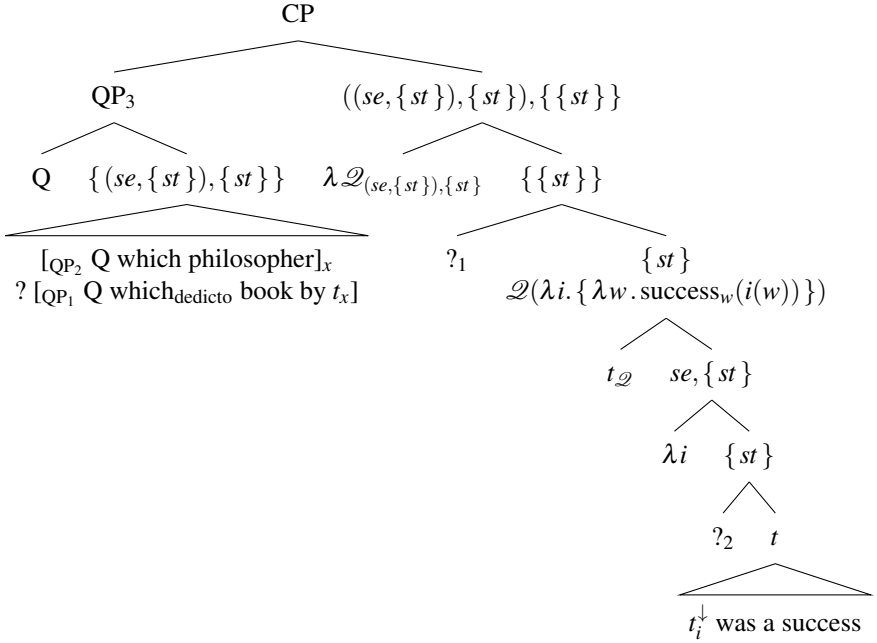
(43) $[_{\text{QP}_2}$ Q which philosopher$]$ λx ? $[_{\text{QP}_1}$ Q $[\text{which}_{\text{dedicto}}$ book by $t_x]]$

a. $[\![\text{QP}_1]\!]^@ = \lambda k.\bigcup\{k(\lambda w.\iota y[\text{book.by}_w(y)(x), y = z]) \mid z \in D_e\}$
b. $[\![?]\!]^@([\![\text{QP}_1]\!]^@) = \{[\![\text{QP}_1]\!]^@\}$
c. $[\![\text{QP}_2]\!]^@ = \lambda k.\bigcup\{k(x) \mid \text{philosopher}_@(x)\}$

d. $[\![\mathrm{QP}_2]\!]^{@}(\lambda x.\,\{\lambda k.\,\bigcup\{k(\lambda w.\iota y[\mathrm{book.by}_w(y)(x), y=z]) \mid z \in D_e\}\})$
$= \{\lambda k.\,\bigcup\{k(\lambda w.\iota y[\mathrm{book.by}_w(y)(x), y=z]) \mid z \in D_e\} \mid \mathrm{philosopher}_{@}(x)\}$

The resulting *wh*-phrase denotation may, as before, take scope via Q, but this time, due to its higher type, it may leave behind a QP-type trace, which itself takes scope. Concretely, scoping the QP-type trace over an independent question operator derives the same unattested PL reading as the one in (41):

(44) $\{\{\lambda w.\,\mathrm{success}_w(\iota y[\mathrm{book.by}_w(y)(x), y=z]) \mid z \in D_e\} \mid \mathrm{philosopher}_{@}(x)\}$



Although derived by different routes, the two LFs in (41) and (44) yield the same interpretation, and for a principled reason: in both, the pied-piped material—*which book by x*—is semantically reconstructed under $?_1$, where it takes scope over the lower question nucleus. The two LFs differ only in how this configuration is reached. In (44), Q applies to the container *before* ?; the reconstructed object is therefore already of the type of a scope-taker, and the trace $t_{\mathscr{Q}}$ may scope over $?_2$ directly, with no further application of Q. In (41), by contrast, ? applies to the bare *wh*-phrase denotation—a set of individual concepts—and it is instead the trace t_Y that Q converts into a scope-taker.

3.3 Blocking PL readings via the A-over-A condition

We have seen in the previous subsection that, even granting the assumption that an *in situ wh*-phrase may not evacuate its container, a PL reading can be derived by

allowing the contained *wh*-phrase to pied-pipe its container. This will then allow for the contained *wh* to take scope above the higher question operator, and for the pied-piped container to take scope above the lower question operator. In a sense it is unsurprising that a theory as powerful as Charlow's over-generates in the domain of *wh*-questions; the question is whether it can be constrained in a natural way.

We first observe that both offending LFs have one common feature: they both involve a QP moving out of a containing QP. For example, to generate the offending LF in (41), we must form a nested QP which sits between the two occurrences of the ?-operator in the matrix clause, as shown in (45a). The crucial step to derive (41) is that of moving QP_2 to the edge of the clause across QP_1, as in (45b).

(45) a. $?_1$ [$_{\text{QP}_1}$ Q_1 [$_{\text{QP}_2}$ Q_2 [which book by whom]]] λi $?_2$ $t_i^{\downarrow}$ was a success

b. [$_{\text{QP}_2}$ Q_2 [which book by whom]] λY $?_1$ [$_{\text{QP}_1}$ Q_1 Y] λi $?_2$ $t_i^{\downarrow}$ was a success

The same kind of configuration is found in our second offending LF, but internally to the nested *wh*-phrase, as shown in (46): for [Q *which philosopher*] to move to the edge of a QP shifted by ?, it must of course move out of that QP.

