Interpreting Questions with Non-exhaustive Answers

A dissertation presented
by

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to

The Department of Linguistics

in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy
in the subject of
Linguistics

Harvard University
Cambridge, Massachusetts

May 2016

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Abstract

This dissertation investigates the semantics of questions, with a focus on phenomena that challenge the standard views of the related core issues, as well as those that are technically difficult to capture under standard compositional semantics. It begins by re-examining several fundamental issues, such as what a question denotes, how a question is composed, and what a *wh*-item denotes. It then tackles questions with complex structures, including mention-some questions, multi-*wh* questions, and questions with quantifiers. It also explores several popular issues, such as variations of exhaustivity, sensitivity to false answers, and quantificational variability effects.

Chapter 1 discusses some fundamental issues on question semantics. I pursue a hybrid categorial approach and define question roots as topical properties, which can supply propositional answers as well as nominal short answers. But different from traditional categorial approaches, I treat *wh*-items as existential quantifiers, which can be shifted into domain restrictors via a BeDom-operator. Moreover, I argue that the live-on set of a plural or number-neutral *wh*-item is polymorphic: it consists of not only individuals but also generalized conjunctions and disjunctions.

Chapter 2 and 3 are centered on mention-some questions. Showing that the availability of mention-some should be grammatically restricted, I attribute the mention-some/mention-all ambiguity of $\diamond$-questions to structural variations within the question nucleus. The variations include the scope ambiguity of the higher-order *wh*-trace and the absence/presence of a null *dou*. Further, I solve the dilemma between uniqueness and mention-some by allowing the short answers to be interpreted with wide scope.

Chapter 4 investigates the role of false answers (FAs) in interpreting indirect questions. I focus on the following two facts: first, FA-sensitivity is involved in interpreting mention-some questions; second, FA-sensitivity is concerned with all types of false answers, not just those that are potentially complete. These facts challenge the current dominant analysis that derives FA-sensitivity by exhaustifications.

In Chapter 5 and 6, I turn to multiple-*wh* questions and questions with quantifiers. Crucially, contra the current dominant view, I argue that pair-list readings of multi-*wh* questions are not subject to domain exhaustivity, unlike those of questions with a universal quantifier. Chapter 6 explores two approaches to composing quantifying-into question readings, including a higher-order question approach and a function-based approach. Both approaches manage to treat quantifying-into question as regular quantification.

Chapter 7 presents a uniform treatment for the seemingly diverse functions of the Mandarin particle *dou*. I argue that *dou* is an exhaustifier that operates on pre-exhaustified sub-alternatives. This chapter provides a baseline theory for the derivation of disjunctive mention-all answers to mention-some questions.

Contents

Acknowledgement

First and foremost, I would like to thank my dissertation committee members, Gennaro Chierchia, Jim Huang, and Danny Fox. Their detailed comments, encouragements, and advice have greatly influenced the development of this work.

Gennaro shapes my line of thought as a linguist. Each time I got lost in the details and techniques, he pulled me back to the big picture. Over the years, Gennaro has been an incredible advisor – wise, patient, dedicated, and generous with his time and insights. I really appreciate the numerous hours that he spent for me. I can barely express my gratitude to him with my limited vocabulary in non-academic writing. His influence is on every page of this work.

Jim, who I would more love to call "Huang Laoshi," is "the" person who introduced me to the realm of formal linguistics; without him, I probably wouldn't have a chance to study in this area. His care and support are in every stage and aspect of my graduate life, even in the first few years when I was very dumb and behind. Thank you, Huang Laoshi, for always standing by me.

It was extremely lucky for me to have Danny on my committee. Weekly meetings with him over one and half years have been full of academic joy and excitement. Despite of his own pioneering works on question semantics, Danny is always open minded and gives me freedom to explore alternative approaches. This dissertation is greatly benefited from his constructive comments on both contents and presentations.

Alongside my committee members, I thank Uli Sauerland and Jesse Snedeker, who advised me on my generals papers. Uli was the first semanticist whom I had regular meetings with. Thanks to his enduring help, I did my first semantics project on neg-raising, which gained me a lot of self-confidence. Jesse introduced me to the field of experimental semantics. Her insights from the perspective of psychology are always inspiring.

Over the years, many other colleagues in the broader linguistic community have provided suggestions and collaborations on the contents of the current dissertation: Lucas Champollion, Emmanuel Chemla, Alexandre Cremers, Kathryn Davidson, Veneeta Dayal, Patrick Elliott, B. R. George, Jon Gajewski, Martin Hackl, Irene Heim, Aron Hirsch, Daniel Hole, Magdalena Kaufmann, Manfred Krifka, Manuel Križ, Andreas Haida, Mingming Liu, Salvador Mascarenhas, Clemens Mayr, Andreea Nicolae, Carlotta Pavese, Jonathan Phillips, Floris Roelofsen, Yasutada Sudo, Florian Schwarz, Roger Schwarzschild, Benjamin Spector, Anna Szabolcsi, Satoshi Tomioka, Wataru Uegaki, Ming Xiang. I thank Michael Erlewine and Hadas Kotek for instructing me on experiment designs and data analyses. I thank Brian Buccola, Simon Charlow, Robert Henderson, Utpal Lahiri, Jeremy Kuhn, and Barbara Partee for answering my questions on Facebook. I thank Edgar Onea, Ivano Ciardelli, and B. R. George for giving me opportunities to present parts of this work at themed workshops and talk to experts on question semantics and pragmatics. I thank the reviewers and audiences at MIT, UCL, ZAS in Berlin, ILLC at UvA, ImPres, QiD 2015, XPrag 2015, SuB 20, LAGB 2015, EACL 9, CSSP 2015, NELS 46, AC 20, LSA 2016, Attitudes and Questions workshop at CMU, and the Exhaustivity workshop at MIT.

My gratitude also goes to the other professors, staffs and students at Harvard. I would particular like to thank Andreea Nicolae for being a big sister of me over the years. I thank Edwin Tsai, Yujing Huang, and Yuyin He for their friendship and support. Thank Dorothy Ahn, Dora Mihoc, and Aurore Gonzalez for interesting discussions on semantics and other things. Thank the friends from

older years who have provided advice and encouragement over the years, especially Jacopo Romoli, Hazel Pearson, Julie Jiang, Greg Scontras, and Louis Liu. Thank Cheryl Murphy, Helen Lewis, and Kate Pilson for keeping the 3rd floor of Boylston a lovely place.

Thanks to my linguist friends over the world for giving me the sense of community belonging and making each conference travel great.

Thanks to my teachers at Peking University, who led me into the worlds of linguistics and encouraged me to study formal linguistics. I owe great gratitude especially to Rui Guo, Chirui Hu, Jianming Lu, Yang Shen, and Yulin Yuan.

Thanks to my parents. They raised me and taught me, gave me confidence and perseverance. My greatest gratitude is reserved for Dian, who has made me much more positive and rational. Thanks for your love, understanding, and support.

Chapter 1

Introducing a hybrid categorial approach

1.1. Introduction

This chapter discusses and re-evaluates the following fundamental issues on question semantics:

- What does a question denote?
- What counts as a complete true answer?
- What does a *wh*-item denote?

Starting from Caponigro's Generalization on the distributional patterns of *wh*-words in questions and free relatives, I argue that the nominal denotations of short answers must be derivable out of question denotations.

The three canonical approaches to semantics of questions, namely, categorial approaches, Hamblin-Karttunen Semantics, and Partition Semantics, define the root denotations of questions as lambda abstracts, Hamblin sets, and partitions, respectively. As this chapter will show, short answers can only be derived out of lambda abstracts; moreover, lambda abstracts have greater expressive power than Hamblin sets and partitions. For these reasons, I follow categorial approaches and define the root denotations as lambda abstracts, and more precisely, topical properties. This move makes it easy to interpret several other *wh*-constructions, such as free relatives, *wh*-conditionals in Mandarin. It is also helpful for getting the quantificational variability effects in cases where the quantification domain of the matrix adverb cannot be recovered from a Hamblin set.

This proposed hybrid categorial approach of question semantics also overcomes the empirical and technical deficiencies with traditional categorial approaches. The major improvements are as follows. First, it maintains the existential semantics of *wh*-items. Second, using a BeDom-shifter which converts *wh*-items into type-flexible domain restrictors, this approach does not suffer type mismatch in composing multi-*wh* questions. Third, it overcomes the type-mismatch problem with question coordinations by treating question coordinations as generalized quantifiers with a possibly polymorphic domain.

In the last section of this chapter, I re-evaluate the lexical entries of *wh*-items. I argue that, for some *wh*-items, their live-on sets (i.e., quantification domains) are richer than the sets denoted by their *wh*-complements. In replying to questions with necessity modals and questions with collective predicates, some answers are clearly not formed out of items in the set denoted by

the wh-complement, but rather generalized conjunctions and disjunctions over this set. I argue for the following generalization: the live-on set of a *wh*-item can be polymorphic; it is closed under conjunction and disjunction iff the set denoted by the wh-complement is closed under sum (as in *who* and *which books*). To capture this generalization, I argue that the lexical entry of a *wh*-determiner is encoded with a †-closure. This closure closes a mereologically closed set under boolean operations.

1.2. The starting point: Caponigro's Generalization

In answering a matrix question, it is usually more preferable to utter a *short answer* (also called *fragment answer* or *elided answer*). As exemplified in (1.1a), a short answer is the constituent that specifies only the new information. In comparison, the answer in (1.1b) which takes a full declarative form is called a *full answer* (also called *clausal answer* or *propositional answer*).

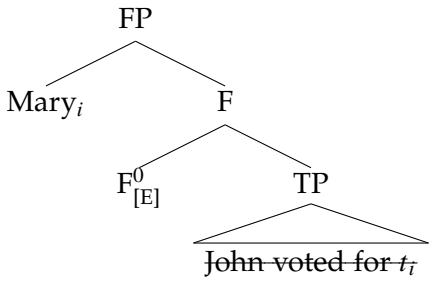
(1.1) Who did John vote for?

a. Mary. (short answer)

b. John voted for Mary. (full answer)

It remains controversial, however, whether a short answer in discourse is covertly clausal (Merchant 2005) or is a bare nominal constituent (Groenendijk and Stokhof 1982, 1984; Stainton 1998, 2005, 2006; Ginzburg and Sag 2000; Jacobson 2016). If a short answer is covertly clausal, it should be regarded as an elliptical form of the corresponding full answer and interpreted as a proposition. The ellipsis approach (Merchant 2005) proceeds as follows: the focused constituent moves to a left-peripheral position; next, licensed by a linguistic antecedent provided by the *wh*-question, the rest of the clause gets elided.

(1.2) Ellipsis approach for short answers (Merchant 2005)



If a short answer is a bare nominal constituent, it should take a nominal interpretation (i.e., interpreted as an item in the domain of the *wh*-item), which therefore calls for a way to derive such nominal denotations out of a question denotation. Previous works taking this position define the denotations of matrix questions as lambda functions, or say, functions that can select for the nominal denotation of a short answer as an argument (Groenendijk and Stokhof 1982, 1984; Ginzburg and Sag 2000; Jacobson 2016). For example, under this view, the *wh*-question in (1.1) denotes the function $\lambda x[\mathsf{human}(x).\mathsf{saw}(j,x)]$, which can take the human individual *mary* as an argument.

This dissertation does not intend to take a position on the syntax or semantics of short answers in discourse. Instead, I'm interested in whether it is for any reason necessary to get meanings

equivalent to the bare nominal denotations of short answers based on the denotation of a question. For the rest of this thesis, "short answers" only refer to the bare nominal denotations of short answers, not the syntactic expressions.

A *wh*-free relative denotes a short answer, more specifically, a nominal item named by a/the complete true answer of the corresponding *wh*-question. In (1.3a), *whom John voted for* refers to the individual or the group of individuals that John voted for. In (1.3b), *where he can get help* refers to one of the places where John could get help.

(1.3) a. We hired [whom John voted for].
b. John went to [where he could get help].

Here arises a question: is it empirically advantageous to analyze *wh*-questions and *wh*-free relatives uniformly? In other words, should we treat these two *wh*-constructions as two independent constructions, or as one being dependent on the other? A cross-linguistic observation due to Caponigro (2003, 2004) suggests that these two constructions are not independent: in 28 languages with *wh*-free relatives (from Indo-European, Finno-Ugric, and Semitic families), the distribution of *wh*-words is cross-linguistically more restrictive in free relatives than in questions. For example, cross-linguistically, *how*-words can be used in questions but not in free relatives. This generalization also extends to languages like Chuj (Kotek and Erlewine 2016), and Tlingit and Haida (Cable 2005).

(1.4) **Caponigro's Generalization** (Caponigro 2003, 2004)
If a language uses the *wh*-strategy to form both questions and free relatives, the *wh*-words found in free relatives are always a subset of those found in questions. Never the other way around. Never some other arbitrary relation between the two sets of *wh*-words.

Based on Caponigro's generalization, we can conjecture that the derivation of a free relative is strictly more complex than that of the corresponding *wh*-question, otherwise, there would have been some *wh*-words that could be used in free relatives but not in questions. We can further conjecture that, the most likely, free relatives are derived from questions (Chierchia and Caponigro 2013), as illustrated in Figure 1.1. Caponigro's Generalization is predicted as long as the operation that turns a questions into free relatives is partial and can be blocked for whatever reason.[1]

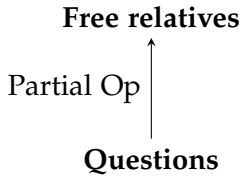


Figure 1.1: Path from questions to free relatives

[1]In theory, the following option is also possible: free relatives and questions share the same sources but are derived via two independent paths, but the path to free relatives is more likely to be blocked than the path to questions. This possibility requires that nominal short answers are derivable from a question denotation or a constituent contained within the denotation. Partition Semantics (Groenendijk and Stokhof 1982, 1984, 1990) basically takes this option: a *wh*-construction firstly forms a lambda abstract, which is then turned into a partition or a free relative via two distinct type-shifters. See details in section 1.3.3. Nevertheless, although there is no empirical evidence to rule out this possibility, it is very mysterious why one shifting-operation (viz., the one for free relatives) is more strictly used than another independent shifting-operation (viz., the one for questions).

1.3. Comparing canonical approaches of question semantics

There are numerous studies on question semantics. This section reviews three canonical approaches of question semantics, including categorial approaches, Hamblin-Karttunen Semantics, and Partition Semantics. Each approach has advantages and disadvantages. Discussions in this chapter will be limited to single-*wh* questions and multi-*wh* questions with single-pair readings. Pair-list readings of *wh*-questions will be discussed in chapter 5. Questions with quantifiers will be discussed in chapter 6.

1.3.1. Categorial approaches

Categorial approaches (Hausser and Zaefferer 1979; Hausser 1983, Von Stechow and Ede Zimmermann 1984, Guerzoni and Sharvit 2007, Ginzburg and Sag 2000, among others) define the root denotations of questions as *lambda* (λ-)*abstracts* and *wh*-items as *lambda* (λ-)*operators*, as exemplified in the following:

(1.5) a. $[\![\text{who came}]\!] = \lambda x[\textit{people}(x).\textit{came}(x)]$
b. $[\![\text{who bought what}]\!] = \lambda x \lambda y[\textit{people}(x) \wedge \textit{thing}(y).\textit{bought}(x, y)]$

(1.6) a. $[\![\text{who}]\!] = \lambda P_{\langle e,t\rangle} \lambda x[\textit{people}(x).P(x)]$
b. $[\![\text{what}]\!] = \lambda P_{\langle e,t\rangle} \lambda x[\textit{thing}(x).P(x)]$

Defining a question as a λ-abstract makes it simple to characterize the relation between questions and short answers: a short answer denotes a possible argument of the λ-abstract denoted by the question root, while a full answer denotes the output of applying this λ-abstract to a short answer. It also convenient for predicting the similarities between questions and free relatives: a free relative denotes an argument of the λ-abstract such that applying the λ-abstract to this argument yields a complete true answer of the corresponding question.

Nevertheless, categorial approaches are less commonly used than the alternative approaches due to the following deficiencies. First, treating *wh*-items as λ-operators, categorial approaches cannot account for the cross-linguistic fact that *wh*-words behave like existential indefinites in non-interrogatives. In German, Romance, Hindi, Japanese, Italian, and many other languages, polarity items with existential semantics are formed out of *wh*-words. More clearly, Mandarin *wh*-phrases like *shenme*-NP 'what'-NP can be licensed as existential epistemic indefinites when appearing below an existential epistemic modal or within the antecedent of a conditional (Liao 2011), as exemplified in the following:

(1.7) a. Yuehan haoxiang jian-le **shenme-ren**
John perhaps meet-PERF what-person
'It seems that John met someone.'

b. Ruguo Yuehan jian-guo **shenme-ren**, qing gaosu wo.
If John meet-EXP what-person, please tell me.
'If John met someone, please tell me.'

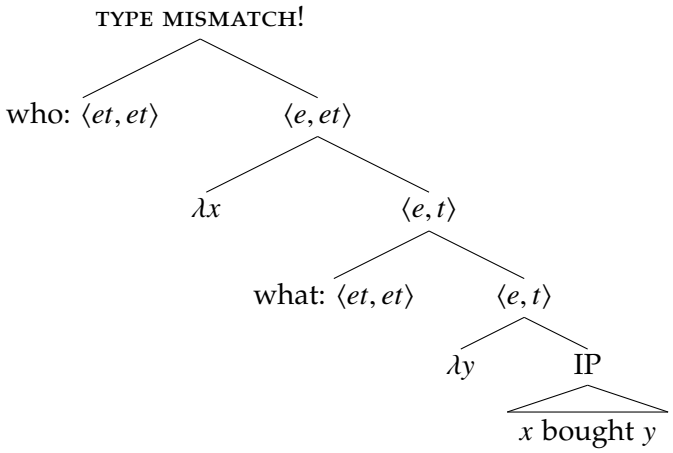
Second, assigning different semantic types to different questions, categorial approaches have difficulties in getting coordinations of question. As shown in (1.8), the single-*wh* question *who came*

and the multi-*wh* question *who bought what* can be naturally conjoined or disjoined and embedded under an interrogative-embedding predicate. Categorial approaches treat these two questions as of type $\langle e, t\rangle$ and $\langle e, et\rangle$, respectively. This treatment conflicts the standard view that only items of the same conjoinable type[2] can be coordinated.

(1.8) a. John asked Mary [[who came] and [who bought what]].
b. John asked Mary [[who came] or [who bought what]].
c. John knows [[who came] and [who bought what]].
d. John knows [[who came] or [who bought what]].

Third, categorial approaches have difficulties in composing the single-pair readings of multi-*wh* question. For example, the composition of the LF in (1.9) suffers type mismatch: *who* selects for an argument of type $\langle e, t\rangle$, while its sister node is of type $\langle e, et\rangle$; therefore, functional application cannot proceed. (See George 2011: §2.4.2 for a solution using tuple types.)

(1.9) Who bought what? (single-pair reading)



1.3.2. Hamblin-Karttunen Semantics

Hamblin (1973) analyzes the root denotation of a question as a set of propositions, each of which is a possible answer of the underlying question. He treats a non-*wh*-expression (such as a proper name or a verb) as the singleton set of its regular interpretation, and a *wh*-expression as the set of objects in the expression's usual domain of interpretation. The alternative semantics of these expressions are composed via the operation called *Point-wise Functional Application*. Accordingly, a declarative denotes a singleton proposition set whose only member identifies the declarative itself, as shown in (1.10a). A question denotes a set of propositions, each of which names an object in the *wh*-expression's interpretation domain, as shown in (1.10b).

[2]Conjoinable types are defined recursively as follows:

(i) **Conjoinable types**
a. t is a conjoinable type.
b. If σ is a conjoinable type, then for any type τ, $\langle \tau, \sigma\rangle$ is a conjoinable type.

(1.10) a. Mary came.

$\{\hat{}\mathsf{came}(m)\}$

Mary — came

$\{m\}$ — $\{\lambda x.\hat{}\mathsf{came}(x)\}$

b. Who came?

