On the semantics of *wh*-questions[1]

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Abstract. This paper develops a new framework for the syntax and semantics of interrogative constructions which unifies the mechanisms of scope-taking employed in *wh*-movement, *wh*-in-situ, and partial *wh*-movement constructions. This framework represents the first major account for a wide range of syntactic and semantic facts relating to the structure and meaning of interrogatives at the same time, including pied-piping, superiority, presuppositions of questions, readings of multiple questions (single-pair vs pair-list), and intervention effects in multiple questions. It thus achieves a wider empirical coverage than other theories of interrogative syntax-semantics (e.g. Hamblin, 1973; Karttunen, 1977; Hagstrom, 1998; Cable, 2007, 2010; Cheng and Demirdache, 2010; Fox, 2012; Nicolae, 2013), and is at the same time simpler than these other proposals.

1. Introduction

The syntax/semantics literature offers two approaches to the interpretation of in-situ *wh*-phrases in questions: they may be interpreted at C via covert movement (Karttunen, 1977: a.o.), (1a), or in their base positions via an in-situ mode of composition (Hamblin, 1973: a.o.), (1b):[2]

(1) **Two possible analyses of *wh*-in-situ in English multiple questions:**
Which student did Mary introduce to *which* professor?
  a. LF: *Which* student *which* professor C did Mary introduce ____ to ____?[3]
  b. LF: *Which* student C did Mary introduce ____ to *which* professor ?

This paper sketches a new framework for the syntax and semantics of *wh*-questions. The proposal builds on the syntactic proposals for *wh*-movement and pied-piping in Pesetsky (2000) and Cable (2007, 2010) and develops a new and simple semantics that combines ingredients familiar from the literature in a novel way. This syntax-semantics is able to combine with Beck's (2006) theory of *intervention effects*, and it is able to explain the distribution of readings of so-called quiz-master readings and of nested *which*-phrases.

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[1]For helpful comments, I thank Luis Allonso-Ovalle, Danny Fox, Martin Hackl, Irene Heim, David Pesetsky, Michael Yoshitaka Erlewine, and audiences at Sinn und Bedeutung 30, IATL 31, McGill University, and MIT. A more elaborate presentation of this framework and its motivation, with a slightly different notation, is presented in Kotek (2014). A full version using the notation used in the paper will appear in a forthcoming LI Monograph (MIT Press).

[2]Here and throughout, I use straight arrows to indicate movement and curly arrows to indicate areas in which Rooth-Hamblin alternatives are computed. These curly arrows are used here for notational convenience only. Dashed arrows indicate covert movement.

[3]I illustrate covert movement with tucking in (Richards, 1997). This will become important later, in order to correctly derive the presuppositions of multiple questions.

2. Background

2.1. Questions, multiple questions, and superiority effects

The formation of a simplex *wh*-question in English involves at least two steps. First, a structure is formed in which a *wh*-phrase is introduced as an argument or adjunct. Second, this *wh*-phrase is fronted to the left edge of the sentence.[4]

(2) **English simplex questions require *wh*-fronting:**
   Which book did John read ____ ?

In a multiple question, only one *wh*-phrase is fronted, with additional *wh*-phrases pronounced in their base-generated positions. In questions with two D-linked *wh*-phrases, two word-orders are possible in multiple questions. In *superiority-obeying* questions, the base-generated higher *wh*-phrase is overtly fronted. In *superiority-violating* questions, the base-generated lower *wh*-phrase is fronted over the higher one.

(3) **English multiple questions allow either *wh* to front:**
   a. *Which* student ____ read *which* book?   superiority-obeying
   b. *Which* book did *which* student read ____ ?   superiority-violating

Based on syntactic considerations, as well as evidence from intervention effects and licensing of Antecedent Contained Deletion, different underlying structures have been proposed for superiority-obeying and superiority-violating questions in the literature (Pesetsky, 2000; Beck, 2006; Cable, 2007, 2010; Kotek, 2014). Superiority-obeying questions are argued to involve covert movement of the (phonologically) in-situ *wh*-phrase (4a), whereas in superiority-violating questions, the surface in-situ *wh*-phrase is argued to be truly in-situ at LF (4b).

(4) **Different syntactic assumptions for obeying and violating questions:**
   a. *Which* student *which* book C ____ read ____ ?   (= 3a)
   b. *Which* book C did *which* student read ____ ?   (= 3b)

A pronunciation rule is responsible for producing the correct word order for the structure in (4a): the *wh* occupying the highest Spec,CP is pronounced at the head of its chain, and all other *wh*s are pronounced at the tail of their chains (see Pesetsky 2000; Cable 2010).[5]

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[4]Here we set aside T-to-C movement, which is irrelevant for the purposes of this paper.
[5]The requirement to have one *wh*-phrase pronounced in Spec,CP is attributed here to C's EPP feature.

2.2. The readings of multiple questions

The literature recognizes three distinct readings of multiple *wh*-questions: the pair-list, single-pair, and echo-question readings (Wachowicz, 1974; Pope, 1976; Bolinger, 1978; Comorovski, 1989; Dayal, 1996: a.o.).[6] In this paper I will concentrate on the first two readings, and will not discuss the latter. For illustration, I use a context with three students, John, Mary, Bill and three books, Moby Dick, War and Peace, Oliver Twist.

(5) **Two readings of multiple questions:**
   Which student read *which* book?
   a. Single-pair: *John read Moby Dick*.
   b. Pair-list: *John read Moby Dick, Mary read War & Peace, and Bill read Oliver Twist*.

The single-pair reading is felicitous just in case the asker presupposes that a single student-book pair satisfies the proposition that some student read some book. The pair-list reading, on the other hand, involves answering a set of questions. For each individual in the domain of *student*, we ask: which book did that individual read?