(46) a. ? [$_{\text{QP}_1}$ Q_1 [which book by [$_{\text{QP}_2}$ Q_2 which philosopher]]]

b. [$_{\text{QP}_2}$ Q_2 which philosopher] λx ? [$_{\text{QP}_1}$ Q_1 [which book by t_x]]

Our proposal is that the LFs capable of generating PL readings are unavailable precisely because they must involve this kind of movement step. Specifically, they both involve a clear violation of the *A-over-A principle* (Chomsky 1964)—*wh*-movement (presumably triggered by a probe in ?) targets QP_2, when it could have targeted the containing QP_1. Concretely, we would like to suggest that the absence of PL readings with nested questions follows from two independently motivated syntactic factors: (i) locality constraints on covert QP-movement, and (ii) the A-over-A principle, as it applies to QP movement. The A-over-A principle as it applies to QP movement is stated below:

(47) *QPs and A-over-A*
*QP_2 ? . . . [$_{\text{QP}_1}$ . . . t_2 . . .] . . .

The A-over-A principle constrains Charlow's theory of pied-piping syntactically, without sacrificing its main results. Attested instances of pied-piping do not necessitate violations of A-over-A. Consider, e.g., *whose picture*-type pied-piping: the pied-piper *who* moves to the edge of the containing DP, as in (48), and the containing QP subsequently moves yielding (49).

(48) a. ? [$_{\text{QP}_2}$ Q who]'s picture

b. [$_{\text{QP}_2}$ Q who] λx ? [t_x's picture]

(49) $[_{\text{QP}_1}$ Q $[[_{\text{QP}_2}$ Q who] λx ?$_2$ t_x's picture]] λy ?$_1$ do you like t_y

There is a semantic corollary to this syntactic constraint on QP movement—namely, violating A-over-A only becomes necessary because we have syntactically constructed an object with a particular semantic type (i.e., $\{\{se\}\}$). As far as we are able to tell, not much hinges on whether we characterize the relevant constraint syntactically or semantically—both are possible, but a conceptual advantage of the syntactic characterization is that it boils down to an independently motivated constraint on movement, namely the A-over-A principle.[13]

3.4 A decompositional approach to the *de re*/*de dicto* ambiguity

We have so far relied on two different entries for 'which': the *de re* entry (19a) simply takes a predicate and returns a set of individuals. The *de dicto* entry (33) takes the intension of a predicate and returns a set of individual concepts. As we demonstrated in the previous sections, both are needed to derive the attested readings of nested *which*-questions.

Before closing this section, we show that this ambiguity can be eliminated from the theory: in fact, both readings already follow from independently motivated compositional primitives. We suggest that the existence of both readings follows if *which* is decomposed into (i) a parameterized definite article **the**, and (ii) an operator for introducing alternatives **wh**. Note that, crucially for us, **wh** has a flexible type—it takes scope over an alternative-set, but remains agnostic as to the nature of those alternatives.[14]

(50) a. $\mathbf{the} = \lambda x_e \,.\, \lambda P_{et} \,.\, \iota y[P(y), y = x]$
b. $\mathbf{wh} = \lambda k_{e,\{\tau\}} \,.\, \bigcup \{ k(x) \mid x \in D_e \}$
c. $[\mathbf{the\ wh}] \approx$ *which*

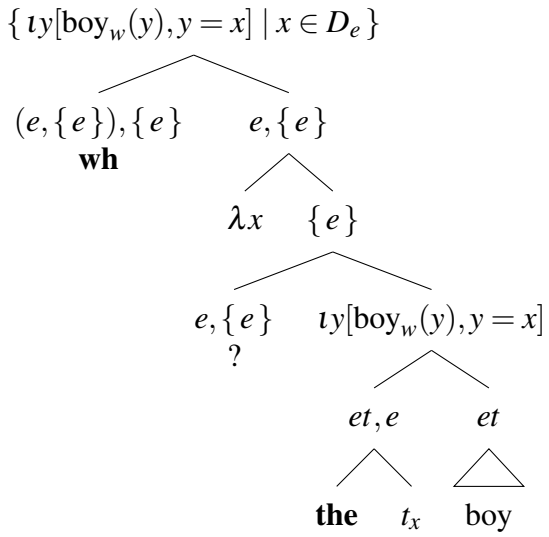
With these pieces in place, both *de re* and *de dicto* readings follow from the options afforded by the logic of pied-piping. To derive the *de re* reading, the trace of **wh** serves as the first argument of **the**, and **wh** scopes out to the edge of the

13 Saito (1989: p. 187) discusses an example, attributed to Howard Lasnik, in which a *wh*-phrase is overtly extracted from a moved *wh*-phrase, yielding a marginally acceptable sentence: ??*Who*$_1$ *do you wonder [which picture of* t_1*]*$_2$ *John likes* t_2*?* Such examples, which Sauerland (1999) dubs *surfing configurations*, appear at face value to violate the A-over-A principle. A proper formulation of the principle that accommodates them goes beyond the scope of this paper, but we note that they do not undermine our proposal: (i) surfing configurations are marginal, suggesting that the principle is indeed active; and (ii) their (relative) acceptability may correlate with the fact that the two movement steps are triggered by probes in different clauses.

14 Here we are essentially building on Rullmann & Beck 1998, Heim 2012, Elliott & Kobayashi 2022 in positing a definite 'core' for *which*-phrases.