$\{\hat{}\mathsf{came}(m), \hat{}\mathsf{came}(j), ...\}$

who — came

$\{m, j, ...\}$ — $\{\lambda x.\hat{}\mathsf{came}(x)\}$

(1.11) **Point-wise Functional Application**

If $\alpha : \langle\sigma, \tau\rangle$ and $\beta : \sigma$, then

a. $[\![\alpha]\!]_g \subseteq D_{\langle\sigma,\tau\rangle}$

b. $[\![\beta]\!]_g \subseteq D_\sigma$

c. $\alpha(\beta) : \tau$ and $[\![\alpha(\beta)]\!] = \{f(d) \mid f \in [\![\alpha]\!]_g, d \in [\![\beta]\!]_g\}$

Karttunen (1977) argues that the root denotation of a question consists of only the true answers. This revision is made to capture the veridicality of indirect questions with a communication verb (e.g., *tell*, *predict*). Compare the sentences in (1.12) for illustration: telling a declarative sentence does not imply that the agent told something true, while telling a question does imply that the agent told a true answer of this question. Based on this contrast, Karttunen concludes that the veridicality of interrogative-embedding *tell* comes from the embedded question.[3]

(1.12) a. Jack told me that Mary came.

b. Jack told me who came.

The major assumptions in Karttunen's semantics of *wh*-questions are summarized as follows. First, a *proto-question rule* shifts the meaning of declarative sentence from a proposition p to a proto-question $\{q : q(w) = 1 \wedge q = p\}$, namely, the a set of true propositions that are identical to p. Second, *wh*-words like *who* and *what* are existentially quantified noun phrases, just like *someone* and *something*, respectively. Last, *wh*-items undergo quantifier raising and existentially quantify into the proto-question, yielding a set of true answers.

(1.13) By *WH-quantification rule*

Question

$\lambda p.\exists x[\mathsf{people}_@(x) \wedge p(w) = 1 \wedge p = \hat{}\mathsf{came}(x)]$

who — By *Proto-question rule*

$\lambda P.\exists x[\mathsf{people}_@(x) \wedge P\{x\}]$ — **Proto-question**

$\{p : p(w) = 1 \wedge p = \hat{}\mathsf{came}(x)\}$

Proposition

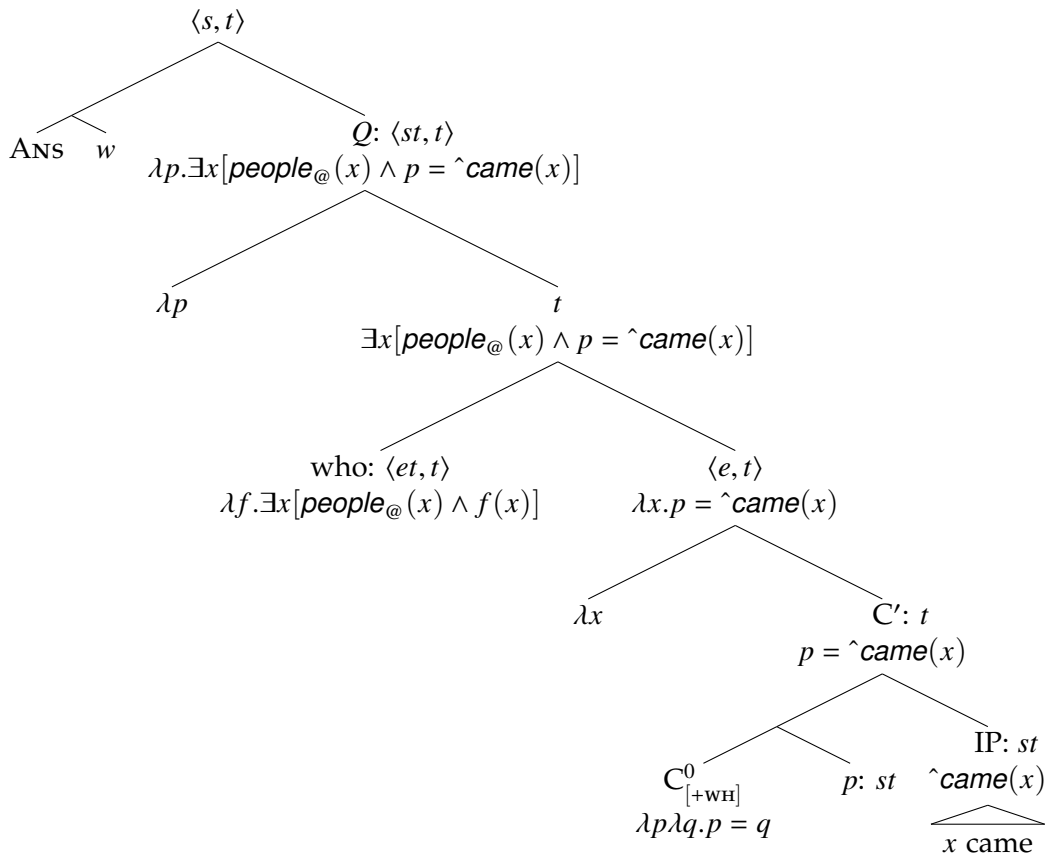
$\hat{}\mathsf{came}(x)$

The formalization of Karttunen Semantics follows Montague's Proper Treatment of Quantification (PTQ). Heim (1995) and many others transport the PTQ-style structures of Karttunen Semantics

[3]Contrary to Karttunen's claim, Spector and Egré (2015b) argue that declarative-embedding *tell* also admits a factive/veridical reading (see §4.2.1).

into Government and Binding (GB-)style LFs. The following tree illustrates the most commonly assumed LF for a single-*wh* question.[4] Different GB-style LFs have been proposed by Cresti (1995), Dayal (1996), Rullmann and Beck (1998), among others.

(1.14) Who came?



In the above LF, the proto-question rule is ascribed to an identify (Id)-function at the interrogative C head. The *wh*-word, interpreted as an existential quantifier, undergoes QR to [Spec, CP] and leaves an individual trace within IP. Abstracting the first argument p of the Id-function returns a set of possible answers (i.e, the Hamblin set). This set is considered the root denotation. For instance, with only two relevant individuals John and Mary, the Hamblin set is as follows:

(1.15)
$$\begin{aligned} Q &= \lambda p.\exists x[\mathit{people}_{@}(x) \wedge p = {}^{\wedge}\mathit{came}(x)] \\ &= \{{}^{\wedge}\mathit{came}(x) : x \in \mathit{people}_{@}\} \\ &= \left\{ \begin{array}{l} {}^{\wedge}\mathit{came}(j) \\ {}^{\wedge}\mathit{came}(m) \\ {}^{\wedge}\mathit{came}(j \oplus m) \end{array} \right\} \end{aligned}$$

Finally, an answerhood-operator applies to the Hamblin set Q and the evaluation world w, returning a/the propositional complete true answer in w. Various answerhood operators have been proposed in the literature. For instance, Heim (1994) proposes one that returns the conjunction of all the true

[4]The thesis consider only *de re* readings, where the extensional value of a *wh*-complement is evaluated under the actual world @. See Sharvit (2002) for a simple treatment of *de dicto* readings.

answers, and Dayal (1996) proposes one that is presuppositional and returns the unique strongest true answer. Setting aside differences of detail among the proposed answerhood-operators, we see that all of these operators introduce truth and bridge answers and questions.

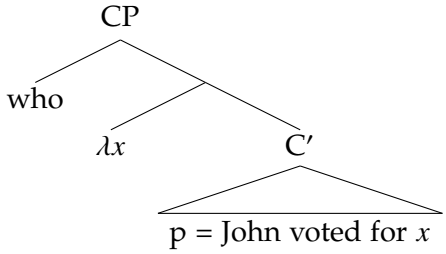
(1.16) $\textsc{Ans}_{Heim}(Q)(w) = \bigcap\{p : w \in p \in Q\}$

(1.17) $\textsc{Ans}_{Dayal}(Q)(w) = \exists p[w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow p \subseteq q]].$
$\iota p[w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow p \subseteq q]]$

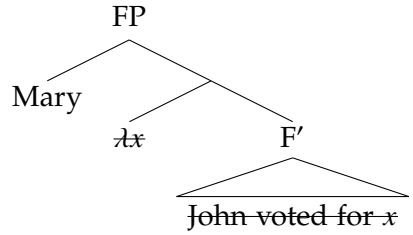
Hamblin-Karttunen Semantics has two major advantages over categorial approaches. First, *wh*-items are analyzed as existential indefinites, which therefore captures the cross-linguistic fact that *wh*-items take existential meanings under non-interrogative uses. Second, all questions are analyzed as propositions sets and uniformly assigned with the type $\langle st, t\rangle$.

On the negative side, however, Hamblin-Karttunen Semantics is incompatible with Caponigro's Generalization that *wh*-items are strictly more limitedly distributed in free relatives than in questions. As argued in section 1.2, this generalization suggests that nominal meanings of short answers should be derivable from the root denotation of a question. Defining questions as proposition sets, Hamblin-Karttunen Semantics loses the capability of deriving nominal short answers out of a question denotation, because individuals cannot be retrieved out of propositions. Moreover, Karttunen Semantics cannot even support the ellipsis approach of short answers. Compare the following LFs for illustration:

(1.18) a. Who did John vote for?



b. Mary.



In (1.18b), the elided expression denotes an abstract over the nucleus (i.e., $\lambda x.\textit{vote-for}(j, x)$). But in (1.18a), the sister node of *who* denotes an abstract over an equation (i.e., $\lambda x.p = {}^\wedge\textit{vote-for}(j, x)$), which does not qualify as a syntactic antecedent of ellipsis.[5][6]

Although Hamblin-Karttunen Semantics uniformly defines questions as proposition sets, it still has problems in analyzing coordinations of questions. Conjunction and disjunction are standardly treated as *meet* and *join*, respectively, recursively defined as follws (Partee and Rooth 1983, Groenendijk and Stokhof 1989). (The symbols '$\wedge$' and '$\vee$' are reserved for coordinating truth values. A' stands for the interpretation of a syntactic expression A.)

[5]This point is inspired by Lucas Champollion (pers. comm.).

[6]Danny Fox (pers. comm.) suggests a solution of this problem: the LF of (1.18) can be structured as follows, where *who* takes cyclic movement and leaves two individual traces (viz., x and y) within IP; λ-abstraction over the lower trace (i.e., the underlined part) provides a syntactic antecedent for the ellipsis.

(i) $[_{\text{CP}}\ \lambda p$ who λy $[[_{\text{ID}}\ p]$ $[_{\text{IP}}$ y $\underline{\lambda x\ [\text{John voted for } x]}]]]$

(1.19) **Meet** $\sqcap$

$$A' \sqcap B' = \begin{cases} A' \wedge B' & \text{if } A' \text{ and } B' \text{ are of type } t \\ \lambda x[A'(x) \sqcap B'(x)] & \text{if } A' \text{ and } B' \text{ are of some other conjoinable type} \end{cases}$$

(1.20) **Join** $\sqcup$

$$A' \sqcup B' = \begin{cases} A' \vee B' & \text{if } A' \text{ and } B' \text{ are of type } t \\ \lambda x[A'(x) \sqcup B'(x)] & \text{if } A' \text{ and } B' \text{ are of some other conjoinable type} \end{cases}$$

Hence, if a questions denotes the set of its possible answers, then the conjunction of two questions would denote the set of common possible answers of these two questions. This prediction is clearly incorrect. For example, in (1.21), the two coordinated questions have no possible answer in common.

(1.21) John asked Mary [[who came] and [who bought what]].

A common solution of this problem is to allow the conjunction to be applied point-wise, as defined in (1.22): a point-wise conjunction of two proposition sets returns a set of conjunctive propositions. Hence, the embedded conjunction of questions in (1.21) denotes a set of conjunctive propositions, as in (1.23).[7]

(1.22) **Point-wise conjunction $\cap_{\mathbf{pw}}$:**
Given two sets of propositions α and β, then $\alpha \cap_{\text{PW}} \beta = \{a \cap b : a \in \alpha, b \in \beta\}$

(1.23) $[\![$ [who came] and$_{\text{PW}}$ [who bought what] $]\!]$

$$= \left\{ \begin{array}{c} \text{a came} \cap \text{a}\oplus\text{b bought a cake} \\ \text{b came} \cap \text{a}\oplus\text{b bought a cake} \\ \text{a}\oplus\text{b came} \cap \text{a}\oplus\text{b bought a cake} \end{array} \right\}$$

1.3.3. Partition Semantics

Partition Semantics (Groenendijk and Stokhof 1982, 1984, 1990) defines the root denotation of a question as a partition over possible worlds. Two world indices belong to the same cell of a partition iff the property denoted by the question nucleaus holds for the same set of items in these two worlds. For example, in (1.24), w and w' are in the same cell iff the very same set of individuals came in w and w'.

(1.24) $[\![\text{who came}]\!] = \lambda w \lambda w'[\lambda x[\mathsf{came}_w(x)] = \lambda x[\mathsf{came}_{w'}(x)]]$

With two relevant individuals John and Mary, we can illustrate the partition in (1.24) as in Table 1.1. Each cell/row stands for a subset of worlds, or equivalently, a strongly exhaustive propositional answer as to *who came*. For instance, the first cell stands for the set of worlds where only John and Mary came, and hence is equivalent to the exhaustified proposition that *only John and Mary came*.

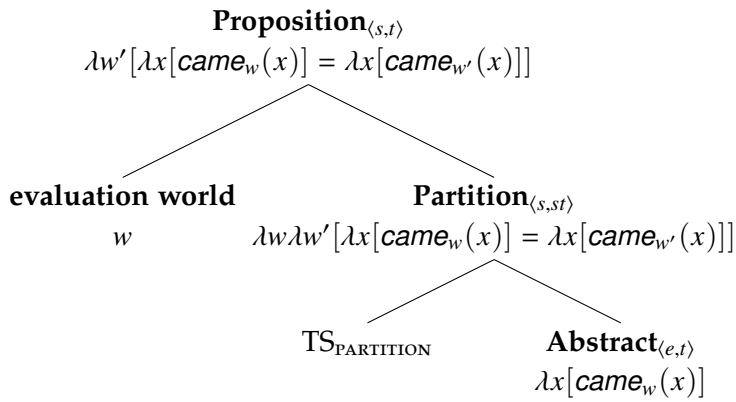
[7] Inquisitive Semantics restores the standard treatment of conjunction. See Ciardelli et al. (2013); Ciardelli and Roelofsen (2015); Ciardelli et al. (To appear)

w: only j and m came in w
w: only j came in w
w: only m came in w
w: nobody came in w

Table 1.1: Partition for *who came*

Under Partition Semantics, interpreting an embedded *wh*-question involves three steps. First, *wh*-items abstract out the corresponding variables from the question nucleus, forming a lambda abstract. Second, the lambda abstract gets type-shifted, yielding a partition of possible worlds. Last, the evaluation world provided by the embedding predicate picks out the cell where it belongs to, yielding an exhaustified proposition.

(1.25) John knows [who came].



Compared with categorial approaches, shifting a lambda abstract to a partition assigns the same semantic type $\langle s, st\rangle$ to all types of questions. For instance, the single-*wh* (1.24) and the multi-*wh* question (1.26) are uniformly functions from worlds to propositions.

(1.26) $[\![\text{who bought what}]\!] = \lambda w \lambda w'[\lambda x \lambda y[\mathsf{bought}_w(x,y)] = \lambda x \lambda y[\mathsf{bought}_{w'}(x,y)]]$

On the negative side, however, shifting an abstract to a partition makes us unable to restore the predictive meaning of a question: short answers and λ-abstracts cannot be extracted out of a partition (see §1.3.4), just like it is impossible to recover the argument x and the function f from the proposition $f(x)$. Hence, Partition Semantics has to use two different type-shifting (TS) operations to derive questions and free relatives, as illustrated in Figure 1.2: TS1 turns a λ-abstract into a partition, forming a question; TS2 turns a λ-abstract into a nominal element, forming a free relative. Since these two TS operations work independently, Partition Semantics cannot account for Caponigro's Generalization. (See fn. 1 and Chierchia and Caponigro 2013)

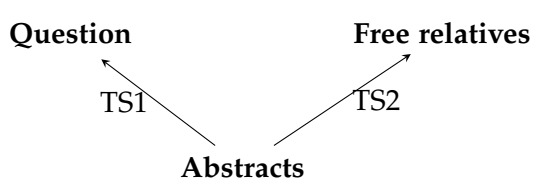


Figure 1.2: Paths from abstracts to questions and free relatives

Moreover, for both mention-some questions and mention-all questions, Partition Semantics allows only strongly exhaustive readings, as described in (1.27a)/(1.28a), which are however too strong (Heim 1994). The more prominent interpretations are what I call "false answer (FA)-sensitive readings," as described in (1.27b)/(1.28b). FA-sensitive readings of these indirect questions have the following conditions: (i) the belief holder knows a true mention-some/mention-all answer of the embedded mention-some/mention-all question, and (ii) the belief holder has no false belief as to the embedded question. I will motivate and present an analysis for these readings in chapter 4.

(1.27) John knows who can chair the committee.
(Context: *only Andy and Billy can chair; single-chair only.*)
a. 'John knows that only Andy and Billy can chair.'
b. 'John knows that Andy can chair, or John knows that Billy can chair; and John has no false belief as to who can chair the committee.'

(1.28) John knows who came.
(Context: *only Andy and Billy came.*)
a. 'John knows that only Andy and Billy came.'
b. 'John knows that Andy and Billy came; and John has no false belief as to who came.'

1.3.4. Comparing lambda abstracts, Hamblin sets, and partitions

In (1.29), I rank the three proposed question denotations with respect to the strength of their expressive power, with 'lambda abstracts' being the strongest and 'partitions' being the weakest. (See also Rooth 1992, Krifka 2006, Beaver and Clark 2003, Onea 2016: chap. 3.) 'A has greater expressive power than B' means that any information that is derivable from B is also derivable from A, but not the other direction.

(1.29) **Rank of expressive power**
Lambda abstracts (topical properties) > Hamblin sets > Partitions

In the following paragraphs, I will only consider lambda abstracts that range over propositions, called "topical properties." A topical property is a function from individuals to propositions. From the perspective of question-answer relation, a topical property of a question is a function from short answers to propositional answers.

(1.30) Who came?
a. Topical property
$\mathbf{P} = \lambda x[\mathit{people}_{@}(x) = 1.{}^{\wedge}\mathit{came}(x)]$
b. Hamblin set
$Q = \{{}^{\wedge}\mathit{came}(x) : \mathit{people}_{@}(x) = 1\}$
c. Partition
$\lambda w \lambda w'[\lambda x[\mathit{people}_{@}(x) = 1.\mathit{came}_{w}(x)] = \lambda x[\mathit{people}_{@}(x) = 1.\mathit{came}_{w'}(x)]]$

Topical properties are ranked higher than Hamblin sets due to the following asymmetry: any information that is derivable from a Hamblin set is also derivable from the corresponding topical

property, but not the other direction. Let **P** stand for a topical property, then the Hamlin set is the set of propositions obtained by applying **P** to the possible arguments of **P**. In the other direction, however, short answers are derivable from **P** but not from the corresponding Hamlin set.

$\{\mathbf{P}(\alpha) : \alpha \in \mathrm{Dom}(\mathbf{P})\}$	Hamblin set
$\{\mathbf{P}(\alpha) : \alpha \in \mathrm{Dom}(\mathbf{P}) \wedge w \in \mathbf{P}(\alpha)\}$	Karttunen set
$\mathrm{Dom}(\mathbf{P})$	the set of possible short answers
$\{\alpha : \alpha \in \mathrm{Dom}(\mathbf{P}) \wedge w \in \mathbf{P}(\alpha)\}$	the set of true short answers

Table 1.2: Deriving answers sets from topical properties

For instance, the two properties in (1.31) yield the same Hamblin set (i.e., $\{f(a), f(b)\}$) but have different domains. The domain of $\mathbf{P}_1$ consists of two propositions $\{f(a), f(b)\}$, while the domain of $\mathbf{P}_2$ consists of two individuals $\{a, b\}$. Hence, based on a Hamblin set of a question, we cannot retrieve the topical property of this question, nor the short answers.

(1.31) a. $\mathbf{P}_1 = \lambda p[p \in \{f(a), f(b)\}.p]$
b. $\mathbf{P}_2 = \lambda x[x \in \{a, b\}.f(x)]$

Partitions have even less expressive power than Hamblin sets. For example, questions in (1.32) yield different lambda abstracts and Hamblin sets but the very same partition. Hence, based on a partition, we cannot tell the singular/plural contrast with *wh*-items, the positive/negative contrast in question nucleuses, or the variations of exhaustivity.

(1.32) a. Who came?
b. Which person came?
c. Who didn't come?
d. Which person didn't come?
e. Which person or people x is such that only x came?
f. Which person or people x is such that only x didn't come?

To be more concrete, compare the number-neutral *wh*-question in (1.32a) and the singular *wh*-question in (1.32b). With only two relevant individuals John and Mary, their Hamblin sets would be as (1.33a) and (1.33b), respectively. The live-on set (viz., quantification domain) of a singular *wh*-item is a proper subset of that of a bare *wh*-word, namely, the former consists of only atomics while the latter also includes sums (and even generalized quantifiers, see §1.6); therefore, the Hamblin set yielded by (1.32b) is a proper subset of the one yielded by (1.32a).