(6) **A set of *which book* questions ranging over students:**
   Which student read *which* book?
   $$\left\{ \begin{array}{l} \text{Which book did John read?} \\ \text{Which book did Mary read?} \\ \text{Which book did Bill read?} \end{array} \right\}$$

On this reading, the question invites the addressee to list all the relevant pairs in the context. Assuming that the meaning of a question is the set of possible answers to the question (Hamblin, 1973; Karttunen, 1977), spelling out the denotation of each question in the set in (6) yields a family of questions "sorted" by the higher *wh*, here *students* (Roberts, 1996; Hagstrom, 1998; Krifka, 2001; Büring, 2003; Willis, 2008; Fox, 2012; Nicolae, 2013; Constant, 2014: a.o.):

(7) **A family of questions denotation for the superiority-obeying question in (5/6):**
   $$\left\{ \left\{ \begin{array}{l} \text{John read MD} \\ \text{John read WP} \\ \text{John read OT} \end{array} \right\}, \left\{ \begin{array}{l} \text{Mary read MD} \\ \text{Mary read WP} \\ \text{Mary read OT} \end{array} \right\}, \left\{ \begin{array}{l} \text{Bill read MD} \\ \text{Bill read WP} \\ \text{Bill read OT} \end{array} \right\} \right\}$$

A similar procedure can be employed for the interpretation of a superiority-violating question. Intuitively, such a multiple question is different from its superiority-obeying counterpart—it asks for a comprehensive list of readers for each book in the domain (whereas the superiority-obeying

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[6]At first blush, one might imagine that the single-pair is a special case of the pair-list reading, appropriate in a context that supports exactly one pair as a possible answer. However, there are reasons to think that that is not the case. In particular, we find cases in which the pair-list reading of the question is possible, but the single-pair reading is not. Such cases are exemplified in Wiltschko (1997), and discussed in greater detail in Kotek (2014: §6.5).

question asks for a list of books read by each person in the domain). Evidence for this difference comes from presuppositions, as will be discussed below. In this case, then, we construct a set of questions about the books in the domain:

(8) **A set of questions for the superiority-violating question:**
Which book did *which* student read?
$$\left\{ \begin{array}{l} \text{Which student read Moby Dick?} \\ \text{Which student read War and Peace?} \\ \text{Which student read Oliver Twist?} \end{array} \right\}$$

Spelling out the meaning of each question, using the same procedure as for the superiority-obeying question above, yields now a family of questions sorted by *books*:

(9) **A family of questions denotation for a superiority-violating question:**
Which book did *which* student read?
$$\left\{ \left\{ \begin{array}{l} \text{John read MD} \\ \text{Mary read MD} \\ \text{Bill read MD} \end{array} \right\}, \left\{ \begin{array}{l} \text{John read WP} \\ \text{Mary read WP} \\ \text{Bill read WP} \end{array} \right\}, \left\{ \begin{array}{l} \text{John read OT} \\ \text{Mary read OT} \\ \text{Bill read OT} \end{array} \right\} \right\}$$

Notice that the set in (7) ensures that each person read a book, but there may be books that no one read; and the set in (9) ensures that each book was read by someone, but there may be individuals who did not read any book. In contrast to the nested structure of pair-list readings, the single-pair reading of the question can be modeled as a simple question: itself a 'flat' set of propositions without internal structure:

(10) **A single-pair reading is modeled as a set of propositions:**
$$\left\{ \begin{array}{l} \text{John read MD, John read WP, John read OT, Mary read MD,} \\ \text{Mary read WP, Mary read OT, Bill read MD, Bill read WP, Bill read OT} \end{array} \right\}$$

The denotations of superiority-obeying and superiority-violating questions are thus distinct in terms of the structure of their possible answer sets. These differences are motivated by differences in the presuppositions of these questions, which I discuss in the next section.

> **Modeling the pair-list readings of multiple questions as these nested set structures is a central goal of the proposal below.**

2.3. The presuppositions of multiple questions:

Dayal (2002) shows that multiple questions have two presuppositions (see also Fox, 2012)—domain exhaustivity and point-wise uniqueness—defined in (11). These presuppositions can be paraphrased as requiring that for each question in the family of questions, there must be exactly

one true answer. For (9), this means that there must be a unique student who read each book, and we must provide information about each book in the domain. Under this description, all the books must have a reader, but it is possible that some students will not have read any book.

(11) **The presuppositions of a multiple question (Dayal, 2002):**
   a. <u>Domain exhaustivity</u>: every member of the set quantified over by the overtly moved *wh* is paired with a member of the set quantified over by the in-situ *wh*.
   b. <u>Point-wise uniqueness</u> (*functionhood*): every member of the set quantified over by the overtly moved *wh* is paired with no more than one member of the set quantified over by the in-situ *wh*.

The exhaustivity and uniqueness presuppositions are illustrated in examples (12)-(13) (from Fox 2012). The context in (12a) allows for a pair-list answer (as well as a single-pair) because it is possible to give an exhaustive answer that accounts for each of the children. In the context in (12b), on the other hand, to give a pair-list answer we would be forced to assume that two kids are assigned to the same chair, making this reading deviant. Hence only a single-pair answer is felicitous in this context. The context in (13a) allows for a unique chore to be assigned to each boy, but (13b) leaves one chore that is not assigned to any boy, or else the 1:1 pairing is lost. Hence only a single-pair answer is felicitous in this context.[7]

(12) **Exhaustivity presupposition:**
   a. Guess *which* one of these 3 kids will sit on *which* of these 4 chairs.
      Good with a single-pair answer and with a pair-list answer.
   b. Guess *which* one of these 4 kids will sit on *which* of these 3 chairs.
      Only good with a single-pair answer.