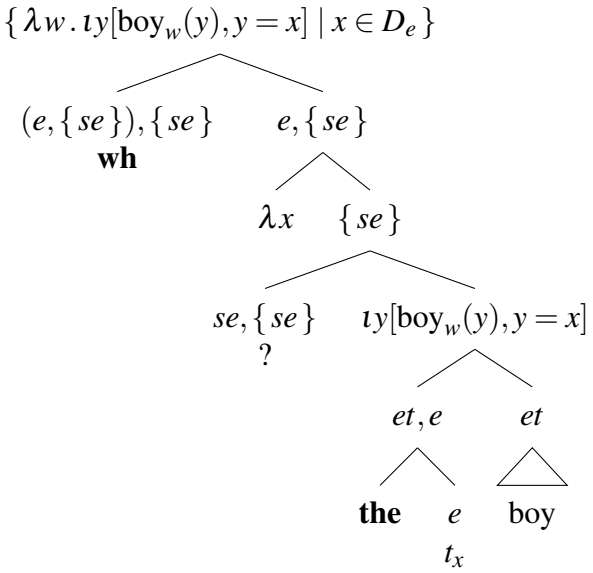
which-phrase over the ? operator. The full LF we propose for a *de re which*-phrase is given in (51).

(51) LF for a *de re which*-phrase:



The LF for the *de dicto* reading is completely isomorphic, modulo the typing of ?. When ? selects for an individual concept, it forces intensionalization of the scope of **wh**. The internal composition of a *de dicto which*-phrase therefore mirrors the external composition of a *de dicto which*-question.

(52) LF for a *de dicto which*-phrase:



N.b., that the root of (52) is exactly (33) applied to the intension of *boy*. The abbreviation $which_{dedicto}$ in section 3.1 therefore need not be stipulated: it is derivable from the entries for **the** and **wh**, together with the type-flexibility of ? and intensional functional application, all of which are independently motivated.

This approach to *de dicto* readings of *which*-phrases is highly reminiscent of the approach developed by Rullmann & Beck 1998, later refined by Heim 2012, and delivers practically equivalent results: it involves deriving a *de dicto* interpretation by interpreting the lower position from which the *which*-phrase moved as a bound definite description. The main difference is that on our account the *de dicto* entry is derived from the (independently motivated) logic of pied-piping.

Finally, we have not yet said why it is that pied-piped material is *obligatorily* interpreted *de dicto* (von Stechow 1996, Demirok 2019), given that *which*-phrases themselves may be interpreted *de re*. We adopt a variant of the proposal of Demirok (2019), who suggests that this follows from constraints on the typing of ?. Instead of laying the blame on ?, we shift the burden to the typing of Q. As far as we can tell this has the same end result of forcing *pied-piped* material to be interpreted *de dicto*, while avoiding problematic interactions with other aspects of our analysis.[15]

Concretely, we adopt the stricter typing for Q in (53). Q takes a set of alternatives of type $\{\sigma\}$, and scopes them into a set of *intensional* alternatives, or into a set of such sets, and so on; i.e., its scope must be of type $\{s\tau\}$, $\{\{s\tau\}\}$, ... (for any types σ, τ). This more rigid typing is of course satisfied by a sentential question nucleus, which is of type $\{st\}$ (i.e., a set of propositions), and by a set of questions, which is of type $\{\{st\}\}$.

(53) **Strict typing for Q**:
$Q : \{\sigma\}, ((\sigma, \rho), \rho)$ $\quad \forall \sigma, \tau \in Typ,\ \rho \in \mathscr{R}_\tau$
where $\mathscr{R}_\tau$ is the smallest set of types such that $\{s\tau\} \in \mathscr{R}_\tau$, and if $\rho \in \mathscr{R}_\tau$, then $\{\rho\} \in \mathscr{R}_\tau$.

To see how this forces pied-piped material to be interpreted *de dicto*, consider a simple case of pied-piping of the *whose picture* type, schematized below. The stricter typing for Q ensures that ? takes an intensional argument, otherwise a type-mismatch will obtain.

(54) $[_{QP}$ Q which philosopher$]_{(e,\{se\}),\{se\}}$ λx $?_{se,\{se\}}$ t_x's picture

The stricter typing for Q of course still allows simple *which*-phrases to be interpreted *de re*, since the typing requirements of Q will be satisfied by the question nucleus. Now let us move on to the case of nested *which*-questions, which involve a

15 For instance, given the decomposition of *which*-phrases we propose in this section, Demirok's stricter typing for ? would rule out *de re* readings of *which*-phrases.

which-phrase pied-piping a *which*-phrase. The stricter typing for Q will be satisfied just in case the containing *which*-phrase is interpreted *de dicto*; if it is interpreted *de re*, then a type-mismatch obtains.

(55) a. ✓ $[_{\text{QP}}$ Q which philosopher$]_{(e,\{se\}),\{se\}}$ λx [which$_{\text{dedicto}}$ book by $t_x]_{\{se\}}$
b. ✗ $[_{\text{QP}}$ Q which philosopher$]_{(e,\{se\}),\{se\}}$ λx [which book by $t_x]_{\{e\}}$

4 Beyond nesting

In this section, we examine two predictions of our proposal, concerning (i) pied-piped constituents that contain more than one *wh*-phrase—what we call *quasi-nesting* configurations—and (ii) embedded nested *which*-questions. We show that both predictions are confirmed, lending further support to our proposal.