(1.33) a. Who came?

$$Q = \left\{ \begin{array}{l} {}^\wedge came(j) \\ {}^\wedge came(m) \\ {}^\wedge came(j \oplus m) \end{array} \right\}$$

b. Which person came?

$$Q = \left\{ \begin{array}{l} {}^\wedge came(j) \\ {}^\wedge came(m) \\ \\ \end{array} \right\}$$

Nevertheless, the two questions in (1.32) yield the very same partition, as illustrated in Table 1.3. For instance, in both partitions, the first cell stands for the set of worlds where only John and Mary

came. In particular, the one yielded by (1.32a) is the set of worlds w such that the set of atomic/sum individuals who came in w is $\{j, m, j \oplus m\}$, while the one yielded by (1.32b) is the set of worlds w such that the set of atomic individuals who came in w is $\{j, m\}$.

Partition yielded by (1.32a)				Partition yielded by (1.32b)
w: $\{x : w \in c(x)\} = \{j, m, j \oplus m\}$		w: only $j \oplus m$ came in w		w: $\{x : w \in c(x)\} = \{j, m\}$
w: $\{x : w \in c(x)\} = \{j\}$	=	w: only j came in w	=	w: $\{x : w \in c(x)\} = \{j\}$
w: $\{x : w \in c(x)\} = \{m\}$		w: only m came in w		w: $\{x : w \in c(x)\} = \{m\}$
w: $\{x : w \in c(x)\} = \varnothing$		w: nobody came in w		w: $\{x : w \in c(x)\} = \varnothing$

Table 1.3: Partitions for (1.32a-b)

1.3.5. Summing up

The advantages and disadvantages of each canonical approach are summarized in Table 1.4. Crucially, only categorial approaches can derive nominal short answers grammatically out of question denotations.[8]

	Categorial	Partition	Hamblin-Karttunen
short answers	√	(√)	×
question coordinations	×	√	(√)
wh-items as ∃-indefinites	×	×	√
exhaustivity variation	√	×	√

Table 1.4: Comparing the canonical approaches of question semantics

I have also shown that topical properties have greater expressive power than Hamblin sets and partitions. Starting from a topical property, we can reach all the information that is reachable from a Hamblin set or a partition, but not in the other direction.

1.4. A hybrid categorial approach

Since topical properties have the greatest expressive power, a natural line of thought would be to define the root denotation as a topical property and let the answerhood-operator directly operate on this topical property. Based on this thought, I propose a hybrid categorial approach to compose question semantics. This approach achieves the advantages of all the canonical approaches while overcoming their disadvantages. The major ingredients of this approach are summarized as follows:

- The root denotation of a question is a topical property, derived as follows: (§1.4.1)

[8] Again, here "short answers" refer to the nominal denotations of *wh*-free relatives, not syntactic expressions. As for the prediction of Partition Semantics on deriving short answers, the check mark is enclosed with parenthesis for the following reason: in Partition Semantics, short answers are not derived from questions, but a sub-constituent of questions, which can hardly predict Caponigro's Generalization. To be more specific, in Partition Semantics the formation of a question has two steps: (i) forming a lambda abstract, and (ii) forming a partition via type-shifting. Short answers can be derived after step (i) but not after step (ii).

  - *Wh*-items are existential indefinites (Karttunen 1977).
  - A BeDom-operator converts a *wh*-item into a domain restrictor.
  - Moving BeDom(*wh*P) to [Spec, CP] yields a partial property that is defined for only individuals in the live-on set of the *wh*-item.

- An answerhood-operator directly operates on the topical property. It evaluates the exhaustivity/uniqueness requirement (see chap. 3) and returns a set of max-informative true answers. These answers can be nominal or propositional, depending on the employed answerhood-operator. (§1.4.2)

- Coordinations of questions are generalized quantifiers; the conjunctive/disjunctive coordinates two predications (of type t), not directly the root denotations of the involved questions. (§1.4.3)

1.4.1. Topical property

This section provides a compositional derivation for topical properties of *wh*-questions. Distinct from traditional categorial approaches and the more recent approaches to compose topical properties or lambda abstracts of questions (Caponigro 2004, George 2011, Champollion et al. 2015), the proposed derivation maintains the existential semantics of *wh*-items and is free from type-mismatch.

For instance, the expected topical property of (1.34) is a function from an atomic boy x to the proposition that x *came*.

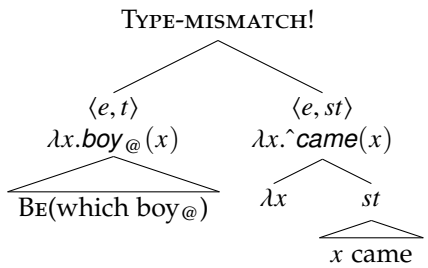
(1.34) Which boy$_@$ came?
$\mathbf{P} = \lambda x[\mathit{boy}_@(x) = 1.\hat{}\mathit{came}(x)]$

The domain of the topical property **P** is equivalent to the extensional value of the *wh*-complement, namely, the set of atomic boys in the actual world $\mathit{boy}_@$. This domain can be extracted out of the *wh*-item as follows: first, following Karttunen (1977), I define *wh*-items as existential indefinites; next, I extract out the set $\mathit{boy}_@$ by applying the type-shifter Be (Partee 1986) to *which boy*. As shown in the following, the type-shifter Be shifts an existential quantifier to its live-on set:

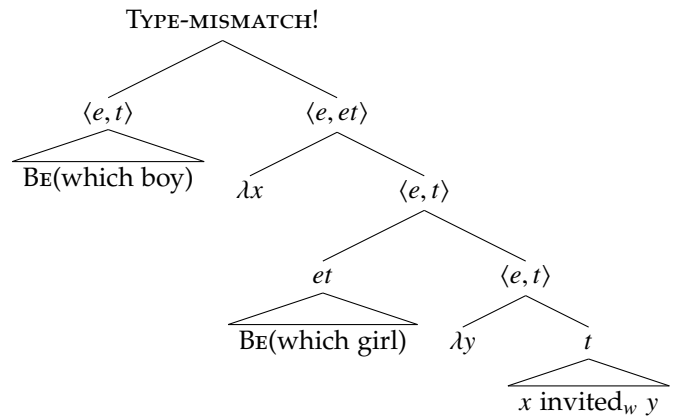
(1.35) a. $[\![\text{which boy}_@]\!] = \lambda f_{\langle e,t\rangle}.\exists x \in \mathit{boy}_@[f(x)]$
b. $\text{Be} = \lambda\mathcal{P}\lambda z[\mathcal{P}(\lambda y.y = z)]$
c. $\text{Be}([\![\text{which boy}_@]\!]) = \lambda z[(\lambda f_{\langle e,t\rangle}.\exists x \in \mathit{boy}_@[f(x)])(\lambda y.y = z)]$
$= \lambda z[\exists x \in \mathit{boy}_@[x = z]]$
$= \{z : z \in \mathit{boy}_@\}$
$= \mathit{boy}_@$

The next step is to combine the property domain $\text{Be}([\![\text{which boy}_@]\!])$ with the nucleus given by the remnant CP (i.e., $\lambda x\lambda w.\mathit{came}_w(x)$). An appealing line of thought would be to compose these two pieces via Predicate Modification (Heim and Kratzer 1998). Nevertheless, employing Predicate Modification suffers type mismatch. **First**, as shown in (1.36), 'Be(which boy)' is extensional (of type $\langle e,t\rangle$) while its sister node is intensional (of type $\langle e,st\rangle$). **Second**, a more severe problem arises in deriving the single-pair reading of a multi-*wh* question. For example, even if we neglect the extension/intension mismatch, the composition in (1.37) still suffers type mismatch: 'Be(which boy)' is of type $\langle e,t\rangle$, but its sister node is of type $\langle e,et\rangle$.

(1.36) Which boy came?



(1.37) Which boy invited which girl?



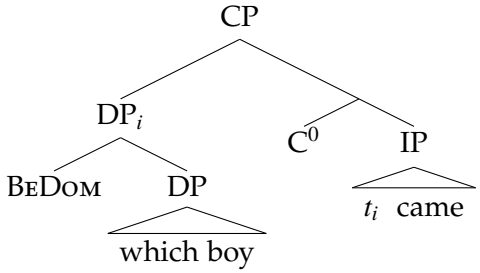
To incorporate the set BE(*wh*P) into the domain of the topical property, I introduce a new type-shifter BEDOM. In semantics, BEDOM shifts a *wh*-item $\mathcal{P}$ (or any existential quantifier) into a *domain restrictor*. As schematized in (1.38), BEDOM($\mathcal{P}$) applies to a function θ (of an arbitrary type τ) and restricts the domain of θ with the live-on set of $\mathcal{P}$.

(1.38) **Type-shifter BeDom**

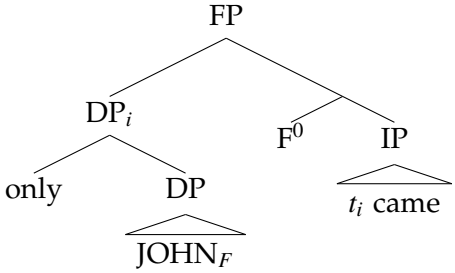
$$\textsc{BeDom}(\mathcal{P}) = \lambda\theta_\tau.\iota P_\tau[[\mathrm{Dom}(P) = \mathrm{Dom}(\theta) \cap \textsc{Be}(\mathcal{P})] \wedge \forall\alpha \in \mathrm{Dom}(P)[P(\alpha) = \theta(\alpha)]]$$

In syntax, BEDOM is a DP-adjunct. In (1.39), for example, BEDOM adjoins to *which boy* and moves together to [Spec, CP]. This movement is syntactically motivated to check off the [+wh] feature of *which boy*. This movement resembles the DP-movement of '*only*+NP', as shown in (1.40): *only* is a DP-adjunct of $JOHN_F$; *only*-$JOHN_F$ as a whole moves to [Spec, FP] so as to check off the [+F] feature of $JOHN_F$.

(1.39) Which boy came?

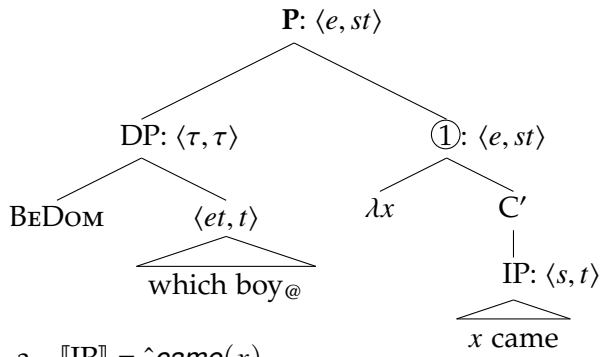


(1.40) Only JOHN_F came.



To see how the computations of single-*wh* and multiple-*wh* questions work out in practice, let us consider (1.41) and (1.42). It can be nicely observed how the BEDOM-shifter turns a *wh*-phrase into a type-flexible domain restrictor (of type $\langle\tau,\tau\rangle$, where τ stands for an arbitrary type): the output partial property P has the identical semantic type as the input property θ. In (1.41), 'BEDOM(which boy)' applies to a total came-property defined for any item of type e, and returns a partial came-property defined for only atomic boys. Likewise, in (1.42), 'BEDOM(which boy)' applies to a total function of type $\langle e, est\rangle$, and returns a partial function of type $\langle e, est\rangle$ defined only for atomic boys. Superior to traditional categorial approaches, this way of composition does not suffer type mismatch.

(1.41) Which boy came?



a. $[\![\text{IP}]\!] = {}^\wedge\textit{came}(x)$

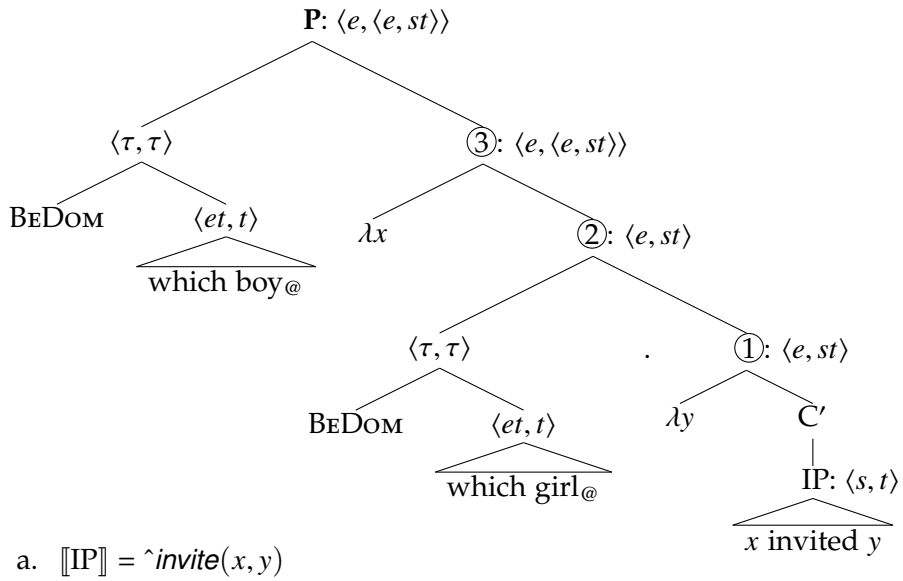
b. $[\![①]\!] = \lambda x[y \in D_e.{}^\wedge\textit{came}(x)]$

c. $[\![\text{which boy}_@]\!] = \lambda f_{\langle e,t\rangle}.\exists x \in \textit{boy}_@[f(x)]$

d. $\mathbf{P} = \iota P[[\text{Dom}(P) = D_e \cap \textit{boy}_@] \wedge \forall\alpha \in \text{Dom}(P)[P(\alpha) = {}^\wedge\textit{came}(\alpha)]]$
$= \lambda x[\textit{boy}_@(x) = 1.{}^\wedge\textit{came}(x)]$

(1.42) Which boy invited which girl? (Single-pair reading)

Option 1: Object-*wh* moves to [Spec, CP]



a. $[\![\text{IP}]\!] = {}^\wedge\textit{invite}(x, y)$

b. $[\![①]\!] = \lambda y[y \in D_e.{}^\wedge\textit{invite}(x, y)]$

c. $[\![②]\!] = \iota P[[\text{Dom}(P) = D_e \cap \textit{girl}_@] \wedge \forall\beta \in \text{Dom}(P)[P(\beta) = {}^\wedge\textit{invite}(x,\beta)]]$
$= \lambda y[\textit{girl}_@(y) = 1.{}^\wedge\textit{invite}(x, y)]$

d. $[\![③]\!] = \lambda x\lambda y[x \in D_e \wedge \textit{girl}_@(y) = 1.{}^\wedge\textit{invite}(x, y)]$

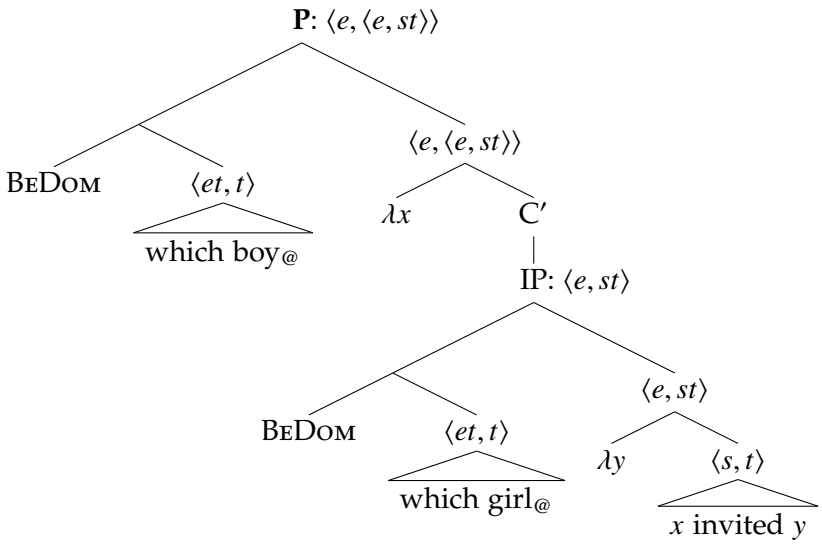
e. $\mathbf{P} = \iota P[[\text{Dom}(P) = D_e \cap \textit{boy}_@] \wedge \forall\alpha \in \text{Dom}(P)[P(\alpha) = \lambda y[\textit{girl}_@(y) = 1.{}^\wedge\textit{invite}(\alpha, y)]]]$
$= \lambda x\lambda y[\textit{boy}_@(x) = 1 \wedge \textit{girl}_@(y) = 1.{}^\wedge\textit{invite}(x, y)]$

In a multi-*wh* question, the movement of the *wh*-object is semantically driven by type-mismatch. In semantics, the movement of the *wh*-object is mandatory, but it doesn't matter whether it moves to [Spec, CP] or [Spec, IP/VP]. If one adopts the view that only one *wh*-phrase can be moved to

the spec of an interrogative CP, she or he can alternatively assume that 'BeDom(which girl)' moves covertly to the left edge of IP/VP so as to avoid type-mismatch, as shown in (1.43).

(1.43) Which boy invited which girl? (Single-pair reading)

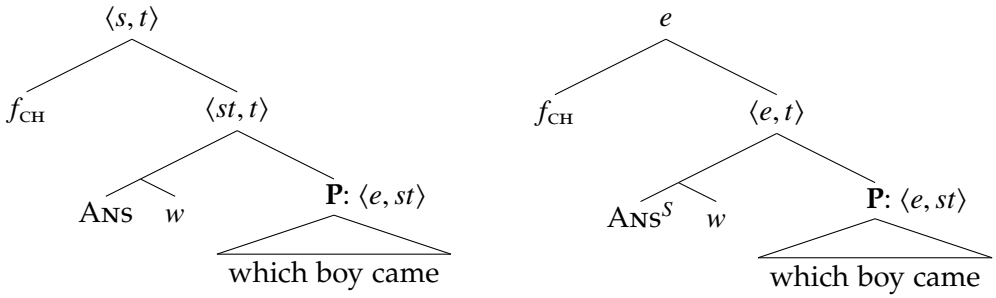
Option 2: Object-*wh* moves to [Spec, IP/VP]



1.4.2. Answerhood

A topical property directly enters into an answerhood-operation, returning a <u>set</u> of complete true answers. These answers can be propositional or short, depending on whether the employed answerhood-operator is Ans or Ans^S.[9] Finally, a choice function f_{CH} is applied to pick out one of these complete true answers. If a question has only one complete true answer, the output set of employing Ans is a singleton set, and employing f_{CH} returns the unique member of this set.

(1.44) a. For propositional answers b. For short answers



An important feature of the proposed framework is that the procedure of question formation has no stage that creates a Hamblin set or a Karttunen set. Instead, answerhood-operators directly operate on the topical property and hence they can access any information that is retrievable from the topical property, especially the property domain, or say, the possible short answers.[10] As will

[9]Note that the superscript 'S' in Ans^S stands for 'short,' rather than 'strong.'

[10]This consequence makes the proposed analysis significantly different from George (2011) and the very recent analysis

see in chapter 3, making the property domain accessible to the answerhood-operators is crucial for predicting the uniqueness effects in singular and numeral-modified *wh*-questions.

As for the definition of completeness, I adopt Fox's (2013) view that any *maximally (max)-informative* true answer counts as a complete true answer. A true answer is max-informative as long as it is not asymmetrically entailed by any true answers. Following Hamblin-Karttunen semantics, Fox defines an answerhood-operator as in (1.45): $\textsc{Ans}_{Fox}$ applies to a Hamblin set Q and an evaluation world w, returning the set of max-informative true members of Q in w.