(13) **Uniqueness presupposition:**
   The Jones family (3 boys) will not sit down for dinner before the boys do all of the chores.
   a.   I wonder *which* one of the 3 boys will do *which* one of the 3 chores.
   b.   # I wonder *which* one of the 3 boys will do *which* one of the 4 chores.
         Suggests that the boys will not do all of the chores.
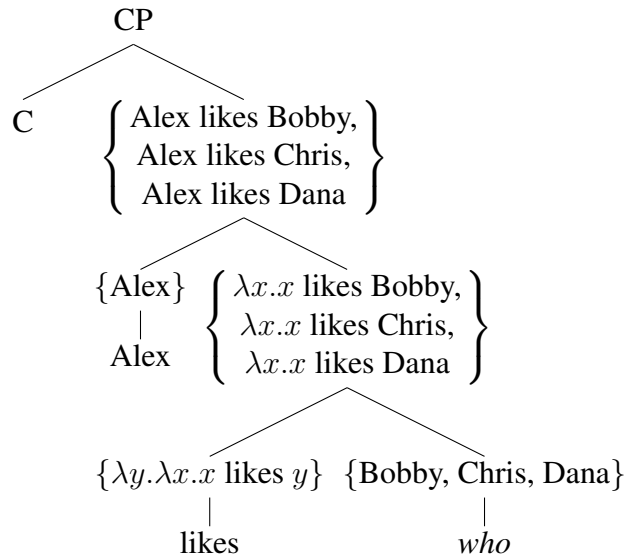

2.4. Alternative semantics

As mentioned above, I assume an interrogative syntax in which *wh*-phrases may be interpreted either in a moved position or in-situ. When a (phonologically) in-situ *wh*-phrase does not undergo covert movement (e.g. *which student* in (4b) above), it is interpreted via *Rooth-Hamblin alternative*

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[7]Note the importance of using singular *which*-phrases, to ensure that we are dealing with a pair-list reading. If plural *which*-phrases are used, e.g. *which boys will do which chores?*, it is possible to give a single-pair answer where each member of the pair is a plurality: *John, Tom, and Bill will set the table, sweep the floor, and do the dishes (respectively)*.

computation (Hamblin, 1973; Kratzer and Shimoyama, 2002: a.o.). Both strategies for establishing a relation between the interrogative C and *wh* have been independently proposed in the literature for the analysis of (phonologically) in-situ *wh*-phrases, and are widely used in current research on the syntax and semantics of multiple *wh*-questions.

Rooth-Hamblin alternatives are a parallel mode of semantic interpretation, where a *focus-semantic value* can be computed compositionally for each syntactic node in the structure, in parallel to its ordinary semantic value (Hamblin, 1973; Rooth, 1985, 1992). This computation has been argued to supply operators such as focus operators and question complementizers with a relevant set of propositional alternatives. Consider the LF representation for the *wh*-in-situ pseudo-English question "Alex likes *who*?" in (14) below. Focus-semantic values—also referred to as *alternatives*—are given for each node.

(14) **A toy LF of question interpretation through Rooth-Hamblin alternative computation:**

In (14), the *wh*-phrase *who* has a focus-semantic value corresponding to relevant individuals in its domain—here, the animate individuals Bobby, Chris, and Dana. These *alternatives* compose pointwise at each nonterminal node, resulting in the complement of the interrogative C having a set of propositions as its focus-semantic value.[8] The interrogative C then computes the question denotation using these alternatives in its complement, so that these alternative propositions correspond to possible (weak) answers to the question. In this way, the focus-semantic value provided by the in-situ *wh*-phrase is interpreted by the interrogative C. This yields the appropriate question semantics without establishing a syntactically local relationship between the *wh*-phrase and C.

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[8]The semantic denotations here must be interpreted intensionally. World variables are not illustrated here to simplify the presentation.

3. Proposal

I propose that the derivation of a question involves three interrogative components: *Wh*-words, the interrogative complementizer C, and a question operator: ALTSHIFT. Below I discuss each of these components in turn, and then illustrate derivations for English simplex and multiple questions to show how they combine. I note, but will not illustrate for reasons of space, that this proposal is compatible with Cable's (2007; 2010), as well as Heck's (2008; 2009), syntax for pied-piping.

As shown in (14), *wh*-words are elements that introduce alternatives into the derivation (Hamblin, 1973). I assume that they do not have a defined ordinary semantic value (Ramchand, 1997; Beck, 2006; Cable, 2010). The denotation of a *which*-NP phrase is equivalent to its NP extension, and its ordinary value is again undefined.

(15) **The semantics of *who* and *what* as sets of alternatives:**

a.
$$\underline{\text{Ordinary value:}} \quad [\![who]\!]^o \text{ is undefined}$$
$$\underline{\text{Alternative value:}} \quad [\![who]\!]^f = \{x_e : x \in \text{human}\}$$

b.
$$\underline{\text{Ordinary value:}} \quad [\![what]\!]^o \text{ is undefined}$$
$$\underline{\text{Alternative value:}} \quad [\![what]\!]^f = \{x_e : x \notin \text{human}\}$$

(16) **The focus-semantic denotation of a *which*-NP phrase is the NP extension:**
$$[\![which \text{ student}]\!]^f = [\![\text{student}]\!]^o = \{ \text{ Alex, Bobby, Chris, Dana... } \}$$

The interrogative complementizer, C, triggers interrogative movement. In English, this complementizer has an EPP feature that requires at least one *wh*-phrase to occupy its specifier, and furthermore exactly one *wh*-phrase to be pronounced in this position. This interrogative complementizer plays no role in the semantics of the question, and simply passes up the denotation of its sister.