4.1 Quasi-nesting configurations

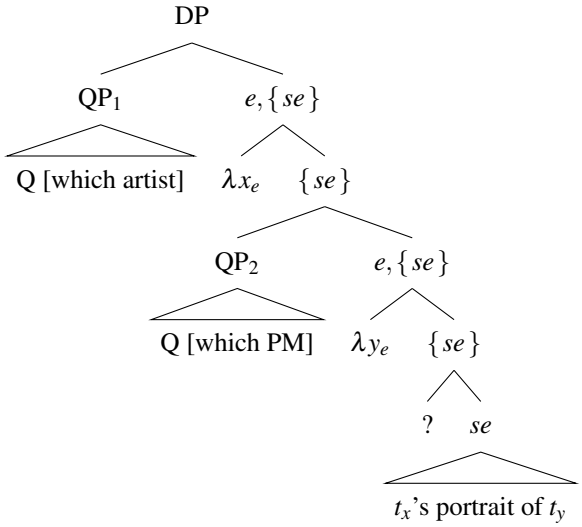
We now consider constructions that do not strictly involve nesting: sentences such as (56), where a pied-piped constituent which is not itself a *wh*-phrase contains multiple *wh*-phrases. We call these *quasi-nesting* configurations. The answerhood conditions of (56) show that this question presupposes that there is a unique *artist-prime minister* pairing x, y such that x's portrait of y is displayed in the National Gallery. As such, it allows for an SP (56a) but not a PL (56b) reading.

(56) [Which artist's portrait of which prime minister] is displayed in the National Gallery?

a. *Karsh*'s portrait of *Churchill*.
b. #*Karsh*'s portrait of *Churchill* and *Donovan*'s portrait of *Thatcher*.

Within the scopal theory of pied-piping, the attested SP reading is derived by having both *wh*-phrases move to the edge of the pied-piped DP, over a single instance of the ?-operator:

(57) $\{\lambda w.\iota z[\text{portrait.of}_w(z)(x)(y)] \mid \text{artist}_@(x), \text{PM}_@(y)\}$



The entire clause is straightforwardly interpreted, yielding the desired SP reading:

(58) $[_{\text{QP}}$ Q [which artist's portrait of which PM]] λi_{se} ? $[t_i^{\downarrow}$ is displayed in the National Gallery]
$\rightsquigarrow \{\lambda w.\text{displayed}_w(\iota z[\text{portrait.of}_w(z)(x)(y)]) \mid \text{artist}_@(x), \text{PM}_@(y)\}$

As we saw with nested *wh*-phrases, when the pied-piped material denotes an object of type $\{se\}$, no PL reading can be derived. The question, however, is whether the unattested readings can be generated via alternative means. Scopal pied-piping easily allows for a derivation on which *which artist's portrait of which prime minister* denotes a higher-order alternative set of type $\{\{se\}\}$, sorted according to artists (59a) or prime ministers (59b)—in other words, a *which*-phrase denotation which itself ranges over *which*-phrase denotations.

(59) a. $[_{\text{QP}_1}$ Q which artist$]_x$?$_1$ $[_{\text{QP}_2}$ Q which PM$]_y$?$_2$ [t_x's portrait of t_y]
$\rightsquigarrow \{\{\lambda w.\iota z[\text{portrait.of}_w(z)(x)(y)] \mid \text{PM}_@(y)\} \mid \text{artist}_@(x)\}$

b. $[_{\text{QP}_2}$ Q which PM$]_y$?$_2$ $[_{\text{QP}_1}$ Q which artist$]_x$?$_1$ [t_x's portrait of t_y]
$\rightsquigarrow \{\{\lambda w.\iota z[\text{portrait.of}_w(z)(x)(y)] \mid \text{artist}_@(x)\} \mid \text{PM}_@(y)\}$

Regardless of whether the higher-order alternative set is sorted according to artists or prime ministers, deriving a PL reading from it requires a higher-order trace together with subextraction from a QP. The relevant derivation, schematized in (60), is thus ruled out by the same constraint that blocks PL readings of nested *which*-questions.

(60) ✗ $[_{\text{QP}_1}$ Q which artist's portrait of which PM] λY ? $[_{\text{QP}_2}$ Q $t_Y]$ λi ? $[t_i^{\downarrow}$ is displayed in the National Gallery]

The only other way of deriving a PL reading would be to have the pied-piped material interpreted as a *wh*-phrase ranging over QPs, by having one of the *wh*-phrases scope over a Q-shifted container, as shown in (61). However, just as with nested *wh*-phrases, the movement of the remaining *wh*-phrase out of the containing QP violates the A-over-A principle.

(61) a. $[_{\text{QP}_1}$ Q which artist$]_x$?$_1$ [Q $[_{\text{QP}_2}$ Q which PM$]_y$?$_2$ [t_x's portrait of t_y]]
$\rightsquigarrow \{\lambda k \,.\, \bigcup \{k(\lambda w \,.\, \iota z[\text{portrait.of}_w(z)(x)(y)]) \mid \text{PM}_@(y)\} \mid \text{artist}_@(x)\}$

b. $[_{\text{QP}_1}$ Q which PM$]_y$?$_1$ [Q $[_{\text{QP}_2}$ Q which artist$]_x$?$_2$ [t_x's portrait of t_y]]
$\rightsquigarrow \{\lambda k \,.\, \bigcup \{k(\lambda w \,.\, \iota z[\text{portrait.of}_w(z)(x)(y)]) \mid \text{artist}_@(x)\} \mid \text{PM}_@(y)\}$

Our account of the absence of PL readings in nested *which*-questions relied on two assumptions: (i) *wh*-phrases within pied-piped constituents never leave their containers, and (ii) derivations must comply with the A-over-A principle. We have shown in this subsection that the very same assumptions rule out PL readings in quasi-nesting configurations. This result is significant: as we discuss in section 5, quasi-nesting configurations distinguish our proposal from accounts on which pied-piping is syntactically undone at LF, i.e., accounts that reject assumption (i).