(1.45) $\textsc{Ans}_{Fox}(Q)(w) = \{p : w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow q \not\subset p]\}$ (Fox 2013)

Compared with the answerhood-operators proposed by Heim (1994) and Dayal (1996) seen in section 1.3.2, $\textsc{Ans}_{Fox}$ leaves some space for getting mention-some readings: it allows a non-exhaustive answer to be complete, and a question to take multiple complete true answers. I will return to this point in section 2.5.1. Adapting the definition in (1.45) to the proposed hybrid categorial approach, I define the answerhood-operators as in (1.46). The major revision is replacing the Hamblin set Q with a topical property $\mathbf{P}$: $\textsc{Ans}(\mathbf{P})(w)$ returns the set of max-informative true answers, and $\textsc{Ans}^S(\mathbf{P})(w)$ returns the set of individuals named by these answers.[11]

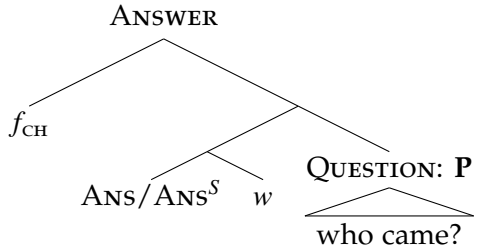
(1.46) **Answerhood-operators** (The asserted components only)

a. *For propositional answers*
$\textsc{Ans}(\mathbf{P})(w)$
$= \{\mathbf{P}(\alpha) : \alpha \in \mathrm{Dom}(\mathbf{P}) \wedge w \in \mathbf{P}(\alpha) \wedge \forall\beta \in \mathrm{Dom}(\mathbf{P})[w \in \mathbf{P}(\beta) \rightarrow \mathbf{P}(\beta) \not\subset \mathbf{P}(\alpha)]\}$

b. *For short answers*
$\textsc{Ans}^S(\mathbf{P})(w)$
$= \{\alpha : \alpha \in \mathrm{Dom}(\mathbf{P}) \wedge w \in \mathbf{P}(\alpha) \wedge \forall\beta \in \mathrm{Dom}(\mathbf{P})[w \in \mathbf{P}(\beta) \rightarrow \mathbf{P}(\beta) \not\subset \mathbf{P}(\alpha)]\}$

Example (1.47) illustrates the applications of $\textsc{Ans}$ and $\textsc{Ans}^S$ in single-*wh* questions. Note that the tree illustrates the derivations of answers, not the LFs of matrix questions. The answerhood-operators and the choice function are semantically active but not syntactically present.

(1.47)



(Context: *Only Andy and Billy came.*)

a. $\mathbf{P} = \lambda x[\mathit{people}_{@}(x) = 1.\hat{}\mathit{came}(m, x)]$

proposed by Champollion et al. (2015) using Inquisitive Semantics. These two analyses also start with a lambda abstract, but then use a question-formation operator to convert this abstract into a set of propositional answers. Hence, under these two proposals, an answerhood-operator cannot interact with the property domain.

[11] This chapter considers only the asserted components of the answerhood-operators. Chapter 3 will discuss their presuppositions, which are crucial for predicting the uniqueness requirements of singular *wh*-questions.

b. $\mathrm{Dom}(\mathbf{P}) = \mathit{people}_{@}$ (possible SAs)

c. $\{\mathbf{P}(\alpha) : \alpha \in \mathrm{Dom}(\mathbf{P})\} = \{\hat{}\mathit{came}(x) : x \in \mathit{people}_{@}\}$ (possible PAs)

d. $\textsc{Ans}(\mathbf{P})(w) = \{\hat{}\mathit{came}(a \oplus b)\}$ (max-informative true PAs)

e. $\textsc{Ans}^{S}(\mathbf{P})(w) = \{a \oplus b\}$ (max-informative true SAs)

f. $f_{\mathrm{CH}}[\textsc{Ans}(\mathbf{P})(w)] = \hat{}\mathit{came}(a \oplus b)$

g. $f_{\mathrm{CH}}[\textsc{Ans}^{S}(\mathbf{P})(w)] = a \oplus b$

Now, let's move on to multi-*wh* questions. Strictly speaking, the lambda abstract **P** in (1.48a) is not a property: it is a function from atomic boys to a property of atomic girls. Moreover, its domain is not a set of short answers, and its range is not a set of propositional answers. Then, how can we derive answers from this **P**? The simplest solution that I have seen so far is to make use of *tuple types*, an idea developed by George (2011: Appendix A). George writes an n-ary sequence as $(x_1; x_2; ...; x_n)$ which takes a tuple type $(\tau_1; \tau_2; ...; \tau_n)$, and then equivocates between the type $\langle \tau_1 \langle \tau_2 \langle ... \langle \tau_n, \sigma \rangle, ... \rangle$ and with the type $\langle (\tau_1; \tau_2; ...; \tau_n), \sigma \rangle$. For instance, $\langle e, \langle e, st \rangle \rangle$ equals to $\langle (e; e), st \rangle$. Using this idea, we can consider the abstract **P** in (1.48a) as a property of duple-sequences from an atomic boy to an atomic girl and write its domain as (1.48b). Then answerhood-operations proceed regularly.

(1.48) Which boy invited which girl?
(Context: *John invited only Mary; no other boy invited any girl.*)

a. $\mathbf{P} = \lambda x \lambda y[\mathit{boy}_{@}(x) = 1 \wedge \mathit{girl}_{@}(y) = 1.\hat{}\mathit{invite}(x, y)]$

b. $\mathrm{Dom}(\mathbf{P}) = \{(x; y) : x \in \mathit{boy}_{@}, y \in \mathit{girl}_{@}\}$ (possible SAs)

c. $\{\mathbf{P}(\alpha) : \alpha \in \mathrm{Dom}(\mathbf{P})\} = \{\hat{}\mathit{invite}(x, y) : x \in \mathit{boy}_{@}, y \in \mathit{girl}_{@}\}$ (possible PAs)

d. $\textsc{Ans}(\mathbf{P})(w) = \{\hat{}\mathit{invite}(j, m)\}$ (complete true PAs)

e. $\textsc{Ans}^{S}(\mathbf{P})(w) = \{(j; m)\}$ (complete true SAs)

1.4.3. Question coordinations

Recall the major criticism to traditional categorial approaches: questions of different kinds are assigned different semantic types, which makes it difficult to account for question coordinations.

(1.49) a. John knows [who came] and [who bought what]

b. John asked Mary [who came] and [who bought what]

The proposed hybrid categorial approach also faces this problem: questions denote topical properties, which can take different semantic types. For example, the two coordinated questions in (1.49a) are treated as of type $\langle e, st \rangle$ and $\langle e, \langle e, st \rangle \rangle$, respectively. In responding to this problem, I argue that question coordinations are not meet and join, but rather generalized quantifiers. To be more specific, when used to coordinate two questions, *and*/*or* does not directly coordinate the denotations of the two questions, but instead two predication operations (of type t).

Recall that conjunction and disjunction are traditionally treated as *meet* and *join*, respectively, which are only defined for conjoinable expressions, namely, expressions of a semantic type of the form $\langle, ...t \rangle$ (Partee and Rooth 1983, Groenendijk and Stokhof 1989). If A' and B' are of a non-conjoinable type or of different types, meet and join cannot proceed. For such cases, I propose

that *A and/or B* can be interpreted as a generalized quantifier, defined as in (1.50b)/(1.51b).[12][13] (For disambiguation, '$\wedge$' and '$\vee$' are reserved for coordinating truth values, while '$\sqcap$' and '$\sqcup$' are reserved for meet and join. See definitions for meet and join in (1.19) and (1.20), respectively.)

(1.50) A conjunction "A and B" is ambiguous between (a) or (b):

a. **Meet**
$[\![A \text{ and } B]\!] = A' \sqcap B'$; defined only if A' and B' are of the same conjoinable type.

b. **Generalized conjunction**
$[\![A \text{ and } B]\!] = A' \bar{\wedge} B' = \lambda\alpha[\alpha(A') \wedge \alpha(B')]$

(1.51) A disjunction "A or B" is ambiguous between (a) or (b):

a. **Join**
$[\![A \text{ or } B]\!] = A' \sqcup B'$; defined only if A' and B' are of the same conjoinable type.

b. **Generalized disjunction**
$[\![A \text{ or } B]\!] = A' \bar{\vee} B' = \lambda\alpha[\alpha(A') \vee \alpha(B')]$

The generalized conjunction $A' \bar{\wedge} B'$ universally quantifies over a polymorphic set $\{A', B'\}$ and selects for an item with an ambiguous type as its scope. Equivalently, in set-theoretical notations, $A' \bar{\wedge} B'$ denotes the family of sets such that each set contains both A' and B' (formally: $\{\alpha : A' \in \alpha \wedge B' \in \alpha\}$).[14] The generalized disjunction $A' \bar{\vee} B'$ is analogous.

To see how this approach works in practice, consider the composition of (1.52). The question-embedding verb *know* is type-ambiguous; it can select for propositions as well as properties of various types. The question coordination denotes a generalized conjunction, labeled as QP. It undergoes QR and moves to left edge of the matrix clause, yielding a wide scope reading of *and* relative to the embedding-predicate *know*. (Domain restrictions with the topical properties are neglected.)

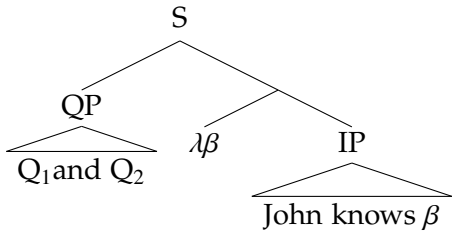
(1.52) John knows [$_{Q_1}$ who came] and [$_{Q_2}$ who bought what].
= 'John knows who came and John knows who bought what.'

[12] In many other works (Partee and Rooth 1983, Groenendijk and Stokhof 1989, among others), the term "generalized conjunction/disjunction" is used to refer to cross-categorical meet/join.

[13] Note that the following expressions are different:

(i) a. $a \bar{\vee} b \bar{\vee} a \oplus b = \lambda P[P(a) \vee P(b) \vee P(a \oplus b)]$
b. $(a \bar{\vee} b) \bar{\vee} a \oplus b = \lambda\theta[\theta(a \bar{\vee} b) \vee \theta(a \oplus b)]$

[14] A similar line of thought would be to say that the conjunctive is applied to the Montague-lifted denotation of each interrogative conjunct (*à la* Partee and Rooth's treatment of noun phrases). But the proposed method is more permissive: it allows the scope of the obtained generalized quantifier to be type-flexible, and hence allows the conjuncts to be of different semantic types. Consider, the traditional Montague lift shifts an expression of type τ to a generalized quantifier of type $\langle\langle\tau, t\rangle, t\rangle$. If two conjuncts are of different types, their Montague-lifted counterparts would still be of different types and cannot be conjoined.



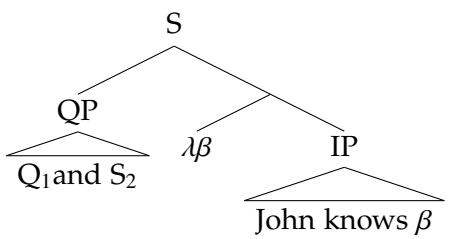
a. $[\![\text{IP}]\!] = \textit{know}(j,\beta)$

b. $[\![\text{Q}_1 \text{ and } \text{Q}_2]\!] = [\![\text{Q}_1]\!] \bar{\wedge} [\![\text{Q}_2]\!] = \lambda\alpha.[\alpha(\text{Q}_1') \wedge \alpha(\text{Q}_2')]$

c. $[\![\text{S}]\!] = \lambda\alpha.[\alpha(\text{Q}_1') \wedge \alpha(\text{Q}_2')](\lambda\beta.\textit{know}(j,\beta))$
$= (\lambda\beta.\textit{know}(j,\beta))(\text{Q}_1') \wedge (\lambda\beta.\textit{know}(j,\beta))(\text{Q}_2')$
$= \textit{know}(j,\text{Q}_1') \wedge \textit{know}(j,\text{Q}_2')$
$= \textit{know}(j,\lambda x.\hat{}\textit{came}(x)) \wedge \textit{know}(j,\lambda x\lambda y.\hat{}\textit{bought}(x,y))$

This analysis also extends to cases where a question is coordinated with a declarative, as shown in the following:

(1.53) John knows [$_{Q_1}$ who came] and [$_{S_2}$ that Mary bought Coke].
= 'John knows who came, and John knows that Mary bought Coke.'



a. $[\![\text{Q}_1 \text{ and } \text{S}_2]\!] = [\![\text{Q}_1]\!] \bar{\wedge} [\![\text{S}_2]\!] = \lambda\alpha.[\alpha(\text{Q}_1') \wedge \alpha(\text{S}_2')]$

b. $[\![\text{S}]\!] = \lambda\alpha.[\alpha(\text{Q}_1') \wedge \alpha(\text{S}_2')](\lambda\beta.\textit{know}(j,\beta))$
$= (\lambda\beta.\textit{know}(j,\beta))(\text{Q}_1') \wedge (\lambda\beta.\textit{know}(j,\beta))(\text{S}_2')$
$= \textit{know}(j,\text{Q}_1') \wedge \textit{know}(j,\text{S}_2')$
$= \textit{know}(j,\lambda x.\hat{}\textit{came}(x)) \wedge \textit{know}(j,\hat{}\textit{bought}(m,c))$

The proposed analysis of question coordinations yields the following prediction: in an indirect question where the question-embedding predicate embeds a coordination of questions, this coordination can and can only take scope <u>above</u> the question-embedding predicate. This prediction cannot be validated or falsified based on sentences like (1.52). The predicate *know* is divisive, and therefore the wide scope reading and the narrow scope reading of the disjunction yield the same truth conditions.

(1.54) *know* (j, Q_1 *and* Q_2) $\Leftrightarrow$ *know* (j, Q_1) $\wedge$ *know*(j, Q_2))

To evaluate this prediction, we can replace the conjunction with a disjunction, or *know* with a non-divisive predicate. The observations in what follows support the prediction.

First, in (1.55) and (1.56), the disjunction clearly takes scope above *know*. For (1.55)/(1.55) to be true, John needs to know the complete true answer of at least one of the involved questions, as described in (1.55a)/(1.56a); by contrast, as in (1.55b)/(1.56b), if what John believes is just a disjunctive inference, we cannot conclude (1.55)/(1.56) to be true.

(1.55) John knows who invited Andy or who invited Billy.
(Context: *Mary invited both Andy and Billy, and no one else invited Andy or Billy.*)
a. √ John knows that Mary invited Andy, or John knows that Mary invited Billy.
b. × John knows that Mary invited Andy or Billy (or both).

(1.56) John knows whether Mary invited Andy or whether Mary invited Bill.
(Context: *Mary invited both Andy and Billy.*)
a. √ John knows that Mary invited Andy, or John knows that Mary invited Billy.
b. × John knows that Mary invited Andy or Billy.

In comparison, observe that (1.57) is ambiguous: the embedded disjunction of two declaratives admits both a narrow scope reading and a wide scope reading. The narrow scope reading is derived when the disjunction is interpreted as a join/union of two propositions, as in (1.57a). The wide scope reading arises if the disjunction is read as a generalized conjunction that quantifies over a set of two propositions, as in (1.57b).[15]

(1.57) John knows [$_{S_1}$ Mary invited Andy] or [$_{S_2}$ Mary invited Billy].
a. *Narrow scope reading*
i. $[\![S_1 \text{ or } S_2]\!] = S_1' \sqcup S_2'$
ii. $[\![\text{John knows } S_1 \text{ or } S_2]\!] = \mathit{know}(j, S_1' \sqcup S_2')$
b. *Wide scope reading*
i. $[\![S_1 \text{ or } S_2]\!] = S_1' \bar{\vee} S_2' = \lambda\alpha[\alpha(S_1') \vee \alpha(S_2')]$
ii. $[\![\text{John knows } S_1 \text{ or } S_2]\!] = \mathit{know}(j, S_1') \vee \mathit{know}(j, S_2')$

Second, conjunctions of questions embedded under non-divisive predicates admit only wide scope readings. The predicate *be surprised (at)* is non-divisive: in (1.58), the agent being surprised at the conjunction of two propositions does not necessarily imply that the agent is surprised at each atomic proposition: $\mathit{surprise}\ (j,\ p \wedge q) \not\Rightarrow \mathit{surprise}\ (j,\ p) \wedge \mathit{surprise}(j,\ q)$.

(1.58) John is surprised that [Mary went to Boston] and [Sue went to Chicago]. (He expected that them would go to the same city.)
$\not\rightsquigarrow$ John is surprised that Mary went to Boston.

Nevertheless, when embedding a conjunction of questions, *be surprised (at)* seemingly takes only a divisive reading: for example, (1.59) expresses that John is surprised at the complete true answer of each involved question.

(1.59) (Context: *Only Mary went to Boston, and only Sue went to Chicago.*)
John is surprised at [$_{Q_1}$ who went to Boston] and [$_{Q_2}$ who went to Chicago].
$\rightsquigarrow$ John is surprised at who went to Boston.
$\rightsquigarrow$ John is surprised that Mary went to Boston.

[15] To observe this ambiguity, we have to drop the complementizer *that*, otherwise prosody easily disambiguates the sentence. This ambiguity is more clear in languages that do not have overt complementizers (e.g., Chinese).

The seeming divisive reading is expected by the proposed analysis: the conjunction of questions is a generalized conjunction; it can and can only scope above *be surprised (at)*. A schematized derivation is given in (1.60).

(1.60) a. $[\![\mathrm{Q}_1 \text{ and } \mathrm{Q}_2]\!] = \mathrm{Q}_1' \barwedge \mathrm{Q}_2' = \lambda\alpha.[\alpha(\mathrm{Q}_1') \wedge \alpha(\mathrm{Q}_2')]$

b. $[\![\text{John is surprised at } \mathrm{Q}_1 \text{ and } \mathrm{Q}_2]\!] = \textit{surprise}(j, \mathrm{Q}_1') \wedge \textit{surprise}(j, \mathrm{Q}_2')$

There seem to be some counterexamples. For instance, as Groenendijk and Stokhof (1989) observe, in (1.61), the disjunction of questions can freely take scope above or below the embedding predicate *wonder*. The wide scope reading says that the speaker knows that Peter wants to know the answer to one of the two questions, but he or she is unsure which one this is. The narrow scope reading says that Peter will be satisfied as long as he gets an answer to one of the questions involved, no matter which one.

(1.61) Peter wonders [whom John loves] or [whom Mary loves].

So, how can we get such narrow scope readings? Based on a long-standing intuition, we can decompose the intensional predicate *wonder* into 'want to know' (Karttunen 1977, Guerzoni and Sharvit 2007, Uegaki 2015: chap. 2). Thus, the seeming narrow scope reading is actually an "intermediate" scope reading: Peter wants it to be the case that he knows whom John loves or that he knows whom Mary loves. Such a reading arises when the disjunction takes QR and gets interpreted between *want* and *know*, as illustrated in (1.62b).

(1.62) Peter <u>wants to know</u> [$_{\mathrm{Q}_1}$whom John loves] or [$_{\mathrm{Q}_2}$whom Mary loves].

a. *Wide scope reading*
[[Q_1 or Q_2] $\lambda\beta$ [Peter wants to know β]]

b. *Intermediate scope reading*
[Peter wants [[Q_1 or Q_2] $\lambda\beta$ [to know β]]]

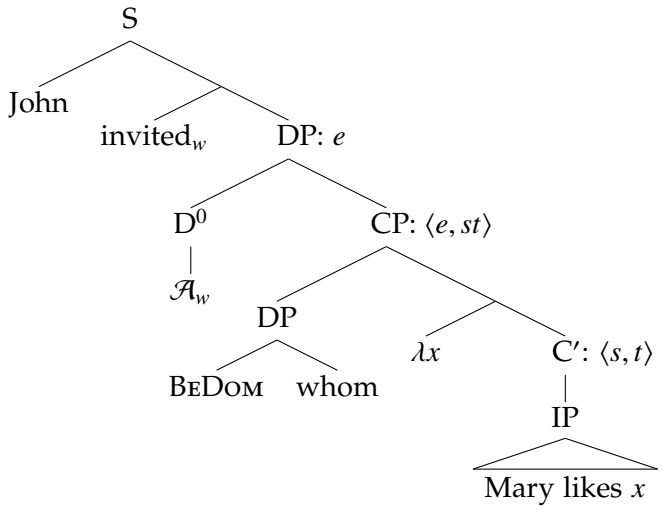
1.5. Applications of the hybrid categorial approach

Enabling question denotations to supply short answers makes it easy to deal with a number of *wh*-constructions. This section sketches out analyses for interpreting free relatives and Mandarin *wh*-conditionals, and an explanation to the quantificational variability effects involved in interpreting indirect questions with collective predicates. This section does not intend to give fully fledged analyses for these issues, but just to demonstrate the convenience of the proposed hybrid categorial approach.

1.5.1. Getting Caponigro's Generalization: Free relatives

I assume the following LF for *wh*-free relatives. A silent $\mathcal{A}$-determiner selects for an interrogative CP-complement and returns a DP. The CP-complement denotes a topical property, derived in the same way as it is in the corresponding root question. The $\mathcal{A}$-determiner can be decomposed into a choice function and an $\textsc{Ans}^S$-operator; it picks out one max-informative true short answer of the question denoted by the CP-complement, which is therefore the denotation of the free relative.