(17) **The semantics of the Complementizer:**
$$[\![C]\!] = \lambda P_\tau. \ P$$

Finally, the **ALTSHIFT-operator** (AS) sits on the clausal spine and is the source of interrogative semantics. This operator takes a set of propositions (or a set of such sets...) and returns the focus-semantic value of that set as the ordinary value of the question—that is, it takes the alternatives introduced by its sister in the focus domain and shifts them into the ordinary domain. Note that this is a type-flexible version of the semantics for C in Shimoyama (2001) and Beck and Kim (2006). This will be crucial to allow for the family of question derivations for the pair-list readings of multiple questions.[9]

(18) **The semantics of the ALTSHIFT-operator:**
a. $[\![\text{ALTSHIFT } \alpha_\sigma]\!]^o = [\![\alpha_\sigma]\!]^f$
b. $[\![\text{ALTSHIFT } \alpha_\sigma]\!]^f = \{ \ [\![\text{ALTSHIFT } \alpha_\sigma]\!]^o \ \}$ $\qquad\qquad \sigma \in \{\langle st, t\rangle, \langle\langle st, t\rangle, t\rangle, ...\}$

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[9]Note that in (14) above, I illustrate C as the operator that is responsible for interrogative semantics, to keep with the more standard notation in the literature, but from now on I will use the operator ALTSHIFT for this purpose.

4. The proposal in action

I this section I illustrate derivations for simplex questions and for the single-pair and pair-list readings of multiple questions in English. I show how the proposal set forth in section 3 can derive the correct reading of the questions based on their independently motivated syntax.

4.1. The derivation of a simplex question

I begin with the derivation of simplex questions. A simplified LF for the question *which book did John read?* is given in (19).[10] Notice here that the *wh*-phrase *which book* moves from its position as the complement of *read* to Spec,CP, and that the question operator ALTSHIFT (abbreviated as **AS** in trees) takes this structure as its complement.

(19) **A (simplified) LF for a simplex *wh*-question:**
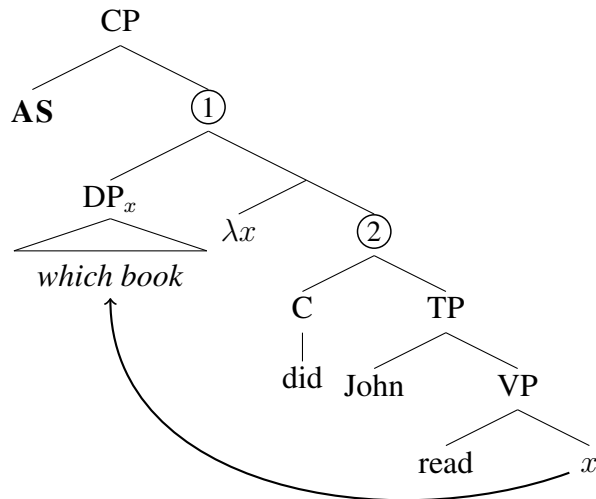
This derivation proceeds as expected—that is, only in the ordinary domain, and using standard composition rules as in Heim and Kratzer (1998)—up to the node labeled ②, whose denotation is the open proposition "that John read x," (20a). This variable is then abstracted over, and it point-wise composes with the set of books in the context, the denotation of the *wh*-phrase *which book*, (20b). Notice that at this point the denotation of node ① can only be composed in the focus dimension. The ordinary dimension of this node is undefined, because the meaning of the *wh*-phrase in it is undefined, (20c). The ALTSHIFT operator takes the alternatives introduced by $[\![①]\!]^{f}$ and shifts them into the ordinary dimension, yielding the desired interpretation of the question, (20d).

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[10]I assume, but do not show here and in other LFs, successive-cyclic *wh*-movement through phase edges, A-movement of the vP internal subject to Spec,TP, T-to-C movement of the auxiliary verb, etc.

(20) **Key parts of the derivation of (19):**[11]

    a. $[\![②]\!]^{o} = \lambda w.$ John read x in w

    b. $[\![①]\!]^{f} = \{\lambda w.$ John read x in $w : x \in book\}$

    c. $[\![①]\!]^{o}$ is undefined

    d. $[\![CP]\!]^{o} = [\![①]\!]^{f} = \{\lambda w.$ John read x in $w : x \in book\}$

Importantly, here the contribution of C is separated from that of ALTSHIFT. C is syntactically **below** the *wh*-phrase, and is responsible for interrogative syntax. ALTSHIFT is syntactically **above** the *wh*-phrase, and is responsible for interrogative semantics. Moreover, in the derivation of the simplex question, the denotation of ALTSHIFT is identical to the denotation for C given in Shimoyama (2001) and Beck and Kim (2006).

The result of (20d), in a simple context with just three books—Moby Dick, War & Peace, and Oliver Twist (as in section 2)—can be spelled out as in (21):

(21) **A set of possible answers to the question:**[12]
    $\{$ that John read MD, that John read WP, that John read OT $\}$

Here I adopt the notion from Dayal (1996) that a question must have a unique maximally informative true answer. This requirement can be enforced by an answer operator, as in (22):

(22) **The *Ans* operator as Max$_{inf}$ (Dayal 1996, cf Fox 2012):**[13]
    $[\![Ans]\!](P) = \mathrm{Max}_{inf}(P)$
    $\mathrm{Max}_{inf}(P)(w) = \iota p \in P$, s.t. $w \in p$ and $\forall q \in P$ $(w \in q \rightarrow p \subseteq q)$

The *Ans* operator takes as input a set as in (21), and is defined iff there is exactly one true proposition in the set that entails all other true propositions in the set. The propositions in (21) are logically independent of one another. Consequently, for *Ans* to apply to this set, there can only be one true member in the set. This correctly models the contribution of the singular *which*-question here.

With this background in mind, I next show that the proposal put forth here can correctly model the derivation of the single-pair reading of a multiple question, without requiring any additions or changes to the basic theory. For concreteness, I will now present a derivation for a superiority-obeying question. The same logic will also hold for the interpretation of a superiority-violating question, but the syntax will be different, as will be shown in section 4.4.