4.2 The *wh*-triangle

As alluded to in Charlow (2019), the scopal theory of pied-piping subsumes Dayal's (1996, 2002) account of the '*wh*-triangle' configuration. The *wh*-triangle configuration is illustrated in (62). The key observation, due to Baker (1968), is that, alongside an expected reading where *who brought which dish* is interpreted as an embedded question, (62) has a PL reading, where attendees are paired with dishes (this is also referred to in the literature as 'Baker's ambiguity'). The availability of the PL reading is puzzling, since 'which dish' is contained within an embedded question, which is typically an island for movement/covert scope-taking.

(62) Which attendee at the potluck knows who brought which dish?
A: *Bill* knows who brought *the goulash*, *Sue* knows who brought *the borscht*, etc.

Dayal develops an account of (62) without scoping out the *in situ wh*-expression, based on the assumption that the embedded question may denote a set of questions, sorted according to dishes. The scopal theory of pied-piping provides a way to compositionally construct the relevant set, the idea being that 'which dish' covertly pied-pipes the embedded question, by scoping to its edge over an inner nucleus. The derivation is schematized in (63).

(63) a. ① $[_{\text{QP}_1}$ Q which dish$]$ λy ?$_1$ [who brought t_y]
$= \{\{\lambda w' \,.\, x \text{ brought}_{w'} y \mid \text{person}_@(x)\} \mid \text{dish}_@(y)\}$

b. $[_{\text{QP}_3}$ Q which attendee] $\lambda z\ ?_3\ [_{\text{QP}_2}$ Q ①] $\lambda X\ ?_2\ [t_z$ knows $t_X]$
$= \{\{\lambda w\,.\,z \text{ knows}_w X \mid X \in ①\} \mid \text{attendee}_@(z)\}$
$= \{\{\lambda w\,.\,z \text{ knows who brought } y \text{ in } w \mid \text{dish}_@(y)\} \mid \text{attendee}_@(z)\}$

Note that no stage of this derivation violates the A-over-A principle. This is worth dwelling on, since the derivation in (63) is, up to the construction of the pied-piped constituent, isomorphic to the quasi-nesting derivation in (59): in both, a *wh*-phrase scopes over an inner ?-operator to the edge of its container—a constituent that is not itself a QP—yielding a higher-order alternative set (of type $\{\{st\}\}$ in the present case, and $\{\{se\}\}$ in the quasi-nesting case). The crucial difference between them lies in how the trace of the moved higher-order phrase is interpreted. In (63), the trace composes directly with *knows*, without the need of any type-shifting operations. In the quasi-nesting case, by contrast, the trace is not interpretable if Q does not turn it into a scope-taker. It is this step that requires the A-over-A-violating configuration in (60).

This account, in tandem with our assumptions concerning nested *which*-questions, makes a prediction that turns out to be correct: concretely, we have suggested that the absence of the PL reading with nested *which*-questions is because a set of questions cannot be compositionally constructed, due to restrictions on QP movement. Since such a higher-order denotation is crucially implicated in the account of the *wh*-triangle, this predicts that nested *which*-questions should not feed Baker's ambiguity. A relevant test case is given in (64). Crucially, an answer may not pair the knower with the author, as indicated by the contextual infelicity of (64b). We take this parallel to be further evidence that the *wh*-triangle configuration involves compositionally constructing a higher-order alternative set.

(64) Who knows [which book by which author Cathy has read]?

a. *Dave* knows which book by which author she has read.

b. #*Dave* knows which book by *Tolstoy* Cathy has read.

In closing this section, we note that our account makes a clear prediction: quasi-nesting configurations, as discussed in the previous subsection, should also fail to feed Baker's ambiguity. Our intuition (confirmed with native speaker informants) is that this is a good prediction, as indicated by the oddness of (65b) as an answer to (65).

(65) Who knows [which artist's portrait of which PM is displayed in the National Gallery]?

a. *Dave* knows which artist's portrait of which PM is displayed in the National Gallery.

b. #*Dave* knows which artist's portrait of *Churchill* is displayed in the National Gallery.

5 Fox and Sudo's account

Fox & Sudo (2025) provide an alternative account of the absence of PL readings in nested *wh*-questions. Their analysis takes as its starting point a different set of assumptions concerning how pied-piping configurations are interpreted: unlike us, they follow von Stechow 1996 in assuming that pied-piping must be syntactically undone before semantic interpretation. This is illustrated below, where *which boy* is interpreted outside of the pied-piped DP at LF:

(66) Which boy's mom is outside? $\rightsquigarrow$ which boy λx ? [t_x's mom] is outside

Since nested *which*-questions involve pied-piping, for Fox & Sudo (2025) this means that they must also be undone at LF. They assume that there are in principle two possible LFs for nested *wh*-questions, depending on which *wh*-phrase takes higher scope, as schematized in (67) (ignore, for the time being, that the LF in (67b) contains an unbound variable; we will come back to this).