(1.63) John invited [$_{\text{FR}}$ whom Mary likes].
(Context: *Mary only likes Andy and Billy.*)



a. $[\![\text{CP}]\!] = \lambda x_e \lambda w[\textit{people}_{@}(x) = 1.\hat{}\textit{like}(m, x)]$ (Topical property)

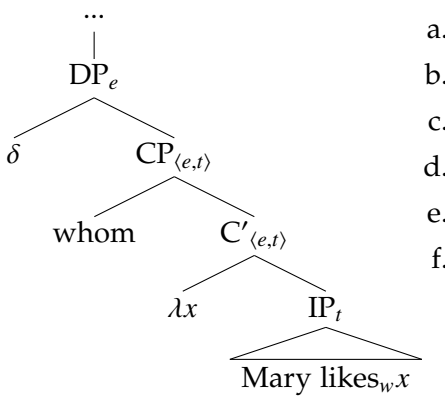
b. $[\![\mathcal{A}_w]\!] = \lambda \mathbf{P}.f_{\text{CH}}[\text{Ans}^S(\mathbf{P})(w)]$

c. $[\![\text{DP}]\!] = f_{\text{CH}}[\text{Ans}^S([\![\text{CP}]\!])(w)] = a \oplus b$ (A complete true SA)

Caponigro's Generalization is thus predicted: questions denote topical properties; a *wh*-free relative is derived applying a $\mathcal{A}$-determiner to the corresponding *wh*-question; this operation forms a DP and yields a nominal interpretation.

Caponigro (2003: chap. 2) also treats a *wh*-free relative as a DP that contains a CP-complement, as illustrated in the following:

(1.64) The LF of free relatives (Caponigro 2003)



a. $[\![\text{IP}]\!] = \textit{like}_w(m, x)$

b. $[\![\text{C}']\!] = \lambda x.\textit{like}_w(m, x)$

c. $[\![\text{whom}]\!] = \lambda X \lambda x_1[\textit{people}(x_1) \wedge X(x_1)]$

d. $[\![\text{CP}]\!] = \lambda x_1[\textit{people}(x_1) \wedge \textit{like}_w(m, x_1)]$

e. $[\![\delta]\!] = \lambda A.\sigma A$

f. $[\![\text{DP}]\!] = \sigma[\lambda x_1[\textit{people}(x_1) \wedge \textit{like}_w(m, x_1)]] = a \oplus b$

The CP-complement denotes a predicate, or equivalently, a set of individuals. Then a δ-operator, interpreted as a σ-closure (Link 1983), selects out the maximal element of the extension of the CP-complement.

(1.65) **The σ-closure** (Link 1983)
For every set A, $\sigma A = \exists x[x \in A \wedge \forall y[y \in A \rightarrow y \leq x]]$.

$$\iota x[x \in A \wedge \forall y[y \in A \rightarrow y \leq x]]$$

(The maximal element in A, defined only if this maximal element exists.)

Despite many similarities, the proposed analysis has two advantages over Caponigro's. First, Caponigro makes use the traditional categorial approach of question semantics, and therefore inherits the problems of this approach. The proposed analysis overcomes these problems. Second, compared with Caponigro's δ-determiner, the proposed $\mathcal{A}$-determiner works uniformly for "existential free relatives," as shown in (1.66).

(1.66) John went to where he could get help.
LF: John went to [$_{\text{DP}}$ $\mathcal{A}$ [$_{\text{CP}}$ where he could get help]]
= 'John went to a place where he could get help.'
≠ 'John went to all the places where he could get help.'

Here the CP-complement within the free relative corresponds to a mention-some question. Each max-informative true answer of this question names <u>one</u> place where John could get help. Applying $\mathcal{A}$ selects out one such place, yielding the desired "existential" reading. In contrast, the δ-determiner returns the sum of all the places where John could get help, yielding an unwelcome universal reading.

1.5.2. Quantificational variability effects

In most cases, a quantificational adverb (e.g., *mostly*, *for the most part*) over an indirect question can be treated as if it quantifies over the set of atomic true propositional answers of the embedded question (Lahiri 2002, 1991; Williams 2000; Cremers 2016: chap. 5; compare Beck and Sharvit 2002). For example, in (1.67), if exactly three of the students *abc* came, the quantification domain of *mostly* would be the following set of propositions: $\{\hat{}\mathsf{came}(a), \hat{}\mathsf{came}(b), \hat{}\mathsf{came}(c)\}$. Then (1.67) states that John knows most propositions in this set. This effect is called quantificational variability (QV).

(1.67) John mostly knows [$_{\text{Q}}$ which students came].
$\rightsquigarrow$ For some proposition p such that p is a complete true answer of Q, most propositions q that are atomic subparts of p are such that John knows p.

If adopting Hamblin-Karttunen Semantics, we can schematize this QV inference as follows:[16]

(1.68) $[\![\text{John mostly knows Q}]\!]^w = 1$ iff
$\exists p \in \textsc{Ans}_{Fox}(Q)(w)[\textsc{Most}\ q\ [p \subseteq q \wedge q \in \text{At}(Q)][\mathsf{know}(j,q)]]$

[16]Note that it is inadequate to define the quantification domain of *mostly* as the set of true atomic propositions in the Hamblin set. When the embedded question takes a mention-some reading, as in (ii), the use of *mostly* is infelicitous.

(i) $\textsc{Most}\ q\ [w \in p \in \textsc{At}(Q)][\mathsf{know}(j,q)]$ (Inadequate)

(ii) John (# mostly) knows [where we can get coffee]$_{\text{MS}}$.

The QV inference schematized in (1.68) captures the infelicity of using *mostly* in (ii): *mostly* requires a non-singleton quantification domain, while a mention-some answer of the embedded question names only an atomic place and supplies only a singleton quantification domain.

(For some max-informative true answer of Q, John knows most of the atomic possible answers of Q that are entailed by this max-informative true answer.)

It is difficult, however, to extend this proposition-based analysis to the following cases, where the embedded questions take a collective predicate:[17]

(1.69) a. John knows for the most part which students formed the bassoon quintet.
b. For the most part Al knows which soldiers surrounded the fort.

Intuitively, in (1.69a-b), the quantification domain of *for the most part* is a set of individuals that are the atomic subparts of the complete true short answer of the embedded question. For example, in (1.69a), if the bassoon quintet was made of the following five students *abcde*, then the quantification domain of *for the most part* would be the following set of atomic individuals: $\{a, b, c, d, e\}$. A similar sub-divisive reading is observed with the mention-some question (1.70). Contrary to the case of (ii) in footnote 18, *mostly* can be felicitously used in (1.70). The reason is that each mention-some answer of the embedded question in (1.70) names a group of individuals, which therefore can supply a non-singleton quantification domain for *mostly*.

(1.70) John mostly knows [who can serve on the committee]$_{\text{MS}}$.

Williams (2000) proposes a way to maintain the proposition-based analysis. He stipulates that the embedded question in (1.69a) provides propositional answers of a sub-distributive form "x is part of a group that formed the bassoon quintet" where x is an atomic student. Williams derives this reading by assigning the determiner *which* with a collective semantics, as schematized in the following:

(1.71) Which students formed the bassoon quintet?
≈ 'Which students x is s.t. x is part of the students that formed the bassoon quintet?'

a. $[\![\text{which}]\!] = \lambda A_{\langle e,t\rangle}\lambda P_{\langle e,t\rangle}\lambda p_{\langle s,t\rangle}.\exists x \in A[p = \lambda w.\exists y \in A[y \geq x \wedge P_w(y)]]$

b. $[\![\text{which students}_{@}\ \text{f.t.b.q.}]\!]$
$= \lambda p.\exists x[\textit{*student}_{@}(x) \wedge p = \lambda w.\exists y[\textit{*student}_{@}(y) \wedge y \geq x \wedge \textit{f.t.b.q.}_{w}(y)]]$
$= \{\lambda w.\exists y[\textit{*student}_{@}(y) \wedge y \geq x \wedge \textit{f.t.b.q.}_{w}(y)] : x \in \textit{*student}_{@}\}$
($\{x$ is part of a group y such that y formed the bassoon quintet: x is student(s)$\}$)

Nevertheless, William's idea, that (1.71) admits a sub-divisive reading, cannot account for the following contrast: the partiality marker *for example* can occur in (1.72a) but not in (1.72b).

(1.72) a. Who is part of the students that formed the bassoon quintet, for example?
b. Which students formed the bassoon quintet, # for example?

The presence of *for example* indicates that the questioner is tolerant of a partial answer, or more precisely, a true proposition in the Hamlin set that is asymmetrically entailed by a max-informative

[17] These examples are taken from Schwarz (1994) and Williams (2000) and have been discussed by Lahiri (2002: 215). I thank Alexandre Cremers (pers. comm.) for bring these data to my attention.

true answer. (For example, a disjunctive partial answer or a negative partial answer is not tolerated.) Hence, it presupposes the existence of such answers, as schematized in (1.73). Accordingly, in case that a question can have only one true answer, the use of *for example* is infelicitous, as exemplified in (1.74).

(1.73) $[\![\text{Q, for example}]\!]^w$ is defined only if $\exists q[w \in q \in Q \wedge \exists p \in \textsc{Ans}_{Fox}(Q)(w)[p \subset q]]$.

(1.74) a. Which boy came, # for example?

b. Is it raining, # for example?

c. Which person or people x is such that only x came, # for example?

The oddness of using a partiality-marker in (1.72a) suggests that embedded question admits only a collective reading and hence can have only one true answer. By contrast, if the sub-distributive reading were available, the infelicity of (1.72b) would be mysterious.

Defining a question as a topical property, the proposed hybrid categorial approach can easily retrieve the short answers and derive the quantification domain for the matrix quantificational adverb. This quantification domain can be obtained based the atomic subparts of some max-informative true propositional answer, or those of some max-informative true short answer. Then, the QV inferences of (1.69) can be schematized as follows:

(1.75) $[\![\text{John mostly knows Q}]\!]^w = 1$ iff
$\exists f_{\text{CH}} \exists x \in \textsc{Ans}^S([\![\text{Q}]\!])(w)[\textsc{Most}\ y[y \in \textsc{At}(x)][\mathit{know}_w(j, \lambda w'.y \leq f_{\text{CH}}[\textsc{Ans}^S([\![\text{Q}]\!])(w')])]]$
(For some x that is a max-informative true short answer of Q, most y that are atomic parts of x are such that John knows that y is a part of some particular max-informative true short answer of Q.)

1.5.3. *Wh*-conditionals in Mandarin

A *wh*-conditional is a conditional made up of two *wh*-clauses. In syntax, the two *wh*-clauses use the very same *wh*-words or *wh*-phrases, as shown in (1.76a-b′). But, the *wh*-item can serve distinct syntactic roles in these two clauses. For example, in (1.76c), the *wh*-word *shei* 'who' serves as the object in the antecedent but the subject in the consequent.

(1.76) a. Shei xian dao, shei xian chi.
who first arrive, who first eat.
'whoever arrives first, he eats first.'

a′. * Shei xian dao, shei xian chi shenme.
who go where, who first eat what

b. Ni qu nar, wo qu nar.
you go where, I go where.

b′. * Shei qu nar, wo qu nar.
who go where, I go where
'Wherever you go, I will go there.'

c. Ni xuan shei, shei daomei.
you chose who, who unlucky
'Whomever you choose, he will be unlucky.'

In semantics, as seen above, a *wh*-conditional usually expresses a universal or exhaustive condition: every true short answer of the antecedent *wh*-clause is also a true short answer of the consequent *wh*-clause. But the exhaustive condition does not hold in the other direction: as shown in (1.77), it is possible that some true short answer of the consequent *wh*-clause is not a true short answer of the antecedent clause, (or equivalently, the exhaustive answer of the antecedent *wh*-clause is a non-exhaustive answer of the consequent one.)[18]

(1.77) Ni xiang jian shui, wo jiu yaoqing shui. Dan wo ye hui yaoqing qita-ren.
You want meet who, I JIU invite who. But I also will invite other-person
'Whomever you want to see, I will invite him. But I will also invite some other people.'

Interestingly, in analogous to an existential free relative, a *wh*-conditional admits an existential reading if the form of the antecedent *wh*-clause resembles a mention-some question (Liu 2016a), as exemplified in (1.78).

(1.78) Nar neng mai-dao jiu, wo jiu qu nar.
where can buy-reach liquor, I JIU go where
'Where I can buy liquor, I will go where.'
Intended: 'I will go to **some** place where I can buy liquor.'

Using the proposed hybrid categorial approach, we can treat the two *wh*-clauses as questions and define the semantics of a *wh*-conditional as a condition on the short answers of the two questions. The syntactic requirement that the two *wh*-clauses must use the same *wh*-items is ascribed to a presupposition that the topical properties denoted by the two *wh*-clauses have the same domain.

---

[18]Surprisingly, *wh*-conditionals involving degree questions seem to express bi-directional exhaustivity. The following example expresses a command that one should take exactly the amount of the food that he will eat.

(i) Chi duoshao, na duoshao.
eat how.much, take how.much
'How much [food] you will eat, how much [food] you take.' (Modified from Liu 2016a)

One way to account for this seeming bi-directional exhaustivity is to assume that the possible answers of a degree question (more precisely, the propositions in the Hamblin set of a degree question) are semantically independent. This assumption is supported by the infelicity of using a partiality-marker *for example* in a degree questions, as exemplified in the following:

(ii) a. How much food will you eat, # for example?
b. How fast did John run, # for example?

As discussed in (1.73), the presence of *for example* indicates that the questioner is tolerant of a partial answer, or more precisely, a true proposition in the Hamlin set that is asymmetrically entailed by a max-informative true answer. Hence, *for example* is defined iff such partial answers exist.

This assumption yields many other semantic predictions, and some inconsistency with current theories on negative island effects and modal obviation effects (Fox and Hackl 2007; Abrusán 2007; Abrusán and Spector 2011). I will keep this issue as an open question.

The truth conditions of *wh*-conditionals are thus schematized as follows uniformly, note that $[\![Q_1]\!]$ and $[\![Q_2]\!]$ are topical properties:[19]

(1.79) $[\![Q_1, Q_2]\!]^w = 1$ iff $\forall w'[\textsc{Acc}(w', w) \rightarrow \exists \alpha \in \textsc{Ans}^S([\![Q_1]\!])(w')[w' \in [\![Q_2]\!](\alpha)]]$;
defined only if $\mathrm{Dom}([\![Q_1]\!]) = \mathrm{Dom}([\![Q_2]\!])$
(Every accessible world w is such that some max-informative true$_w$ short answer of Q_1 is a true$_w$ short answer of Q_2; defined only if the topical properties denoted by Q_1 and Q_2 have the same domain.)

Whether a *wh*-conditional takes a universal reading or an existential reading depends on whether the set $\textsc{Ans}^S([\![Q_1]\!])(w)$ can ever be non-singleton, namely, whether the antecedent *wh*-clause Q_1 can have multiple max-informative true short answers. If Q_1 takes a mention-all reading, $\textsc{Ans}^S([\![Q_1]\!])(w)$ denotes a singleton set containing only the short mention-all answer of Q_1 in w, yielding a universal reading. For instance, in (1.76a), $\textsc{Ans}^S([\![Q_1]\!])(w)$ is the sum of all the individuals who arrive first in w; thus, (1.76a) means that in every accessible world w, the full group of individuals who arrive in w eat first in w. In contrast, if Q_1 takes a mention-some reading, $\textsc{Ans}^S([\![Q_1]\!])(w)$ can be a non-singleton set, each member of which is short mention-some answers of Q_1 in w. For instance, in (1.78), $\textsc{Ans}^S([\![Q_1]\!])(w)$ denotes a set of places where I can buy liquor; thus, the *wh*-conditional (1.78) means that in every accessible world w, there is a place such that I can get liquor from this place in w and I go to this place in w.

1.6. Live-on sets of *wh*-items

Recall that we treat a *wh*-item as an existential quantifier. Then, what is included in its quantification domain, or equivalently, its live-on set?[20] Under the traditional view, the live-on set of a *wh*-item is the set of individuals denoted by the *wh*-complement. Contra this view, however, I argue that the live-on set of a plural or number-neutral *wh*-item is *polymorphic*: it consists of not only individuals but also generalized disjunctions and conjunctions.

1.6.1. The traditional view

Under the traditional view, the live-on set of a *wh*-phrase is the set denoted by the extension of the *wh*-complement. For instance, *which boys*$_@$ lives on the set $^*\mathit{boy}_@$, namely, the set of individuals that are atomic or sum boys in the actual world. Since *wh*-items are existential indefinites, their live-on sets can be extracted via the Be-shifter (Partee 1986).

[19] We can also schematize the existential quantification force using a choice function. Then the truth condition would be schematized as follows:

(i) $[\![Q_1, Q_2]\!]^w = 1$ iff $\forall w'[\textsc{Acc}(w', w) \rightarrow \exists f_{\textsc{ch}}[[\![Q_2]\!](f_{\textsc{ch}}[\textsc{Ans}^S([\![Q_1]\!])(w')])(w') = 1]]$;
defined only if $\mathrm{Dom}([\![Q_1]\!]) = \mathrm{Dom}([\![Q_2]\!])$.

[20] Live-on sets of generalized quantifiers are defined as follow:

(i) **Live-on sets** (Barwise and Cooper 1981)
A generalized quantifier $\mathcal{P}$ lives on a set A iff for any set B: $B \in \mathcal{P} \Leftrightarrow B \cap A \in \mathcal{P}$.

(1.80) **The lexical entry of the *wh*-determiner** (The traditional view)

a. $[\![\text{wh-}]\!] = \lambda A \lambda B.\exists x \in [A \cap B]$

b. $\textsc{Be}([\![\text{which } A]\!]) = A$

Using the ontology of individuals from Sharvy (1980) and Link (1983), we analyze the denotations of singular and plural NPs as follows: a singular term denotes a set of atomic elements, while a plural term ranges over both atomic and sum elements. This idea is illustrated in Figure 1.3, where *abc* each denotes an atomic element.

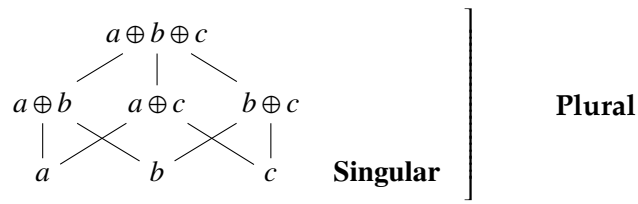


Figure 1.3: Ontology of individuals (Sharvy 1980, Link 1983)

Formally, the extension of a plural term is obtained by employing a star (*)-operator to the extension of the corresponding singular term. This *-operator closes the denotation of a singular term under sum operations.

(1.81) **The *-operator** (Link 1983)

$^*A = \{x : \exists A' \subseteq A[x = \bigoplus A']\}$

($^*A$ is the set that contains any sum of things taken from A.)

1.6.2. Disjunctions

Spector (2007, 2008) makes the first empirical argument for the existence of higher-order items in the live-on sets of *wh*-items. He observes that elided disjunctions can be used as complete answers of questions with universal modals (called "□-questions" henceforth), as exemplified in (1.82a), where the disjunction takes scope below the universal modal.

(1.82) Speaker A: "What does John have to read?"
Speaker B: "*Syntax* or *Morphology*."

a. √ 'John has to read S or M, and the choice is up to him.' (*have to* > *or*)

b. √ 'John has to read S or M, I don't know which exactly.' (*or* > *have to*)

To obtain the reading in (1.82a), where the elided disjunction takes scope below the □-modal, we must interpret the disjunction as a generalized quantifier, as defined in (1.83), and takes semantic reconstruction, as schematized in (1.84). Hence, Spector proposes that the *wh*-word *what* can quantify over generalized quantifiers.

(1.83) $[\![\textit{Syntax} \text{ or } \textit{Morphology}]\!] = s \bar{\vee} m = \lambda P_{\langle e,t \rangle}[P(s) \vee P(m)]$

(1.84) $[\![(1.82a)]\!] = (\lambda G_{\langle et,t \rangle}.\Box[G(\lambda x.\textsf{read}(j,x))])(s \bar{\vee} m)$
$= \Box[(s \bar{\vee} m)(\lambda x.\textsf{read}(j,x))]$
$= \Box[\textsf{read}(j,s) \vee \textsf{read}(j,m)]$

Furthermore, Fox (2013) observes that disjunctions cannot completely answer a singular □-question, as exemplified in (1.85). Using Spector's diagnostic, Fox conjectures that the live-on set of a singular *wh*-phrase like *which book* does not include generalized quantifiers.