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[11]To simplify the notation, throughout I represent assignment dependent elements in the denotation using unbound variables.

[12]This set only contains answers for singular individuals, without any pluralities. This is enforced by the meaning of the singular *which*-phrase that was used in (19). World variables have been removed for simplicity of exposition.

[13]Dayal does not use the term Max$_{inf}$, but the definition she provides is equivalent to Max$_{inf}$, as proposed in Fox and Hackl (2006) and subsequent work. See also von Fintel et al. (2014).

4.2. The single-pair reading of a multiple question

The tree in (23) shows the LF I assume for superiority-obeying questions in English. Following Pesetsky (2000); Beck (2006); Cable (2007, 2010), a.o., I assume the following derivation: (i) an interrogative probe on C probes its c-command domain. The principe *Attract Closest* (Rizzi, 1990: cf Chomsky 1995, 2000) dictates that DP_x will the probe's first target, since it's closer to C than DP_y.[14] (ii) C agrees with DP_x, and attracts it to its specifier. (iii) C continues probing its c-command domain. Its next goal is DP_y. (d) C agrees with DP_y and attracts it to a lower Spec,CP, where DP_y tucks in below DP_x (Richards, 1997). A pronunciation rule then dictates that the highest phrase in Spec,CP—here, DP_x—is pronounced at the head of its chain, and all remaining *wh*-phrases are pronounced at the tail of their respective chains. As in (19), I assume that an ALTSHIFT operator takes this structure as its sister.

(23) **The LF of a superiority-obeying multiple question with a single-pair reading:**
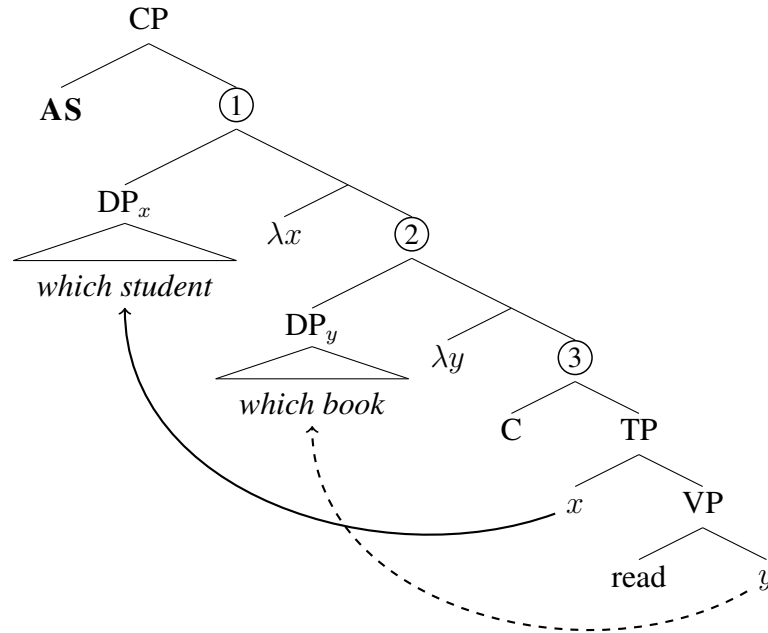
As before, the derivation of the structure up to node ③ is uneventful. At node ③ we have an open proposition "that x read y" (24a). These free variables are bound and point-wise compose with the denotations of the *wh*-phrases *which book* and *which student* at nodes ② and ①, respectively, yielding as the result a set of propositions as the alternatives to node ①, whose ordinary value is again undefined (24e–f). ALTSHIFT takes this alternative value in $[\![①]\!]^f$ and returns it as the ordinary value of the question, yielding the desired interpretation (24g).

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[14]X is closer to A than Y iff X asymmetrically c-commands Y.

(24) **Key parts of the derivation of (23):**

　　a. $[\![③]\!]^o = \lambda w.\ x$ read y in w

　　b. $[\![③]\!]^f = \{\ [\![③]\!]^o\ \} = \{\ \lambda w.\ x$ read y in $w\ \}$

　　c. $[\![②]\!]^f = \{\lambda w.\ x$ read y in $w : y \in book\}$

　　d. $[\![②]\!]^o$ is undefined

　　e. $[\![①]\!]^f = \{\lambda w.\ x$ read y in $w : y \in book, x \in student\}$

　　f. $[\![①]\!]^o$ is undefined

　　g. $[\![\mathrm{CP}]\!]^o = [\![①]\!]^f = \{\lambda w.\ x$ read y in $w : y \in book, x \in student\}$

The resulting meaning is a 'flat' set of propositions, corresponding to the possible answers to the question. In a simple context with three individuals—John, Mary, and Bill—and three books—Moby Dick, War and Peace, and Oliver Twist—this set, can be spelled out as in (25). Again, these propositions are logically independent of one another. Hence, applying the Ans-operator to this set, as above, ensures that exactly one proposition in this set is true, giving rise to a single-pair reading of the multiple question.

(25) **A single-pair reading is modeled as a 'flat' set of propositions:**
$$\left\{\begin{array}{l} \text{John read MD, John read WP, John read OT, Mary read MD,} \\ \text{Mary read WP, Mary read OT, Bill read MD, Bill read WP, Bill read OT} \end{array}\right\}$$

Crucially, the same compositional ingredients are used here as in the simplex question above. The reason this derivation yields a single-pair reading is that the alternatives from all *wh*-phrases in the structure pointwise compose into a single, flat set of propositions, and a single ALTSHIFT then returns the result as the meaning of the question. As we will see next, matters change if we allow more than one ALTSHIFT operator to occur in the structure.