(67) a. *Contained* wh *takes highest scope:*
[Which author]$_y$? [which book by t_y]$_x$? t_x is on the table

b. *Containing* wh *takes highest scope:*
[Which book by t_y]$_x$? [which author]$_y$? t_x is on the table

As evidence for which LF corresponds to English, Fox & Sudo look to Bulgarian, a language in which both structures in (67) can be derived overtly (Richards 2004). As they observe, (68a) corresponds to (67a), and (68b) corresponds to (67b). Furthermore, the overt realizations differ in the availability of the PL reading: (68a) allows for the PL reading, whereas (68b) does not.[16]

(68) a. Ot koy avtor koya kniga e na masata?
by which author which book is on table-DEF

b. Koya kniga ot koy avtor e na masata?
which book by which author is on table-DEF
'Which book by which author is on the table?' *Bulgarian*

Since nested *which*-questions in English lack PL readings, Fox & Sudo accordingly conclude that the LF corresponds to (67b), where the containing *wh*-phrase

16 Note that, within our proposal, it is in fact not surprising that (68a) allows for a PL reading, since 'unnesting' takes place in overt syntax, feeding independent scope of the two *which*-phrases.

takes highest scope. What is left to be explained, then, is (a) how the LF in (67b) is even interpreted, given that the highest *wh*-expression contains an unbound variable, and (b) why this LF lacks a PL reading. Fox & Sudo show that, in fact, under fairly standard assumptions, such LFs give rise to pragmatically deviant questions.

First, on the question of interpretability: in order to resolve the issue of the unbound variable, Fox & Sudo (2025) must assume that the restrictor *book by y* is syntactically reconstructed into the question nucleus. Fox & Sudo adopt the approach to reconstruction of Heim 2012, and, without going into the technical details of their implementation, they arrive at the interpretation in (69): informally, the family of questions of the form *Which author y is such that the book x by y is on the table?* for any book x.

$$(69)\quad \left\{ \left\{ \begin{array}{l} \lambda w : \text{book}_@(x) \wedge \text{by}_w(x,y) \\ \quad .\, x \text{ is on the table in } w \end{array} \;\middle|\; \text{author}_@(y), y \in D_2 \right\} \;\middle|\; x \in D_1 \right\}$$

The key observation of Fox & Sudo is that families of questions such as (69) are pragmatically deviant. To see why, consider (70), which roughly corresponds to the subquestion in (69) that asks *Which author is such that the book* Emma *by them is on the table?*:

$$(70)\quad \left\{ \lambda w : \begin{array}{l} \text{book}_@(\text{Emma}) \wedge \text{by}_w(\text{Emma}, y) \\ \quad .\, \text{Emma is on the table in } w \end{array} \;\middle|\; \text{author}_@(y), y \in D_2 \right\}$$

The issue is that the propositions in (70) only differ in their presuppositions—for example, the answer in (71a) presupposes that *Emma* was written by Austen, while the one in (71b) presupposes that it was written by Woolf; but both of them assert that *Emma* is on the table. The propositions in (71) are thus all *Strawson-equivalent*: in every world in which they are all defined, they have the same truth value. Questions with Strawson-equivalent answers are thus *degenerate*, in the following sense: either they are undefined, or their answers are all equivalent to each other.

(71) a. $\lambda w : \text{book}_@(\text{Emma}) \wedge \text{by}_w(\text{Emma}, \text{Austen})\,.\,\text{Emma is on the table in } w$
b. $\lambda w : \text{book}_@(\text{Emma}) \wedge \text{by}_w(\text{Emma}, \text{Woolf})\,.\,\text{Emma is on the table in } w$

It is worth emphasizing that it is difficult to compare Fox & Sudo's account to the present work, since they have a completely different conception of pied-piping—for them, pied-piping configurations are not directly interpretable, and thus recourse must be made to syntactic reconstruction in order to 'undo' pied-piping. Nevertheless, we believe that Fox & Sudo's approach to the lack of PL readings in English nested *which*-questions has a number of significant drawbacks, some of

which they discuss themselves.[17] In our view, the most compelling evidence that Fox & Sudo's account is insufficient relates to the *quasi-nesting* configuration from section 4.1, which we repeat in (73). Recall from our discussion that quasi-nesting configurations lack a PL reading.

(73) [Which artist's portrait of which prime minister] is displayed in the National Gallery?

For Fox & Sudo however, recall that pied-piping must be syntactically undone; the pied-piped material ''s portrait of which prime minister' must reconstruct into the question nucleus for interpretation. Since "which prime minister" has moved to a lower position (by assumption), what ultimately reconstructs is ''s portrait of t', as illustrated schematically in (74).

(74) [Which artist's portrait of t_y] ? which PM_y ? _ is displayed in the National Gallery.
$\rightsquigarrow$ which artist λz ? which PM λy ? [z's portrait of y] is displayed in the National Gallery.

The resulting question denotation is given in (75). Since the inner *wh*-phrase is not contained in the restrictor of the outer *wh*-phrase, reconstruction of the restrictor is not necessary for interpretation. The question denotation is clearly not deviant: it is simply a set of questions such as "Which prime minister x is such that Karsh's portrait of x is displayed in the National Gallery?". Therefore, without further assumptions, Fox & Sudo (2025) seem to predict (73) to have a PL reading.