(1.85) Speaker A: "Which book does John have to read?"
Speaker B: "*Syntax* or *Morphology*."
a. # 'John has to read S or M, and the choice is up to him.' (*have to* > *or*)
b. √ 'John has to read S or M, I don't know which exactly.' (*or* > *have to*)

1.6.3. Conjunctions

Spector (2007, 2008) and Fox (2013) have proposed to add conjunctions to the live-on sets of *wh*-items, but they have not discussed any independent evidence for this assumption. I argue for this assumption based on the fact that questions with certain collective predicates admit conjunctive answers.

First, observe in (1.86a) that the predicate *formed a team* supports only a collective reading, which is false in the given scenario.[21] In comparison, its plural counterpart *formed teams* supports a covered reading, as shown in (1.86b).

(1.86) (Context: *The kids* ***abcd*** *formed two teams in total:* ***ab*** *formed one, and* ***cd*** *formed one.*)
a. # The kids **formed a team**.
⇝ The kids all together formed one team. (collective)
b. √ The kids **formed teams**.
⇝ For some contextually determined cover of the kids, the individuals in each cover member formed a team. (covered)

Next, compare the sentences in (1.87) based on the same discourse: (1.87a) suffers presupposition failure, because the factive verb *know* embeds a false collective statement; but (1.87b), where *know* embeds an interrogative counterpart of the collective declarative, does not suffer presupposition failure. Moreover, intuitively, (1.87b) expresses that John knows the component members of all the teams formed by the considered kids, which is a conjunctive inference.

(1.87) a. # John knows [that **the kids** formed a team].
b. √ John knows [**which kids** formed a team].
⇝ John knows that *ab* formed a team and *cd* formed a team.

Where does the conjunctive closure come from? Clearly, regardless of how we analyze collectivity, this conjunctive closure cannot come from the collective predicate *formed a team* or anywhere within the question nucleus, otherwise the embedded clause in (1.87a) would admit a covered reading and be felicitous. I argue that this conjunctive closure is provided by the *wh*-phrase: the live-on set of *which kids* includes also generalized conjunctions like $a \oplus b \barwedge c \oplus d$, which yields a conjunctive possible answer, as in (1.89).

[21] This observation challenges the generalization by Schwarzschild (1996) that every predicate admits a covered reading. Surprisingly, very few predicates, perhaps only those expressing the formation of a single group (e.g., *forming a team/group/pair/committee*) behave in this way.

(1.88) $[\![ab \text{ and } cd]\!] = a \oplus b \bar{\wedge} c \oplus d = \lambda P_{\langle e,t\rangle}[P(a \oplus b) \wedge P(c \oplus d)]$

(1.89) $(\lambda G_{\langle et,t\rangle}.G(\lambda x.\mathsf{f.a.team}(x)))(a \oplus b \bar{\wedge} c \oplus d) = \mathsf{f.a.team}'(a \oplus b) \wedge \mathsf{f.a.team}(c \oplus d)$

In analogous to the case of generalized disjunctions, generalized conjunctions are not included in the live-on set of a *wh*-phrase that takes a singular or numeral-modified NP-complement (e.g., *which kid*, *which two kids*). In the following (b) utterances, the elided conjunctive questions are not proper specifications of the preceding *wh*-question, because these conjunctions are not in the live-on sets of the *wh*-phrases in the preceding questions.

(1.90) a. 'Which boy came? John?'
b. 'Which boy came? # John and Bill?'

(1.91) a. 'Which two boys formed a team? This two guys?'
b. 'Which two boys formed a team? # This two guys and that two guys?'

One might suggest to ascribe the conjunctive closure to the $\bigcap$-closure in Heim's (1994) answerhood-operator, which returns the conjunction of all the true answers, as in (1.92).

(1.92) $\bigcap\{\mathsf{f.a.team}(a \oplus b), \mathsf{f.a.team}(c \oplus d)\} = \mathsf{f.a.team}(a \oplus b) \wedge \mathsf{f.a.team}(c \oplus d)$

Nevertheless, this approach cannot capture the contrast in (1.93): in (1.93b), the embedded question has a numeral-modified *wh*-phrase and presupposes a uniqueness inference, which however is false in the given discourse.

(1.93) (Context: *The kids* **abcd** *formed two teams in total:* **ab** *formed one, and* **cd** *formed one.*)
a. √ John knows [**which kids** formed a team].
b. # John knows [**which two kids** formed a team].
⇝ Exactly two of the kids formed a team.

This uniqueness presupposition is standardly explained by "Dayal's presupposition" (Dayal 1996): a question is defined only if it has a strongest true answer, namely, the unique true answer that entails all the true answers.[22] With Dayal's presupposition, the proposed lexical difference between *which kids* and *which two kids* captures the contrast in (1.93): the live-on set of *which kids* includes generalized conjunctions and hence the embedded question in (1.93a) has conjunctive answers as possible answers. In the given scenario, the conjunction $a \oplus b \bar{\wedge} c \oplus d$ yields the strongest true answer. In contrast, the live-on set of *which two kids* consists of only sums of some two kids, and hence the embedded question in (1.93b) has two true answers, namely, $\mathsf{f.a.team}(a \oplus b)$ and $\mathsf{f.a.team}(c \oplus d)$, none of which counts as the strongest true answer. In sum, (1.93b) is infelicitous because the embedded question does not satisfy Dayal's presupposition, and this presupposition failure is inherited by the factive *know*.

[22] Dayal's presupposition is too strong to rule in mention-some readings of questions (see §2.5.1). Hence in chapter 3, I weaken Dayal's presupposition with a repair strategy using internal lifting operations. This repair strategy preserves all the advantages of Dayal's presupposition in predicting uniqueness.

1.6.4. Analysis

Given that higher-order answers like generalized quantifiers are only available in questions with number-neutral or plural *wh*-items, we conclude that the live-on set of a *wh*-item includes higher-order elements iff the set denoted by its *wh*-complement is closed under sum. To capture this generalization formally, I propose that the lexical entry of a *wh*-determiner contains a *dagger* (†-)*closure*. It closes a set under generalized conjunction and disjunction iff this set itself is closed under mereological sum, as schematized in (1.95).[23]

(1.94) **Lexicon of the *wh*-determiner**

a. $[\![\text{wh-}]\!] = \lambda A \lambda B.\exists \alpha \in [\dagger A \cap B]$

b. $\textsc{Be}([\![\text{which } A]\!]) = \dagger A$

(1.95) **The †-operator**

$$\dagger A = \begin{cases} \textsc{min}\{\alpha : A \subseteq \alpha \wedge \forall \beta \neq \varnothing[\beta \subseteq \alpha \rightarrow \bar{\bigvee}\beta \in \alpha \wedge \bar{\bigwedge}\beta \in \alpha]\} & \text{if } {}^*A = A \\ A & \text{otherwise} \end{cases}$$

(if a set A is closed under sum, then $\dagger A$ is the minimal superset of A that is closed under generalized conjunction and disjunction; other wise $\dagger A = A$.)

Generalized conjunction and disjunction are defined cross-categorically as in (1.96). (See also (1.19)/(1.20) and (1.50)/(1.51) for comparisons with *meet* and *join*.)

(1.96) **Generalized conjunctions and disjunctions**

a. For any two items a and b (of the same or distinct semantic types)

$a \bar{\wedge} b = \lambda P[P(a) \wedge P(b)]$

$a \bar{\vee} b = \lambda P[P(a) \vee P(b)]$

b. For any non-empty set α:

$\bar{\bigwedge}\alpha = \lambda P.\forall x \in \alpha[P(x)]$

$\bar{\bigvee}\alpha = \lambda P.\exists x \in \alpha[P(x)]$

Adding a †-closure to the lexicon of the *wh*-determiner predicts the desired live-on sets for *wh*-items. Singular *wh*-phrases and numeral-modified *wh*-phrases live on sets consisting of only individuals, as exemplified in (1.97a) and (1.97b), respectively. While bare *wh*-words and plural

[23] The following two definitions of the star (*-)operator are equivalent. The definition (1.95) is analogous to (ib).

(i) a. ${}^*A = \{x : \exists A' \subseteq A[x = \bigoplus A']\}$ (Link 1983)

b. ${}^*A = \textsc{min}\{\alpha : A \subseteq \alpha \wedge \forall \beta \neq \varnothing[\beta \subseteq \alpha \rightarrow \bigoplus \beta \in \alpha]\}$

We are not able to define the †-operator in a way analogous to (ia). The following definition is inadequate:

(ii) $$\dagger A = \begin{cases} \{x : \exists A' \subseteq A[[x = \bar{\bigwedge}A'] \vee [x = \bar{\bigvee}A']]\} & \text{if } {}^*A = A \\ A & \text{otherwise} \end{cases}$$

For instance, let $A = \{a, b, a \oplus b\}$ where a and b are individuals of type e, then the set $\dagger A$ obtained based on definition (ii) includes basic generalized disjunctions and conjunctions of type $\langle et, t\rangle$ (e.g., $a \bar{\vee} b$, $a \bar{\wedge} b$), but not the ones like $(a \bar{\vee} b) \bar{\wedge} b$ and $(a \bar{\wedge} b) \bar{\vee} (a \bar{\wedge} a \oplus b)$.

wh-phrases lives on sets consisting of not only individuals but also generalized conjunctions and disjunctions over individuals, as exemplified in (1.97c).

(1.97) a. $\textsc{Be}(\llbracket \text{which person} \rrbracket) = \left\{ \; a, b, \ldots \; \right\}$

b. $\textsc{Be}(\llbracket \text{which two people} \rrbracket) = \left\{ \; a \oplus b, b \oplus c, \ldots \; \right\}$

c. $\textsc{Be}(\llbracket \text{who} \rrbracket) = \textsc{Be}(\llbracket \text{which people} \rrbracket) = \left\{ \begin{array}{l} a, b, \ldots, a \oplus b, \ldots \\ a \bar{\wedge} b, a \bar{\vee} b, a \bar{\wedge} a \oplus b, \ldots \\ (a \bar{\wedge} b) \bar{\vee} (a \bar{\wedge} a \oplus b), \ldots \end{array} \right\}$

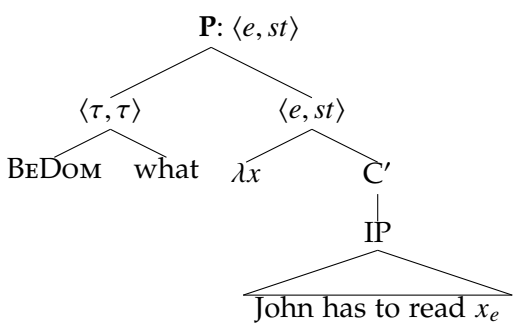
If the live-on set of a *wh*-item have items of different types, the semantic type of the highest *wh*-trace determines the semantic type of the topical property. This is so because the input and output of $\textsc{BeDom}(wh\text{P})$ are always of the same type. Consider the $\Box$-question (1.98) for a simple illustration. This question, as Spector (2007, 2008) observes, is ambiguous between an *individual reading* (1.98a) and a *higher-order reading* (1.98b). Using the proposed analysis, we can reduce this ambiguity to a structural ambiguity within the question nucleus, namely, whether or not the *wh*-word takes an IP-internal QR before *wh*-movement.[24]

(1.98) What does John have to read?

a. **Individual reading**

'What is a thing x such that John has to read x?'

$\mathbf{P} = \lambda x[x \in D_e \wedge \dagger\, {}^*\mathit{thing}_{@}(x) = 1.\hat{}\Box \mathit{read}(j, x)]$



b. **Higher-order reading**

'What is a GQ π over things such that John has to read π?'

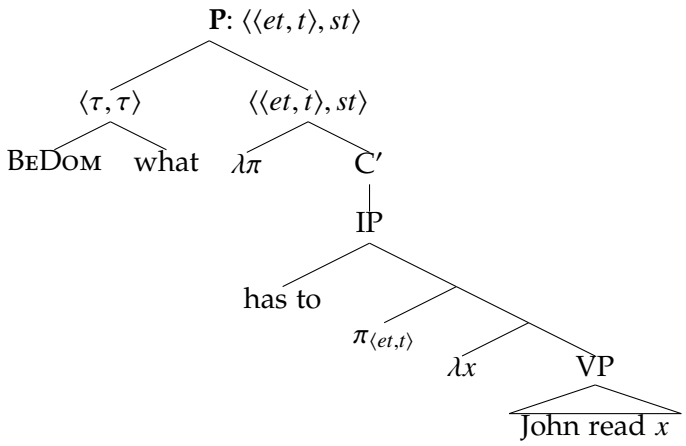
$\mathbf{P} = \lambda\pi[\pi \in D_{\langle et,t\rangle} \wedge \dagger\, {}^*\mathit{thing}_{@}(\pi) = 1.\hat{}\Box\pi(\lambda x.\mathit{read}(j, x))]$

[24] Spector (2007) uses a different way to capture the two distinct readings. He proposes that the *wh*-word *what* is lexically ambiguous: it can live on either a set of individuals or a set of increasing generalized quantifiers, as schematized in (ia) and (ib), respectively.

(i) a. $\llbracket \mathit{what}_i\ \mathrm{S} \rrbracket = \lambda p.\exists x_e[x \in {}^*\mathit{thing} \wedge p = \llbracket \mathrm{S} \rrbracket^{i \to x}]$

b. $\llbracket \mathit{what}_G\ \mathrm{S} \rrbracket = \lambda p.\exists X_{\langle et,t\rangle}[X$ is increasing and its smallest live-on set belongs to ${}^*\mathit{thing} \wedge p = \llbracket \mathrm{S} \rrbracket^{G \to X}]$

In comparison, the proposed analysis poses no lexical ambiguity in *what*, but instead attributes the ambiguity to a structural ambiguity within the question nucleus.



If the phrase 'BeDom(what)' moves directly to [Spec, $CP_{[+wh]}$] from its base position, as in (1.98a), then it has only one *wh*-trace which is of type e, and hence the topical property is only defined for elements of type e. Alternatively, if 'BeDom(what)' takes an IP-internal QR (from x to π) before reaching [Spec, $CP_{[+wh]}$], it leaves a higher-order trace of type $\langle et, t\rangle$, and thus the topical property is a property of generalized quantifiers of type $\langle et, t\rangle$.

Following Cresti (1995) and Rullmann (1995), we can say that the derivation of a higher-order reading involves semantic reconstruction:

(1.99) **Semantic reconstruction of *wh*-phrases**
The movement of the *wh*-phrase creates an individual trace x (of type e) and a higher-order trace π (of type $\langle et, t\rangle$), and then the compositional interpretation assigns the *wh*-phrase the logical scope corresponding to the site of π, yielding a reconstructed reading.

It remains open whether a †-closure is also involved in the lexical entry of the determiner *some*. The sentence (1.100) is true under the discourse that John's only reading obligation is '*Syntax* or *Morphology*.' If the live-on set of *some books* consists of only individual books, the desired interpretation would be obtained by interpreting *some books* below the necessity modal, as in (1.100a). If the live-on set of *some books* is the same as that of *which books*, we would also have the option of interpreting *some books* with a wide scope, as in (1.100b). So far, I see no reason to rule out any of these options.

(1.100) John has to read some books.

a. $\Box\exists x_e[{}^*\mathit{book}(x) \wedge \mathit{read}(j, x)]$

b. $\exists\pi_{\langle et,t\rangle}[\dagger\, {}^*\mathit{book}(\pi) \wedge \Box\pi(\lambda x.\mathit{read}(j, x))]$

1.7. Summary

Chapter 1 started with the goal of predicting Caponigro's Generalization. Caponigro (2003, 2004) observes that, cross-linguistically, any *wh*-word that can be used in a *wh*-free relative can also be used in a *wh*-question, but not the other direction. This generalization suggests that, most likely, free relatives are derived out of questions. This conjecture leaves lambda abstracts the only possible

denotations of questions. Hence, I proposed a hybrid categorial approach to compose question semantics.

The proposed hybrid categorial approach achieves the advantages of traditional categorial approaches but also overcomes their deficiencies. On the one hand, similar to traditional categorial approaches, the proposed approach defines question roots as topical properties, so that short answers and free relatives can be grammatically derived from question roots. On the other hand, the proposed approach makes the following improvements over traditional categorial approaches. First, like Karttunen (1977), it treats *wh*-items as existential indefinites, which captures the cross-linguistic existential semantics of *wh*-items. The key technique for composing topical properties is a two-place operator BeDom, which shifts a *wh*-item into a domain restrictor. Second, the domain restrictor BeDom(*wh*P) is type-flexible, and hence it never suffers type-mismatch. Third, in analyzing question coordinations, I proposed to treat question coordinations as generalized quantifiers, which may conjoin or disjoin items of different semantic types.

The idea of deriving propositional answer sets out of abstracts has already been explored in Partition Semantics and other recent works (George 2011, Champollion et al. 2015, among others). But different from these approaches, the proposed approach makes answerhood-operators be applied directly to topical properties, returning complete true answers. As I will show in chapter 3, this characteristic is crucial for predicting uniqueness effects. Moreover, in the proposed approach, the shifting operations from lambda abstracts to propositional answer sets are semantically active but are not syntactically present in the LF; in other words, the question denotation is just a topical property, and there is no node at the LF of a question that creates a partition or a Hamblin set. This treatment ensures *wh*-questions to be sub-constituents of *wh*-free relatives, which therefore captures Caponigro's Generalization.

Moreover, based on empirical evidence from □-questions and question with collective predicates, I showed that the live-on set of a plural and number-neutral *wh*-item is polymorphic: it consists of not only individuals but also generalized conjunctions and disjunctions. To capture this observation, I added a †-closure to the lexical entry of the *wh*-determiner. This closure closes a set under conjunction and disjunction iff this set itself is closed under sum.

The remaining chapters use the hybrid categorial approach of question semantics as a canvas. But the core ideas, except the one on the dilemma between uniqueness and mention-some (chap. 3) and the one for deriving QV effects in pair-list readings (§5.4.4), also apply to other frameworks of questions semantics (e.g., Hamblin-Karttunen Semantics, Inquisitive Semantics).

Chapter 2

Mention-some questions

2.1. Introduction

This chapter is centered on the interpretations of *wh*-questions like (2.1), which contains an existential priority modal.[25] I call *wh*-questions of this form "$\diamond$-questions."

(2.1) Who can chair the committee?

What makes $\diamond$-questions special and puzzling is that they admit mention-some answers (Groenendijk and Stokhof 1984). For example, the $\diamond$-question (2.1) can be properly answered by naming one of the qualified chair candidates. Therefore, we say that (2.1) can take a mention-some reading and call it a "mention-some question." Moreover, (2.1) admits also mention-all answers, meaning it can be answered by specifying all the qualified chair candidates, and hence we say that its interpretation involves a mention-some/mention-all ambiguity.

In most earlier works, mention-some readings were treated pragmatically and were not distinguished from partial readings, such as the one in (2.2).

(2.2) Who came, for example?

Nevertheless, I show that mention-some readings behave differently from other non-exhaustive readings (such as partial readings and choice readings) in many respects. For instance, unlike a partial answer, a mention-some answer takes a particular form of non-exhaustivity: it specifies exactly one of the possible choices. To this extend, mention-some readings are exclusive to $\diamond$-questions. Hence, we must pursue a structural approach to predict the limited distribution of mention-some readings and explain the mention-some/mention-all ambiguity.

The proposed analysis of mention-some and conjunctive mention-all readings succeeds and refines the proposal by Fox (2013). Moreover, I present a simple way to derive disjunctive mention-all readings, based by observations with the Mandarin particle *dou*: *dou* behaves as an exhaustivity-marker in $\diamond$-questions and triggers universal free choice inferences in disjunctive declaratives.

At the end of this chapter, I compare my O_{DOU}-operator (i.e., the covert counterpart of *dou*) with other two exhaustifiers that have been employed in deriving free choice inferences, including the

[25] Priority modals include bouletic, deontic, and teleological modals (Portner 2009).

recursive exhaustifier (Fox 2007), and the pre-exhaustification operator for domain alternatives (Chierchia 2006, 2013).

2.2. What is a mention-some reading?

Most *wh*-questions admit only exhaustive answers. For example, to properly answer (2.3), the addressee needs to specify all the actual attendants to the party, as in (2.3a). If the addressee does not have enough knowledge about this question and can only provide a non-exhaustive answer, he would have to flag the incompleteness of his answer in some way. For instance, he can mark his answer with a prosodic rise-fall-rise (RFR) contour, as in (2.3b). This RFR contour involves a rising accent on *John*, followed by a fall, and then a final rise at the end of the utterance (in the following indicated by '.../'). Given this difference, we call (2.3a) a "complete answer" while (2.3b) a "partial answer." If a partial answer is not properly marked, as in (2.3c) which takes a falling tone (in the following indicated by '\'), it gives rise to an undesired exhaustive inference.