4.3. The pair-list reading of a superiority-obeying multiple question

Next I turn my attention to the derivation of pair-list readings of multiple questions. I focus first on superiority-obeying multiple questions. I assume here a syntactic derivation identical to the one illustrated in section 4.2 for the single-pair reading of the question, with just one modification: I introduce a second ALTSHIFT-operator into the derivation. This will allow each *wh*-phrase in the structure to be interpreted by a separate ALTSHIFT-operator. As we will see, this yields the desired family of questions denotation for the question.

(26) **The LF of a superiority-obeying multiple question with a pair-list reading (cf 23):**
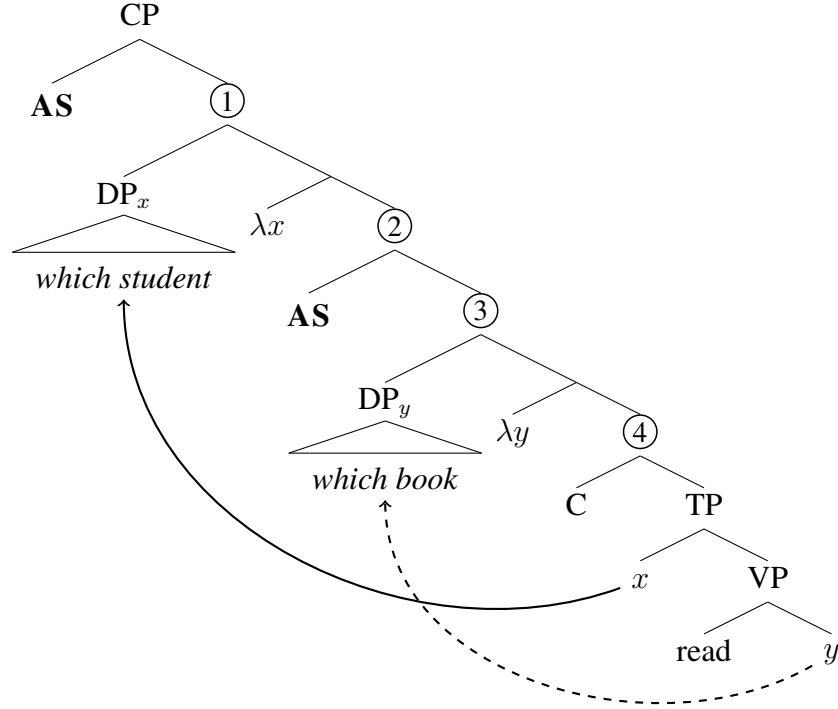
The derivation her proceeds as in (24) up to node ③: the result is the open set of proposition $\{\lambda w.\ x \text{ read } y \text{ in } w : y \in book\}$ (27a). Crucially, at this point, an ALTSHIFT operator takes this set of focus-alternative propositions and returns it as the ordinary value of node ② (27b). As with any other non-focused node, I assume, following Rooth (1985, 1992), that the focus-semantic value of ② is identical to the singleton set of its ordinary value (27c). This node then point-wise composes with the meaning of *which student*, yielding as the meaning of ① the set of sets of alternative propositions: $\{\{\lambda w.\ x \text{ read } y \text{ in } w : y \in book\} : x \in student\}$ (27d). Finally, the higher ALTSHIFT operator takes this set of focus-alternative propositions and returns it as the ordinary value of the question (27e). The result, then is a set of *questions*, or a family of questions denotation.

(27) **Key parts of the derivation of (26):**

a. $[\![③]\!]^{f} = \{\lambda w.\ x \text{ read } y \text{ in } w : y \in book\}$

b. $[\![②]\!]^{o} = [\![③]\!]^{f} = \{\lambda w.\ x \text{ read } y \text{ in } w : y \in book\}$

c. $[\![②]\!]^{f} = \{\{\lambda w.\ x \text{ read } y \text{ in } w : y \in book\}\}$

d. $[\![①]\!]^{f} = \{\{\lambda w.\ x \text{ read } y \text{ in } w : y \in book\} : x \in student\}$

e. $[\![CP]\!]^{o} = [\![①]\!]^{f} = \{\{\lambda w.\ x \text{ read } y \text{ in } w : y \in book\} : x \in student\}$

This yields a family of questions denotation sorted by the higher *wh*-phrase—*student*. Spelling this out for our small context, the result is (28), identical to our desideratum in (7):

(28) **A family of questions sorted by *student* yields a pair-list reading:**

$$\left\{ \left\{ \begin{array}{l} \text{John read MD} \\ \text{John read WP} \\ \text{John read OT} \end{array} \right\}, \left\{ \begin{array}{l} \text{Mary read MD} \\ \text{Mary read WP} \\ \text{Mary read OT} \end{array} \right\}, \left\{ \begin{array}{l} \text{Bill read MD} \\ \text{Bill read WP} \\ \text{Bill read OT} \end{array} \right\} \right\} \qquad (= 7)$$

At this point, notice that Dayal's Ans-operator, defined in (22), cannot apply to this set. However, it is possible to recursively define a generalized *Ans*-operator based on (22) that will apply to each question in this set and yield the *exhaustivity* and *uniqueness* presuppositions of the questions (Dayal, 2002).

(29) **A recursive definition for Generalized *Ans*:**
   a. $[\![Ans]\!] \left(P_{\langle st, t \rangle} \right) = \lambda w.\text{Max}_{\text{inf}}(P)(w)$
      where $\text{Max}_{\text{inf}}(P)(w) = \iota p \in P$, s.t. $w \in p$ and $\forall q \in P \, (w \in q \to p \subseteq q)$
   b. $[\![Ans]\!] \left(K_{\langle \sigma, t \rangle} \right) = \lambda w. \forall P_\sigma \in K \, ([\![Ans]\!] \, (P)(w)) \qquad\qquad \sigma \in \{ \langle st, t \rangle, \langle \langle st, t \rangle, t \rangle, ... \}$

As before, the ι operator introduces a uniqueness presupposition, which derives the presuppositions of the multiple question observed by Dayal in (11). This generalized *Ans* operator will recursively apply to each question in the set in (28) and ensure that it has a unique maximally informative true answer. The result is a single answer to each question in the family of questions—a pair-list reading of the multiple question, where for each student in the context, we must specify the single book that this student read.