(75) $$\left\{ \left\{ \lambda w. \begin{array}{l} z\text{'s portrait of } y \\ \text{is displayed in the NG} \end{array} \;\middle|\; \text{PM}_{@}(y), y \in D_2 \right\} \;\middle|\; \text{artist}_{@}(z), z \in D_1 \right\}$$

6 Conclusion and open issues

We have shown that the scopal theory of pied-piping clearly over-generates in the domain of nested *which*-questions, predicting unattested PL readings. The reason for this is that nothing prevents the contained *wh* from pied-piping its container, which may then semantically reconstruct and scope over a question nucleus distinct from that of the contained *wh*. However, we have aimed to show that the scopal theory of

17 For instance, as they discuss (Fox & Sudo 2025: p. 797), they surprisingly predict that the presence of a bound pronoun outside of the nested *which*-phrase, as in (72), should make the PL reading available. They concede however that this does not seem to be the case—our account in terms of *A-over-A* makes no such prediction.

(72) Which book by which author_x made him_x rich?

pied-piping can be constrained by a simple, and very natural syntactic principle: the *A-over-A* principle.

QPs and A-over-A

(47) *QP_2 ? . . . $[_{\text{QP}_1}$ . . . t_2 . . .] . . .

A virtue of our approach is that it makes novel empirical predictions, beyond cases of nested *which*-phrases, to cases of nested QPs more generally. In our discussion of quasi-nesting configurations, we argued that these predictions are correct. To conclude this paper, we reflect on the scopal theory of pied-piping beyond *wh*-questions.

The scopal theory of pied-piping was originally developed in Charlow 2014 to provide an account of the exceptional scope of indefinites via LF-pied-piping. Charlow (2014) proposes that indefinites range over alternatives, and are integrated into the composition via η (which has the same semantics as ?), and $\star$ (which has the same semantics as the original, polymorphic entry for Q). Unlike *wh*-questions, sentences with indefinites are existentially closed, and the scope of an indefinite is not necessarily a set of *intensional* alternatives. Otherwise, the explanation for how, e.g., an indefinite takes scope out of a possessor is isomorphic to the derivation for *whose picture* type pied-piping.

(76) A (certain) man's friend is here.

(77) $\exists\,[\star\,[\star$ a man$]\;\lambda x\;\eta\;[t_x$'s friend$]]\;\lambda y\;\eta\;t_y$ is here.
$= \exists(\star(\{\,\iota y[\text{friend}_w(x)(y)] \mid \text{man}_w(x)\,\})(\lambda y\,.\,\{\,\text{here}_w(y)\,\}))$
$= \exists\,\{\,\text{here}_w(\iota y[\text{friend}_w(x)(y)]) \mid \text{man}_w(x)\,\}$

A natural question to ask is whether we also find a reflex of the A-over-A principle constraining pied-piping at LF, in the case of indefinites. It turns out that violations of the A-over-A principle are in fact *necessary*, in order to account for selective scope in the case of nested indefinites (see Charlow 2019: §5). To illustrate this, consider (78), which involves a nested indefinite in the scope of a modal. This clearly has a reading on which the contained indefinite 'a certain relative of mine' takes scope above the modal, whereas the containing indefinite takes scope below the modal.

(78) We might hire an$_x$ [employee of a$_y$ certain relative of mine].
$\exists y > \text{might} > \exists x$

Charlow's account is sufficiently expressive to accommodate this reading via recursive scope-taking, without scoping the contained indefinite out of its container. Without going into too much detail, this mirrors the kind of derivation we argued

must be unavailable in the case of nested *which*-phrases: namely, the contained indefinite 'a certain relative of mine' pied-pipes the containing indefinite, and the pied-piped material is semantically reconstructed below the modal operator, where it may independently take scope. This is schematized in (79).

(79) $[\star \text{ a rel}]\ \lambda y\ \eta\ [\text{an employee of } y]$
$= \{\lambda w.\ \{x \mid \text{employee}_w(y)(x)\} \mid \text{rel}_@(y)\}$ $\{s, \{e\}\}$

The higher-order alternative set takes scope via $\star$, leaving behind a trace of type $s, \{e\}$, which is extensionalized, and takes scope via $\star$ within the scope of the modal.

(80) $\exists\ [\star \text{ an employee of a rel}]\ \lambda Y_{s,\{e\}}\ \eta \Diamond \exists\ [[\star\ t_Y^{\downarrow}]\ \lambda y\ \eta \text{ we hire } t_y]$

Without going into too much further detail, one can appreciate that this derivation involves scoping a '$\star$-phrase' out of another $\star$-phrase. This lack of parallelism between indefinites and *wh*-phrases is surprising, if we assume that the compositional machinery necessary for integrating alternatives is uniform. One possibility is that the Q operator has a syntactic reality that Charlow's $\star$-operator lacks, and is therefore subject to additional syntactic constraints such as A-over-A. Indeed, some languages seem to explicitly realize a morpheme corresponding (roughly) to Q—see, e.g., Cable 2010. The relationship between indefinites and *wh*-phrases, and the status of Q, require further investigation.

References

Baker, C. L. 1968. *Indirect questions in English*. University of Illinois dissertation.

Cable, Seth. 2010. *The grammar of Q: Q-particles,* Wh-*movement, and pied-piping* (Oxford Studies in Comparative Syntax). New York: Oxford University Press. 249 pp.

Charlow, Simon. 2010. Can DP Be a Scope Island? In Thomas Icard & Reinhard Muskens (eds.), *Interfaces: Explorations in Logic, Language and Computation* (Lecture Notes in Computer Science), 1–12. Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-14729-6_1.