(2.3) Who went to the party?
(Context: *only John and Mary went to the party.*)

a. John and Mary.

b. John did .../ $\rightsquigarrow$ *I don't know who else did.*
L H* L-H%

c. # John did.\ $\rightsquigarrow$ *Only John did.*
H* L-L%

In contrast, $\Diamond$-questions admit not only exhaustive answers but also non-exhaustive answers (Groenendijk and Stokhof 1984). For instance, (2.4) can be naturally answered by specifying one of the chair candidates, as in (2.4a). Crucially, while being non-exhaustive, the answer (2.4a) does not need to carry an ignorance mark: it does not yield an exhaustivity inference even if taking a falling tone. Moreover, an exhaustive answer of (2.4) can take either a conjunctive form as in (2.4b), or a disjunctive form as in (2.4c).[26]

(2.4) Who can chair the committee?
(Context: *only John and Mary can chair; single-chair only.*)

a. John can.\ $\not\rightsquigarrow$ *Only John can chair.*

b. John and Mary.\

c. John or Mary.\

Since it remains controversial whether (2.4c) is complete or partial, we tag the answers in (2.4a-c) with respect to a different dimension. (2.4a) is a *mention-some answer*, since it specifies only some

[26]Notice that in (2.4) only an elided disjunctive answer can take an exhaustive reading. For example, the following full disjunctive answer takes only a partial reading.

(i) Q: "Who can chair the committee?"
A: "John or Mary can chair the committee." $\rightsquigarrow$ *Either John or Mary can chair, but I don't know which.*

In contrast, (2.4c) is an argument of the topical property of the given question, and its scope is determined by the topical property (see §2.6.3).

chair candidate; while (2.4b-c) are *mention-all answers*, since they specify all of the chair candidates. Questions admitting and rejecting mention-some answers are called *mention-some questions* and *mention-all questions*, respectively. The readings under which a question admits mention-some answers are called *mention-some readings*.

In addition to matrix questions, indirect questions and other *wh*-constructions (e.g., free relatives, antecedents of *wh*-conditionals in Mandarin) exhibit the same distributional pattern of mention-some: mention-some/existential reading is available iff the form of the *wh*-construction resembles a $\Diamond$-question.

(2.5) **Indirect questions**

a. Jack knows who arrived.
$\rightsquigarrow$ *For **every** individual x, if x arrived, Jack knows that x arrived.*

b. Jack knows who can chair the committee.
$\rightsquigarrow$ *For **some** individual x such that x can chair the committee, Jack knows that x can chair the committee.*

(2.6) **Free relatives**

a. John ate what Mary cooked for him.
$\rightsquigarrow$ *John ate **everything** that Mary cooked for him.*

b. John went to where he could get help.
$\rightsquigarrow$ *John went to **some** place where he could get help.*

(2.7) **Mandarin *wh*-conditionals**

a. Ni qu-guo nar, wo jiu qu nar.
you go-EXP where, I JIU go where
'Where you have been to, I will go where.'
Intended: 'I will go to **every** place where you have been to.'

b. Nar neng mai-dao jiu, wo jiu qu nar.
where can buy-reach liquor, I JIU go where
'Where I can buy liquor, I will go where.'
Intended: 'I will go to **some** place where I can buy liquor.'

Moreover, this distributional pattern of mention-some is also observed with *question-answer* (*QA-*)*clauses* in American Sign Language (ASL) (Caponigro and Davidson 2011, Davidson et al. 2008). A QA-clause is uttered by a single signer. It consists of two parts, namely, a question constituent which looks like an interrogative clause conveying a question, and an answer constituent which resembles a propositional answer or a short answer to that question. As shown below, just like their corresponding discourse-level question-answer pairs in (a), the answer constituent of each QA-clause in (b) resembles a mention-some answer iff the question constituent resembles a $\Diamond$-question.

(2.8) (Context: *John bought a book, a CD, and a DVD.*)

a. Signer A: JOHN BUY WHAT?
'John bought what?'
Signer B: #BOOK.
'Book.'

b. JOHN BUY WHAT, # BOOK.
'What John bought is a book.'

(2.9) (Context: *There are two coffee places nearby, Starbucks and Peet's.*)

a. Signer A: CAN FIND COFFEE WHERE?
'Where can you find coffee?'
Signer B: STARBUCKS.
'Starbucks.'

b. CAN FIND COFFEE WHERE, STARBUCKS.
'You can find coffee at Starbucks.'

It is important to notice that the form of non-exhaustivity in mention-some readings of $\diamond$-questions is quite unique: a mention-some answer specifies exactly one of the possible options. Hence, it is more precise to call mention-some "mention-one." In replying to a $\diamond$-question, if an answer provides multiple choices and is not ignorance-marked, it will be interpreted exhaustively, as shown in (2.10b). Moreover, the embedded $\diamond$-question in (2.11) admits a "mention-one" reading (2.11b) but not a "mention-three" reading (2.11c). This characteristic challenges the pragmatic analysis of mention-some. I will return to this point in section 2.4.1.

(2.10) Who can chair the committee?

a. Andy.\ $\not\rightsquigarrow$ *Only John can chair.*

b. Andy and Billy.\ $\rightsquigarrow$ *Only John and Billy can chair.*

(2.11) John knows who can chair the committee.

a. 'For **some** individual x such that x can chair, John knows that x can chair.' (OK)

b. 'For **every** individual x, if x can chair, John knows that x can chair.' (OK)

c. 'For **some three** individuals xyz such that xyz each can chair, John knows that xyz each can chair.' (#)

The mention-some reading of a $\diamond$-question can be blocked under three conditions. First, it is blocked if the conversational goal explicitly or implicitly requests an exhaustive answer. For instance, in (2.12), the chair of the job search committee expected the assistant to list all the candidates who can teach Experimental Semantics; hence an answer without an ignorance mark would be understood exhaustively.

(2.12) (Context: *In making the final decision of a job search, the committee decided to consider only candidates who can teach Experimental Semantics or Field Methods.*)
Chair: "Who can teach Experimental Semantics?"
Assistant: "John can.\"
$\rightsquigarrow$ *Among the candidates, only John can teach Experimental Semantics.*

Second, mention-some is blocked when an *exhaustivity marker* appears above the existential modal. Exhaustivity markers are found cross-linguistically, such as English *all* in a variety of dialects, German particle *alles* (and variants like *überall*), and Mandarin particle *dou*.[27] For instance, the

[27] I thank Christopher Davis and Robert Henderson for data in Texan English, and Manuel Križ for data in German.

following (a) questions each demands an exhaustive list of individuals who can teach Introduction to Linguistics, and the following (b) questions each requests an exhaustive list of coffee places in the surroundings.

(2.13) English *all* (Texan English)

a. Who **all** can teach Introduction to Linguistics?

b. Where **all** can we get coffee around here?

(2.14) German *alles*

a. Wer kann **alles** Einführung in die Sprachwissenschaft unterrichten?
who can all introduction into the linguistics teach
'Who all can teach Introduction to Linguistics?'

b. Wo kann ich hier **überall** Kaffee bekommen?
where can I here everywhere coffee get
'Where all can we get coffee around here?'

(2.15) Mandarin *dou*

a. **Dou** shui keyi jiao yuyanxue jichu?
DOU who can teach linguistics introduction
'Who all can teach Introduction to Linguistics?'

b. Zai fujin women **dou** keyi zai nali mai dao kafei?
at near we DOU can at where buy get coffee
'Where all can we get coffee around here?'

Third, mention-some readings are blocked if the *wh*-item takes a singular or numeral-modified *wh*-complement. For instance, the questions in (2.16) each can have only one true answer, and therefore there is no room for mention-some. I will discuss these uniqueness effects and their interactions with mention-some in chapter 3.

(2.16) a. Which candidate can teach Morphology?
$\rightsquigarrow$ *Only one of the candidates can teach Morphology.*

b. Which two candidates can teach Morphology?
$\rightsquigarrow$ *Only two of the candidates can teach Morphology.*

To sum up, mention-some readings of questions have three characteristics. First, they are systematically available not only in matrix questions but also in other embedded *wh*-constructions such as indirect questions, free relatives, Mandarin *wh*-conditional, and QA-clauses in ASL. Second, they express a particular form of non-exhaustivity: a mention-some answer specifies exactly one of the possible choices. Third, they can be blocked by exhaustive conversational goals and grammatical factors, such as the presence of exhaustivity-markers and uniqueness effects of singular or numeral-modified *wh*-items.

2.3. What is not a mention-some reading?

In addition to $\Diamond$-questions, questions with a partiality-marker (e.g., *for example*, *for instance*) (called "EX-questions" henceforth) and questions with an existentially quantificational expression (called

"∃-questions" henceforth) also admit non-exhaustive readings. For instance, the EX-question (2.17) only requests to name some of the party attendants; the ∃-question (2.18) demands just a list of individuals that were voted for by some particular professor.

(2.17) Who came to the party, **for example**? EX-question

(2.18) Who did **one of the professors** vote for? ∃-question

Nevertheless, the non-exhaustive readings of EX-questions and ∃-questions differ from mention-some readings of ◇-questions in many respects. Hence, I do not consider them as mention-some readings, but instead "partial readings" and "choice readings," respectively.

2.3.1. Ex-questions with partial readings

Unlike ◇-questions, EX-questions can rarely occur in embeddings. In (2.19), presence of the partiality-marker *for example* makes these sentences ungrammatical.[28]

(2.19) a. John knows who (*for example) came to the party.
b. John ate what (*for example) Mary bought.

Therefore, it is more appropriate to treat *for example* as a discourse expression outside the root denotation: it signals that the questioner is tolerant of partial answers (or more precisely, a true proposition in the Hamlin set that is asymmetrically entailed by a max-informative true answer). See also (1.73) in section 1.5.2.

Moreover, the partial reading of an EX-question and the mention-some reading of a ◇-question involve different forms of non-exhaustivity. As discussed in section 2.2, mention-some readings rule in only non-exhaustive answers that specify exactly one of the available choices, which we call "mention-one answers." In contrast, partial readings admit any non-exhaustive answer. For example, in replying to the EX-question (2.20), the addressee is free to name any number of attendants: (2.20a) names one attendant while (2.20b) names two. Moreover, in replying to (2.20), regardless of how many attendants an answer specifies, this answer does not give rise to an exclusive inference.

(2.20) Who went to the party, for example?
a. John.\ $\not\rightsquigarrow$ *Only John did.*
b. John and Mary.\ $\not\rightsquigarrow$ *Only John and Mary did.*

[28] Beck and Rullmann (1999) find out that some partiality-markers, such as Dutch *zoal* and German *so*, are acceptable in embeddings, as exemplified below.

(i) Jan wil weten wie er **zoal** (niet) op het feest waren.
Jan wants know who there ZOAL (not) at the party were
'John wants to know who for example were (not) at the party'

(ii) Hans will wissen, wer **so** (?nicht) auf dem Fest war.
Hans wants know who SO (not) at the party was
'John wants to know who for example were (not) at the party'

Nevertheless, embedded questions with *zoal* or *so* are acceptable only in rogative environments.

2.3.2. ∃-questions with choice readings

There are, quite generally, two paths to the non-exhaustive readings of ∃-questions. One path is to treat them as mention-some reading, derived in the same way as the mention-some readings of ◇-questions (George 2011, Fox 2013). This path is motivated by the fact that ◇-questions and ∃-questions both contain expressions of existential quantification force, namely, existential modals and existential generalized quantifiers, respectively. The other path, which I will pursue in chapter 6, is to treat them as choice readings (Groenendijk and Stokhof 1984), on a par with the pair-list readings of questions with universal quantifiers (abbreviated as "∀-questions" henceforth). The following discusses two empirical facts in favor of the choice reading analysis.

On the one hand, unlike mention-some readings of ◇-questions, choice readings of ∃-questions are not blocked by the presence of an exhaustivity-marker or the uniqueness effect of a singular *wh*-phrase, as shown in (2.21a-b). In (2.21a), the presence of *all* marks local exhaustivity, which demands the addressee to provide an exhaustive list of candidates that **one** particular student voted for. Likewise, in (2.21b), the uniqueness inference triggered by the singular *wh*-phrase is assessed beneath the existential quantifier (Fox 2013); it does not imply that only one of the candidates got votes from the students, but instead that one of the students voted for only one of the candidates. In contrast, in the ◇-question (2.22), exhaustivity and uniqueness take effects above the existential modal and therefore block mention-some.

(2.21) **∃-questions**

a. Who all did one of the students vote for? (∃ > *all*)
   ⇝ *As for one of the students, who are all the individuals that he voted for?*

b. Which candidate did one of the students vote for? (∃ > ι)
   ⇝ *As for one of students, who is the unique person that he voted for?*

(2.22) **◇-questions**

a. Who all can teach Introductory Chinese? (*all* > ◇)
   ⇝ *Who are all the individuals that can teach Introductory Chinese?*

b. Which person can teach Introductory Chinese? (ι > ◇)
   ⇝ *Who is the unique person that can teach Introductory Chinese?*

On the other hand, choice readings of ∃-questions and pair-list readings of ∀-questions have similar distributions. Both readings exhibit a subject-object/adjunct asymmetry (Chierchia 1993, 1991): they are more likely to be available when the quantifier serves as the subject and c-commands the *wh*-trace at the object or an adjunct position. For instance, the examples in (2.23a) illustrate the subject-object asymmetry in choice readings: (2.23a-i) accepts a choice reading, and here the existential quantifier *one of the students* serves as the subject, c-commanding the object *wh*-trace; while (2.23a-ii) can hardly get choice readings, and here the *wh*-phrase is moved from the subject position. The subject-adjunct asymmetry is analogous, as shown in (2.23b) and (2.24b).

(2.23) **Choice readings of ∃-questions**

a. Subject-Object

   i. Which candidate did [one of the students] vote for? √ choice

ii. Which person voted for [one of the students]? ?choice

b. Subject-Adjunct

i. At which station did [one of the guests] get gas? √ choice

ii. Which guest got gas at [one of the nearby stations]? ?choice

(2.24) **Pair-list readings of ∀-questions**

a. Subject-Object

i. Which candidate did everyone vote for? √ pair-list

ii. Which voter voted for every candidate? × pair-list

b. Subject-Adjunct

i. At which station did every guest get gas? √ pair-list

ii. Which guest got gas from every gas station? × pair-list

2.4. Earlier approaches of mention-some

The availability of mention-some in ◇-questions challenges the traditional view that questions admit only exhaustive answers. Before getting into the details, we need to first figure out two basic issues, namely, whether mention-some is semantically licensed, and whether the distribution of mention-some is grammatically constrained. I classify the previous approaches into the following three lines, based on views and predictions they make on these two issues:

The pragmatic line: Complete answers must be exhaustive. Mention-some answers are partial answers that are sufficient for the conversational goal behind the question. (Groenendijk and Stokhof 1984, Van Rooy 2004, among others)

The post-structural line: Mention-some reading is semantically licensed. The distribution of mention-some is mainly restricted by pragmatic factors. Mention-some and mention-all are two independent readings derived via different operations outside the question nucleus. (Beck and Rullmann 1999, George 2011: chap. 2)

The structural line: The mention-some/mention-all ambiguity is a result of a structural variation within the question nucleus. (George 2011: chap. 6, Fox 2013)

	Pragmatic	*Post-structural*	*Structural*
Mention-some is semantically licensed	No	Yes	Yes
Mention-some is grammatically restricted	No	No	Yes

Table 2.1: Summary of current lines of approaches on mention-some

This section reviews the pragmatic line and the post-structural line. Both lines face the problem that they can only restrict the distribution of mention-some by pragmatic factors, which are not restrictive enough.

2.4.1. The pragmatic line

Most works on questions consider only exhaustive answers as complete answers. Since mention-some answers are non-exhaustive, works holding this view attribute the acceptability of mention-some to pragmatic factors, such as the conversational goal of the question. Consider (2.25) for instance. If the goal is just to get some gas, the addressee only needs to name one accessible gas station; if the goal is to investigate the local gas market, the addressee needs to list all the local gas stations.

(2.25) Where can I get gas?

This pragmatic treatment of mention-some was initiated by Groenendijk and Stokhof (1984) and remained popular under various frameworks of questions. Van Rooy (2004) develops a theory of *utility* which gives a formal characterization for the circumstances where mention-some is accepted and preferred.

A commonly seen criticism to the pragmatic view, pointed out by Groenendijk and Stokhof (1984) themselves and reiterated by George (2011), is that pragmatics cannot predict the availability of mention-some in embeddings. As seen in section 2.2, mention-some is available not only in root questions, but also in indirect questions, free relatives, and QA-clauses. In responding to this concern, Ginzburg (1995), Lahiri (2002), and Van Rooij and Schulz (2004) build contextual parameters into question denotations and encode sensitivity to the question goals. For instance, Lahiri (2002) proposes that interpreting an indirect question involves picking a sub-question, and that the size of the selected sub-question, compared with the size of the full question, needs to be large enough for the speaker's purpose.

I do not object to the existence of contextual parameters in question interpretations. I also agree that pragmatics plays a role in distributing mention-some in several respects; for instance, if a question is semantically ambiguous between mention-some and mention-all, a conversational goal that calls for an exhaustive answer can block mention-some. Nevertheless, I doubt that pragmatics is restrictive enough to predict the very limited and systematic distribution of mention-some: mention-some is only available in $\diamond$-questions.

Below, I provide two additional empirical arguments against the pragmatic treatment of mention-some. Both arguments are related to what I call *mention-intermediate answers*. These answers are, as the name implies, non-exhaustive answers that are stronger than mention-some answers. I show that the pragmatic view cannot capture the differences between mention-some and mention-intermediate: contrary to the case of mention-some, mention-intermediate is unacceptable in root questions and embedded questions.

First, in answering a mention-some question, mention-intermediate answers, while being informative enough for the question goal, must be ignorance-marked. For instance, assume that the goal of asking (2.26) is to find a qualified person to chair the committee. Under a discourse where three individuals are qualified, a mention-some answer names one of the candidates, as in (2.26a), while a mention-intermediate answer names two of the candidates, as in (2.26b-c). Crucially, while both mention-some and mention-intermediate answers are sufficient for the question goal, the mention-intermediate answers must to be ignorance-marked; otherwise they yield an undesired exhaustivity inference, as seen in (2.26b') and (2.26c').

(2.26) Who can chair the committee?
(Context: *only John, Mary, and Sue can chair; single-chair only.*)

a. John.\ $\not\rightsquigarrow$ *Only John can chair.*

b. John and Mary.../

b′ # John and Mary.\ $\rightsquigarrow$ *Only John and Mary can chair.*

c. John or Mary.../

c′ # John or Mary.\ $\rightsquigarrow$ *Only John and Mary can chair.*

The obligatory ignorance-marks on mention-intermediate answers suggest the following: in responding to a $\Diamond$-question, whether an answer can be interpreted inclusively is primarily determined by the grammatical structure of this answer, rather than the question goal. When taking a falling tone, simple individual answers like (2.26a) can be interpreted inclusively, while answers taking a conjunctive form or a disjunctive form like (2.26b-c) admit only exhaustive readings.

Second, interpretations of indirect questions show that good answers are always "mention one (group)" or "mention all (groups)," as exemplified in (2.27a)/(2.28a) and (2.27b)/(2.28b), respectively. The conversational goal of a question, however, can be any "mention N (groups)" where N is a number in the available range. For instance, assume that the dean wants to meet with three chair candidates so as to make plans for the committee, then the goal of the embedded question in (2.27) would be "mention three." A pragmatic account predicts (2.27) to take the mention-three reading (2.27c), which however is infeasible. A semantic account does not have this prediction: complete answers derived from the possible logical forms of a mention-some question are either mention-one or mention-all, not mention-intermediate.

(2.27) John knows who can chair the committee.

a. 'For **some** individual x such that x can chair, John knows that x can chair.' (OK)

b. 'For **every** individual x, if x can chair, John knows that x can chair.' (OK)

c. 'For **some three** individuals xyz such that xyz each can chair, John knows that xyz each can chair.' (#)

(2.28) John knows who can form the committee.

a. 'For **some** group of individuals X s.t. X together can form the committee, John knows that X together can form the committee.' (OK)

b. 'For **every** group of individuals X, if X together can form the committee, John knows that X together can form the committee.' (OK)

c. 'For **three** groups of individuals XYZ s.t. each group among XYZ can form the committee, John knows that each group among XYZ can form the committee.' (#)

2.4.2. The post-structural line

Another commonly seen line of approaches, which I call "the post-structural line," treats mention-some as an independent reading on a par with mention-all. Approaches following this line are sometimes referred to as "semantic approaches," to the extend that they acknowledge the existence of mention-some in semantics. But I call them "post-structural approaches" so as to distinguish

them from the structural approaches. Structural approaches attribute the mention-some/mention-all ambiguity to the structural ambiguity within the question nucleus, which is structurally contained within the root denotation; while post-structural approaches attribute this ambiguity to an operation outside the nucleus or even outside the root denotation.