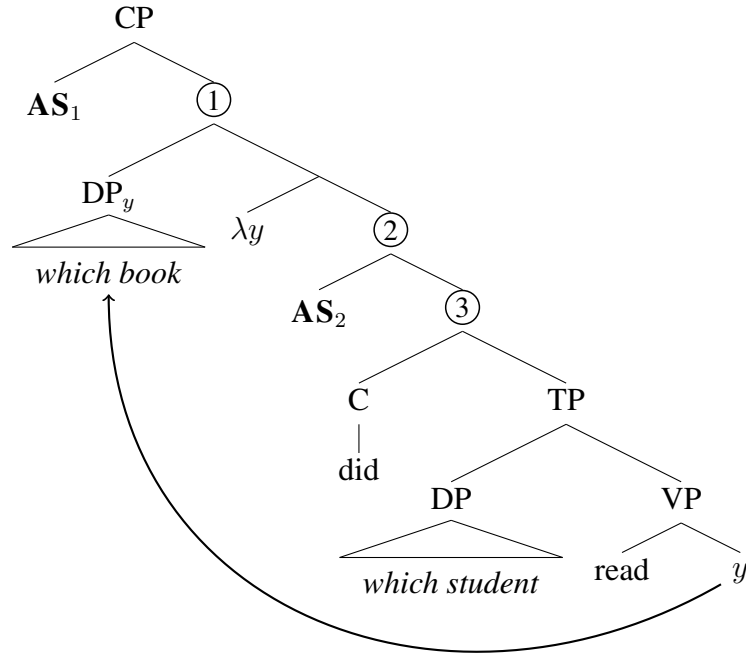4.4. The pair-list reading of a superiority-violating multiple question

Finally, I turn to the derivation of the pair-list reading of a superiority-violating question. An LF for such a question is illustrated in (30). Following Pesetsky (2000); Beck (2006); Cable (2007, 2010), a.o., I assume that the syntax of such a question is different from that of superiority-obeying questions in one important way. The derivation begins as with a superiority-obeying question: an interrogative probe on C probes its c-command domain. *Attract Closest* dictates that DP_x will the probe's first target, since it's closer to C than DP_y. At this point C agrees with DP_x, but—unlike in superiority-obeying questions—*C does not attract DP_x to its specifier but instead leaves it in-situ*. C continues probing its c-command domain and finds its next goal, DP_y. C agrees with DP_y and attracts it to its specifier. DP_y is hence the only (and hence, the highest) *wh*-phrase in Spec,CP. Following the pronunciation rule from above, it will be pronounced in its moved position—above the in-situ *wh*-phrase DP_x, yielding the superiority-violating word order.[15]

At this point, if a single ALTSHIFT operator takes the structure as its sister, this yields a single-pair question meaning as in section 4.2. For brevity, I will not illustrate this derivation, as it is parallel

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[15]Here it is important to note that there is no way to derive a superiority-violating word-order if the higher DP_x were attracted to Spec,CP—the pronunciation rule requires that DP_x is LF-in-situ to achieve this word order.

to the derivation sketched in (23–24) and yields an identical semantics for the question. Instead, I illustrate here the derivation of the pair-list reading of this structure. Like with the superiority-obeying question, the pair-list reading is modeled as a family of questions. To yield this structure, two ALTSHIFT operators are introduced into the structure: one above *which student* and another above *which book*. This will yield a family of questions denotation keyed on *books*, as desired.

(30) **The LF of a superiority-violating question with a pair-list reading:**

As with the parallel superiority-obeying question, the pair-list reading is derived via a nested set structure, created by interpreting each *wh*-phrase with a separate ALTSHIFT operator.

(31) **Key parts of the derivation of (30):**

a. $[\![③]\!]^f = \{\lambda w.\ x \text{ read } y \text{ in } w : x \in student\}$

b. $[\![②]\!]^o = [\![③]\!]^f = \{\lambda w.\ x \text{ read } y \text{ in } w : x \in student\}$

c. $[\![②]\!]^f = \{\{\lambda w.\ x \text{ read } y \text{ in } w : x \in student\}\}$

d. $[\![①]\!]^f = \{\{\lambda w.\ x \text{ read } y \text{ in } w : x \in student\} : y \in book\}$

e. $[\![CP]\!]^o = [\![①]\!]^f = \{\{\lambda w.\ x \text{ read } y \text{ in } w : x \in student\} : y \in book\}$

This yields a family of questions denotation sorted by the higher *wh*-phrase—*book*. Spelling this out for our small context, the result is (32), identical to our desideratum in (9). Moreover, applying the generalized Ans operator in (29) to this family of questions results in the requirement that each question in the set have one unique maximally informative true answer, correctly modeling the presuppositions of this question. That is, we yield a pair-list reading of the multiple question, where for each book in the context, we must specify the single student who read it.

(32) **A family of questions sorted by *book* yields a pair-list reading:**

$$\left\{ \left\{ \begin{array}{l} \text{John read MD} \\ \text{Mary read MD} \\ \text{Bill read MD} \end{array} \right\}, \left\{ \begin{array}{l} \text{John read WP} \\ \text{Mary read WP} \\ \text{Bill read WP} \end{array} \right\}, \left\{ \begin{array}{l} \text{John read OT} \\ \text{Mary read OT} \\ \text{Bill read OT} \end{array} \right\} \right\} \qquad (= 9)$$

The difference between this superiority-violating LF and the one for the superiority-obeying question lies in the fact that non-trivial focus-alternatives are computed across a larger portion of the structure. The fact that the base-generated higher *wh*-phrase *which student* is left in-situ in this LF makes predictions for the sensitivity of this structure to *intervention effects*. Following Beck (2006); Kotek (2014), a.o., parts of the structure in which alternatives are computed are susceptible to ungrammaticality, caused by c-commanding *interveners*—certain quantifiers and focus-sensitive operators. For more on this, see the above mentioned works and authors cited therein.