Charlow, Simon. 2014. *On the semantics of exceptional scope*. NYU dissertation.

Charlow, Simon. 2019. The scope of alternatives: Indefiniteness and islands. *Linguistics and Philosophy*. https://doi.org/10.1007/s10988-019-09278-3.

Chomsky, Noam. 1964. *Current Issues in Linguistic Theory*. The Hague: Mouton. 126 pp.

Cresti, Diana. 1995. Extraction and reconstruction. *Natural Language Semantics* 3(1). 79–122. https://doi.org/10.1007/BF01252885.

Dayal, Veneeta. 1996. *Locality in WH quantification*. Vol. 62 (Studies in Linguistics and Philosophy). Dordrecht: Springer Netherlands. http://link.springer.com/10.1007/978-94-011-4808-5.

Dayal, Veneeta. 2002. Single-pair versus multiple-pair answers: Wh-in-situ and scope. *Linguistic Inquiry* 33(3). 512–520. https://muse.jhu.edu/journals/linguistic_inquiry/v033/33.3dayal.pdf.

Dayal, Veneeta. 2017. *Questions* (Oxford Surveys in Semantics and Pragmatics). Oxford, New York: Oxford University Press. 352 pp.

Demirok, Ömer. 2019. *Scope theory revisited: Lessons from pied-piping in* wh-*questions*. Massachusetts Institute of Technology dissertation.

Elliott, Patrick D, Andreea C Nicolae & Uli Sauerland. 2022. Who and What Do *Who* and *What* Range Over Cross-Linguistically? *Journal of Semantics* 39(3). 551–579. https://doi.org/10.1093/jos/ffac008.

Elliott, Patrick D. 2015. Sorting out multiple questions.

Elliott, Patrick D. 2019. Nesting habits of flightless wh-phrases. Invited talk given at the workshop Complex Wh-phrases. Nantes.

Elliott, Patrick D. & Filipe Hisao Kobayashi. 2022. Deconstructing which: 'reconstruction' and environment sensitivity. Unpublished handout from a talk given at LFRG. Massachusetts Institute of Technology.

von Fintel, Kai & Irene Heim. 2023. Intensional semantics. Unpublished textbook. MIT.

Fox, Danny. 2012. The semantics of questions. MIT.

Fox, Danny & Yasutada Sudo. 2025. Nested *Wh*-phrases and degenerate questions. *Semantics and Linguistic Theory*. 783–800. https://doi.org/10.3765/87x9dy51.

Groenendijk, Jeroen & Martin Stokhof. 1982. Semantic analysis of *Wh*-complements. *Linguistics and Philosophy* 5. 175–233. https://doi.org/10.1007/BF00351052.

Hamblin, C. L. 1973. Questions in Montague English. *Foundations of Language* 10(1). 41–53. http://www.jstor.org/stable/25000703.

Heim, Irene. 1994. Lecture notes for semantics proseminar. Unpublished lecture notes. MIT.

Heim, Irene. 2012. Functional readings without type-shifted noun phrases. Unpublished manuscript. MIT. https://semanticsarchive.net/Archive/TUwYzUwZ/functional%20readings.pdf.

Higginbotham, James & Robert May. 1981. Questions, quantifiers and crossing. *The Linguistic Review* 1(1). 41–80. https://doi.org/10.1515/tlir.1981.1.1.41.

Karttunen, Lauri. 1977. Syntax and semantics of questions. *Linguistics and Philosophy* 1(1). 3–44. https://doi.org/10.1007/BF00351935.

Kuno, Susumu. 1982. The focus of the question and the focus of the answer. In *Papers from the parasession on nondeclarative sentences*, 134–157. Chicago Linguistic Society.

Lahiri, Utpal. 2002. *Questions and answers in embedded contexts.* Oxford University Press.

Partee, Barbara. 1986. Noun-phrase interpretation and type-shifting principles. In J. Groenendijk, D. de Jongh & M. Stokhof (eds.), *Studies in discourse representation theory and the theory of generalized quantifiers*, 115–143. Dordrecht: Foris.

Richards, Norvin. 2004. Against Bans on Lowering. *Linguistic Inquiry* 35(3). 453–463. https://doi.org/10.1162/0024389041402643.

Rullmann, Hotze & Sigrid Beck. 1998. Presupposition Projection and the Interpretation of *Which*-Questions. *Semantics and Linguistic Theory* 8. 215–232. https://doi.org/10.3765/salt.v8i0.2811.

Saito, Mamoru. 1989. Scrambling as semantically vacuous A'-movement. In Mark R. Baltin & Anthony S. Kroch (eds.), *Alternative conceptions of phrase structure*, 182–200. Chicago: University of Chicago Press.

Sauerland, Uli. 1999. Erasability and interpretation. *Syntax* 2(3). 161–188.

Sauerland, Uli. 2005. DP is not a scope island. *Linguistic Inquiry* 36(2). 303–314. https://muse.jhu.edu/journals/linguistic_inquiry/v036/36.2sauerland.pdf.

von Stechow, Arnim. 1996. Against LF pied-piping. *Natural Language Semantics* 4(1). 57–110. https://doi.org/10.1007/BF00263537.

Sudo, Yasutada. 2017. *De Re* readings of nested *Which*-phrases in embedded questions. *Snippets* (31). 30–31. https://doi.org/10.7358/snip-2017-031-yasu.

Nested *which*-phrases and the logic of pied-piping

10141 words