4.5. Summary

The theory developed here builds on existing proposals regarding interrogative syntax, the semantics of *wh*-phrases, the meaning of the interrogative operator, and the presuppositions of the question, combined in a novel way. The primary innovation is the ability of the ALTSHIFT operator to iterate in the structure, deriving the desired nested set structures for superiority-obeying and superiority-violating questions. This is compatible with the range of syntactic structures attested for questions cross-linguistically: here I illustrated structures with overt and covert movement to C, as well as *wh*-in-situ. This proposal is also compatible with languages that are fully in-situ (e.g. Japanese) and those that allow partial movement to positions other than C (e.g. Shona).

In this system, the syntactic and the semantic composition of the question are driven by two separate operators. In syntactic terms, the ALTSHIFT-operator is *higher* than the *wh*-phrases(s) that it interprets. It occupies a position in the C domain, above the C head. It is type-flexible, and it may occur more than once in a structure. In contrast, C is syntactically *lower* than the *wh*-phrase(s) that it attracts to its specifier(s). It is semantically inert, and it only occurs once in a question.[16]

5. Quiz-master questions and nested *which*-phrases

In this section I show that the proposal developed above is able to explain the distribution and interpretation of the possible readings of so-called 'quiz-master' questions and of questions with nested *which*-phrases. Example (33) illustrates a quiz master question. Such questions exceptionally require *wh* to remain in-situ, and often require a unique intonation that gives the question its name. They have been argued to only allow a single-pair answer, but not a pair-list answer:

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[16]Nothing goes wrong if multiple ALTSHIFT operators are stacked at the top of the question, without being separated by *wh*-phrases. In that case, the recursively-defined *Ans*-operator will apply, and ensure that the singleton set it contains must have a unique maximally informative true answer. Hence, regardless of how many sets this singleton set is embedded in, the result is a single-pair reading. Such a derivation may be independently ruled out by considerations of economy, but nothing hinges on this.

(33) **Quiz-master questions only have single-pair answers:**
[TP Elvis Presley introduced *which* actress to *which* rock band]?

Similarly, nested *wh*-phrases have been recently argued to systematically lack a pair-list reading (Elliott, 2015). This can be illustrated using the strongly distributive predicate *list*. The examples in (34) show that *list* may only embed a multiple question with a pair-list answer.

(34) *List* **may only embed questions with a pair-list answer:**
Context: There are two girls.
a.   Mary listed *which* girl hit *which* boy.
b.   # Mary listed *which* one hit *which* one first.

Example (35) now shows that nested *wh*-phrases cannot be embedded under *list*. This incompatibility of *list* and its embedding is explained if nested *wh*-questions may only have a single-pair reading, making them unsuitable complements to the predicate *list*.

(35) *List* **can't embed a nested *wh*-question:**
a.   Mary listed *which* book she had borrowed from *which* library.
b.   # Mary listed [DP *which* book by *which* author] she had read.

The two structures in (33) and (35b), though unusual, have one property in common: *in both cases, the two wh-phrases they contain will necessarily pointwise compose with one another, before an* ALTSHIFT *operator is encountered.* In the case of quiz-master questions, the *wh*-phrases are contained inside TP (and perhaps even *v*P). In the case of nested *wh*-questions, the *wh*-phrases are contained inside a single DP. However, the ALTSHIFT-operator must occupy a position on the clausal spine, above C. This syntactic restriction on the position of ALTSHIFT restricts the available interpretations for these multiple *wh*-questions in a principled manner. In particular, because all the *wh*-phrases in the structure will necessarily point-wise compose with one another into a 'flat' set before any ALTSHIFT operator is encountered, we correctly predict that only single-pair readings are available for these questions. There is no way to interleave the *wh*-phrases and ALTSHIFT-operators in these structures, as is required for the derivation of pair-list readings.

6. Conclusion

This paper presented a new framework for the syntax and semantics of interrogative constructions, building on well-motivated syntactic assumptions for the derivations of simplex and multiple questions. This proposal is compatible with both major approaches to the syntax and semantics of pied-piping (Cable, 2007, 2010; Heck, 2008, 2009), and it combines insights developed in different parts of the literature concerning superiority effects, the presuppositions of questions, the readings of multiple questions (single-pair vs pair-list), and intervention effects in multiple questions. It thus achieves a wider empirical coverage than other theories of interrogative syntax-semantics

(e.g. Hamblin, 1973; Karttunen, 1977; Hagstrom, 1998; Cable, 2007, 2010; Cheng and Demirdache, 2010; Fox, 2012; Nicolae, 2013). At the same time, this proposal is simpler than these other previous proposals:

(36) **A simple semantics for the interrogative components in a derivation:**
   a. *Wh*-words introduce alternatives into the derivation.
   b. The interrogative complementizer C passes up the denotation of its sister. It may only occur once in the structure, *below* moved *wh*-phrases.
   c. The interrogative operator ALTSHIFT turns the alternative value of its sister into the ordinary value of the question. It is type-flexible, may recur in the structure, and occurs *above* the *wh*-phrases that it interprets.

The single-pair and pair-list readings of multiple questions are derived from minimally different LFs, which differ only in the number of ALTSHIFT operators that occur in the structure. Finally, I showed that this theory explains exceptional cases where only a single-pair reading of the question is available, in quiz-master questions and in nested *wh*-questions.

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