The rest of this section briefly reviews two representative post-structural approaches, including Beck and Rullmann (1999) and George (2011: chap. 2). Beck & Rullmann attribute the mention-some/mention-all ambiguity of *wh*-questions to answerhood-operators with different quantificational force. While George's system has only one existential answerhood-operator, and it attributes the ambiguity to the optional presence of a strengthening operator within the root denotation.

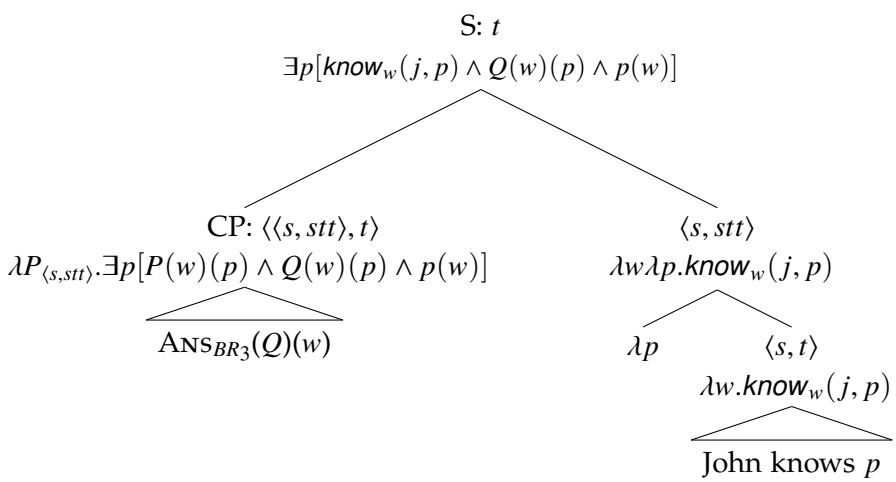
Beck and Rullmann (1999) assume that the root denotation of a question is the Hamblin-Karttunen intension (of type $\langle s, stt\rangle$), namely, a function that maps a world to the Karttunen set in this world (viz., the set of propositional answers that are true in this world). The root denotation Q can be operated by different answerhood-operators, yielding different readings. Employing $\textsc{Ans}_{BR_1}$ returns the conjunction of all the true propositional answers, yielding a mention-all answer. While employing the higher-order $\textsc{Ans}_{BR_3}$-operator shifts the root denotation into an existential generalized quantifier over a family of sub-question intentions.

(2.29) a. $\textsc{Ans}_{BR_1}(Q)(w) = \bigcap\{p : Q(w)(p) \wedge p(w)\}$ (for mention-all)

b. $\textsc{Ans}_{BR_3}(Q)(w) = \lambda P_{\langle s,stt\rangle}.\exists p[P(w)(p) \wedge Q(w)(p) \wedge p(w)]$ (for mention-some)

As exemplified in (2.30), interpreting an embedded mention-some question involves raising the entire type-shifted question. The existential quantification force within $\textsc{Ans}_{BR_3}$ introduces mention-some.

(2.30) John knows Q_{MS}.



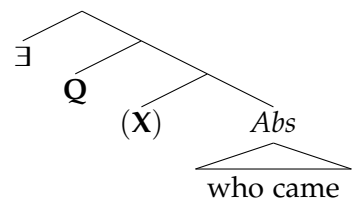
The account proposed by George (2011: chap. 2) involves two stages in the question formation, including an abstract formation which denotes the intension of a lambda abstract *Abs*, and a question formation which produces a set of possible answers via a question-formation operator **Q**. The mention-some/mention-all ambiguity comes from the absence/presence of a strengthening operator **X** between *Abs* and **Q**, as illustrated in (2.31).

(2.31) Who came?

a. $[\![Abs]\!] = \lambda x[\textsf{people}_{@}(x) \wedge \textsf{came}_{w}(x)]$

b. $[\![\mathbf{Q}]\!] = \lambda\alpha_{\langle s,\tau t\rangle}\lambda p_{st}\exists\beta_{\tau}(p = \lambda w.\alpha(w)(\beta))$

c. $[\![\mathbf{X}]\!] = \lambda\gamma_{\tau}\lambda\delta_{\tau}(\delta = \gamma)$



When the **X**-operator is absent, question formation delivers the Hamblin set, as schematized in (2.32a). When the **X**-operator is present between *Abs* and **Q**, question formation delivers a partition, or equivalently, a set of exhaustified propositions of the form that "only the individuals in β came," as schematized in (2.32b). Finally, answerhood operation unambiguously applies existential quantification over the output Hamblin set or partition, yielding mention-some and strongly exhaustive, respectively.[29]

(2.32) a. Without **X**: mention-some

$$\begin{aligned}[\![\mathbf{Q}(Abs)]\!] &= \lambda p_{\langle s,t\rangle}\exists\beta_{e}[p = \lambda w[\textsf{people}_{@}(\beta) \wedge \textsf{came}_{w}(\beta)]]\\ &= \{\lambda w[\textsf{people}_{@}(\beta) \wedge \textsf{came}_{w}(\beta)] : \beta \in D_{e}\}\\ &= \{\textsf{came}(\beta) : \beta \in \textsf{people}_{@}\}\end{aligned}$$

b. With **X**: strongly exhaustive

$$\begin{aligned}[\![\mathbf{Q}(\mathbf{X}(Abs))]\!] &= \lambda p_{\langle s,t\rangle}\exists\beta_{\langle e,t\rangle}[p = \lambda w\lambda x[\textsf{people}_{@}(x) \wedge \textsf{came}_{w}(x) = \beta]]\\ &= \{\lambda w\lambda x[\textsf{people}_{@}(x) \wedge \textsf{came}_{w}(x) = \beta] : \beta \in D_{\langle e,t\rangle}\}\end{aligned}$$

Regardless of the technical details, post-structural approaches all face the problem that they do not restrict the availability of mention-some grammatically. For instance, no grammatical factor blocks the use of Beck & Rullmann's $\textsc{Ans}_{BR_3}$-operator or forces the presence of George's **X**-operator. Hence, post-structural approaches predict that mention-some is always semantically licensed, and that its limited distribution come from pragmatic restrictions. These predictions, however, lead to the very same problems that we just saw with the pragmatic line.

2.5. A structural approach: Fox (2013)

The structural line attributes the interpretation ambiguity of a question to a structural variation within the question nucleus. George (2011: chap. 6) proposes the first structural treatment of mention-some/mention-all ambiguity. But his treatment only applies to ∃-questions, which are not considered to be mention-some questions in this dissertation (§2.3.2). As far as I know, only Fox (2013) has made a structural treatment for the mention-some/mention-all ambiguity in ◇-questions.[30] This treatment has two major assumptions. First, any max-informative true answer counts as a complete true answer. Second, the mention-some/mention-all ambiguity comes from the the scope ambiguity of distributivity with the question nucleus.

[29] A non-trivial assumption that George (2011: chap. 2) makes is that mention-some and weakly exhaustive are the same reading, derived when the **X**-operator is absent.

[30] Since Danny Fox had not written out his analysis into a paper by the time when this dissertation was written, the work 'Fox 2013' refers to the handouts of a series of lectures on mention-some that he gave since 2013 at MIT and other occasions. Please look out for any further updates.

2.5.1. Completeness and answerhood

Earlier works assume that complete answers are always exhaustive. As one of the most popular views, Dayal (1996) assumes that a complete true answer is the *strongest true answer*, namely, the unique true answer that entails all the true answers. This view of completeness leaves no space for mention-some, as we saw in section 2.4.1. To rule in mention-some answers as complete answers, Fox (2013) weakens the definition of completeness and proposes that any *maximally (max)-informative* true answer counts as a complete true answer. A true answer is max-informative as long as it is not asymmetrically entailed by any of the true answers.

(2.33) Given a set of propositions α,

a. the **strongest member** of α: $\iota p[p \in \alpha \wedge \forall q[q \in \alpha \rightarrow p \subseteq q]]$
(The unique member that entails all the members of α)

b. the set of **max-informative members** of α: $\{p : p \in \alpha \wedge \forall q[q \in \alpha \rightarrow q \not\subset p]\}$
(The members of α that are not asymmetrically entailed by any members of α)

For a simple illustration of the two notions in (2.33a-b), compare the two proposition sets in (2.34). Set α is closed under conjunction; it has only one max-informative member, which is also the strongest member, while set β has no strongest member but instead two max-informative members.

(2.34) Assume that p and q are semantically independent and non-contradictory,

a. $\alpha = \{p, q, p \wedge q\}$

i. The strongest member of α:	$p \wedge q$
ii. The max-informative member(s) of α:	$p \wedge q$

b. $\beta = \{p, q\}$

i. The strongest member of β:	Non-existent
ii. The max-informative member(s) of β:	p, q

The two views of completeness by Dayal and Fox make no difference in cases where the answer space is closed under conjunction, as in (2.34a). But, defining completeness as max-informativity leaves space for mention-some: it allows non-exhaustive answers to be complete, so that a question to have multiple complete true answers. Under Fox's view, a mention-some answer is a max-informative true answer that is non-exhaustive, a question is interpreted as mention-some if it can have multiple max-informative true answers, and a question does not take mention-some if its answer space is closed under conjunction.

Using the weaker definition of completeness, Fox defines the answerhood-operator as in (2.35): the root denotation of a question is a Hamblin set; $\textsc{Ans}_{Fox}$ applies to the Hamblin set Q and the evaluation world w, returning the set of max-informative true answers of Q in w. Accordingly, a question takes a mention-some reading iff the output set of employing $\textsc{Ans}_{Fox}$ can be non-singleton.

(2.35) **Fox's (2013) answerhood-operator**
$\textsc{Ans}_{Fox}(Q)(w) = \{p : w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow q \not\subset p]\}$
($\{p$: p is true answer of Q in w; and p is not asymmetrically entailed by any of the true answers of Q in w.$\}$)

2.5.2. Deriving the ambiguity

Fox (2013) attributes the mention-some/mention-all ambiguity to the scopal ambiguity of distributivity. The core idea is as follows: mention-some reading is available only if the answer space is not closed under conjunction; in a $\Diamond$-question, the answer space is not closed under conjunction only if distributivity takes scope below the existential modal.

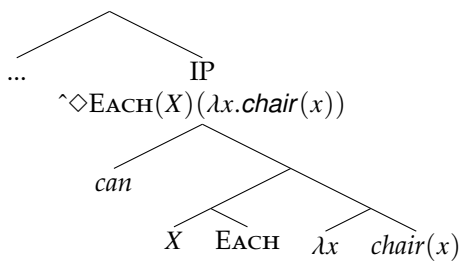
To realize this idea, Fox firstly inserts a covert distributor EACH to the LF as a phrase-mate of the *wh*-trace X. EACH distributes over the atomic subparts of X:

(2.36) $[\![X \text{ EACH}]\!] = \lambda f_{\langle e,t\rangle}.\forall x[x \in \text{AT}(X) \rightarrow f(x)]$

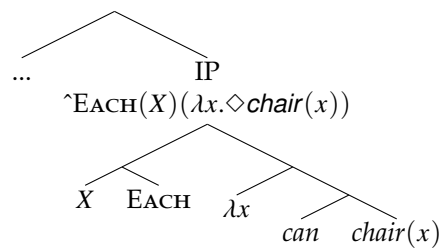
In a $\Diamond$-question, the distributive phrase 'X EACH' flexibly takes scope above or below the existential modal. For a simple illustration, observe that the two LFs in (2.37) for the question nucleus differ only with respect to the scope of 'X EACH' relative to the modal *can*.

(2.37) Who can chair the committee?

a. Global distributivity



b. Local distributivity



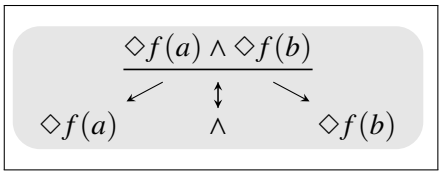
The two LFs yield the Hamblin sets in (2.38a) and (2.38b), respectively. For a more intuitive comparison, see the two pictures in (2.39). Each square stands for an answer space (viz., a Hamblin set); shading marks the true answers; underlining marks the max-informative true answers; arrows indicate entailments.

(2.38) a. $\{^\wedge\text{EACH}(X)(\lambda x.\Diamond\textit{chair}(x)) : X \in \textit{people}_@\}$ Global distributivity

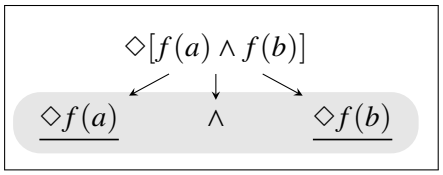
b. $\{^\wedge\Diamond\text{EACH}(X)(\lambda x.\textit{chair}(x)) : X \in \textit{people}_@\}$ Local distributivity

(2.39) (Context: *only Andy and Billy can chair the committee; single-chair only.*)

a. Global distributivity



b. Local distributivity



The answer space in (2.39a) is closed under conjunction; therefore, it has and can have only one max-informative true answer, yielding a mention-all reading. In contrast, the answer space (2.39b) is not closed under conjunction due to the entailment asymmetry in $\Diamond$-environments (e.g, $\Diamond[f(a) \wedge f(b)] \subset [\Diamond f(a) \wedge \Diamond f(b)]$); it has two max-informative true answers in the given discourse, yielding a mention-some reading.

This approach is supported by observations with the particle *alles* in Austrian German: as exemplified in (2.40), the presence of *alles* above the existential modal blocks mention-some (Martin Hackl and Manuel Križ pers. comm. to Fox 2015). This contrast is also observed with the distributor *all* in several English dialects.

(2.40) a. (*alles* > ◇ > *with €3*)

Was **alles** kann ich mit 3 Euro kaufen?
What alles can I with 3 Euro buy

'What are all the things that I can buy for €3.' (mention-all)

b. (◇ > *with €3* > *alles*)

Was kann ich **alles** mit 3 Euro kaufen?
What can I all with 3 Euro buy

'What is a set of items s.t. with €3 I can buy them all?' (mention-some)

Fox considers only questions with atomic distributive predicates. In questions like (2.41a), distributivity distributes down to subgroups instead of atoms. For such cases, a natural move would be to replace EACH with the generalized distributor PART (Schwarzschild 1996: chap. 5).

(2.41) Who can lift the piano?

a. $\{{}^\wedge\textsc{Part}_C(X)(\lambda x.\Diamond \textit{l.t.p.}(x)) : X \in \textit{people}_@\}$ Global distributivity

b. $\{{}^\wedge\Diamond\textsc{Part}_C(X)(\lambda x.\textit{l.t.p.}(x)) : X \in \textit{people}_@\}$ Local distributivity

This PART-operator distributes over subparts of X that are members of the free cover variable C. The value of C is determined by both linguistic and non-linguistic factors.[31]

[31] How to define and use covers is tricky. To predict the mention-all reading of (i), we need to ensure both entailments in (ia-b); otherwise, all the true answers of (i) would be predicted to be max-informative.

(i) Who lifted the piano? ($f = \lambda x.\textit{l.t.p.}(x)$)
(Context: *the piano was lifted twice, once by* ***ab****, once by* ***cd****.*)

a. $[\textsc{Part}_C(a \oplus b)(f) \wedge \textsc{Part}_C(c \oplus d)(f)] \Rightarrow \textsc{Part}_C(a \oplus b \oplus c \oplus d)(f)]$

b. $[\textsc{Part}_C(a \oplus b)(f) \wedge \textsc{Part}_C(c \oplus d)(f)] \Leftarrow \textsc{Part}_C(a \oplus b \oplus c \oplus d)(f)]$

If the cover variable C is existentially bound, as in (ii), the entailment in (ib) wouldn't hold. For example, in case that *abc* together lifted the piano and *ad* together lifted the piano, definition (ii) predicts $\textsc{Part}_C(a \oplus b \oplus c \oplus d)(f)$ to be true, while $\textsc{Part}_C(a \oplus b)(f)$ and $\textsc{Part}_C(c \oplus d)(f)$ to be false.

(ii) $[\![X\ \textsc{Part}_C]\!] = \lambda f.\exists C[C \text{ is a cover of } X \wedge \forall x[x \in C \wedge x \leq X \rightarrow f(x)]]$

Hence, following Schwarzschild (1996: chap. 5), we'd better treat C as a free variable and assign it the same value across the possible answers. In the given scenario, with only four individuals *abcd*, it is the most convenient to assume $C = \{a \oplus b, c \oplus d\}$. For comparison, if $C = \{a \oplus b\}$, then $\textsc{Part}_C(c \oplus d)(f)$ would be vacuously true, because C does not contain any subparts of $c \oplus d$; if $C = \{a \oplus b, c \oplus d, a \oplus d\}$, then $\textsc{Part}_C(a \oplus b \oplus c \oplus d)(f)$ would be false, because it would also entail the false inference that *ad* together lifted the piano. In conclusion, to rule in all the true answers in w, C should be the set consisting of exactly all the groups who lifted the piano in w.

Nevertheless, this method is still problematic. It requires the value of C to be pre-determined by the true answers; in other words, this method predicts that whoever asks a question already knows the true answers of this question. This prediction is clearly implausible.

(2.42) $[\![X \textsc{Part}_C]\!] = \lambda f_{\langle e,t\rangle}.\forall x[x \in C \wedge x \leq X \rightarrow f(x)]$ where C is a cover of X.

(2.43) C is a cover of X iff

a. C is a set of subparts of X;

b. every subpart of X belongs to some member in C.

2.5.3. Advantages and remaining issues

Fox's (2013) treatment of mention-some makes two major breakthroughs. First, mention-some answers and mention-all answers are uniformly treated as complete answers. Compared with the pragmatic approaches, this treatment captures the systematic availability of mention-some in root and embedding environments. Second, mention-some and mention-all are derived via employing the very same Ans-operator; the mention-some/ mention-all ambiguity comes from a structural variation within the question nucleus. Compared with the post-structural approaches, this treatment provides a grammatical constraint as to the distribution of mention-some: mention-some is possible only if the answer space is not closed under conjunction.

This analysis still has some remaining issues. First of all, as pointed out by Fox himself, allowing a question to have multiple max-informative true answers makes it difficult to predict the uniqueness effects of singular and numeral-modified *wh*-phrases. As we saw briefly in section 2.2, questions with a singular or numeral-modified *wh*-phrase can have only one true answer. For instance, (2.44a) is incoherent because the singular question evokes a uniqueness inference that 'only one of the boys came to the party', which contradicts the second clause; in contrast, this incoherency disappears if the singular *wh*-phrase *which boy* is replaced with the plural one *which boys* or the bare *wh*-word *who*.

(2.44) a. "Which boy came to the party? # I heard that many boys did."

b. "Which boys came to the party? I heard that many boys did."

c. "Who (among the boys) came to the party? I heard that many boys did."

Dayal (1996) captures this uniqueness effect using a presuppositional $\textsc{Ans}_{Dayal}$-operator: $\textsc{Ans}_{Dayal}(Q)(w)$ presupposes the existence of the strongest true answer of Q in w. In a singular question, this presupposition is not satisfied if the question has multiple true answers, which therefore gives rise to a uniqueness effect. Clearly, the presupposition of $\textsc{Ans}_{Dayal}$ cannot be directly incorporated into Fox's analysis of mention-some: for Dayal, to avoid a presupposition failure, a question must have a unique strongest true answer; while for Fox, to get a mention-some reading, a question needs the possibility of having multiple max-informative true answers instead of a unique strongest true answer. To solve this dilemma, Fox (2013) proposes a weaker presupposition using innocently exclusive exhaustifications. But this solution still faces some problems. I will discuss this dilemma in more detail and offer a solution in chapter 3.

Second, in certain cases, good mention-some answers are predicted to be partial answers. For example, consider the $\Diamond$-question (2.45). Intuitively, both (2.45b-c) are good mention-some answers; but (2.45b) is asymmetrically entailed by (2.45c) and hence would be predicted to be a partial answer under Fox's analysis. In section 2.6.1, I refine Fox's analysis of mention-some and solve this problem by inserting a local exhaustifier below the existential modal.

(2.45) Who can serve on the committee?
(Context: *The committee can be made up of Andy and Billy, and can be made of Andy, Billy, and Cindy.*)

a. # Andy. $\Diamond[\mathsf{serve}(a)]$

b. √ Andy and Billy. $\Diamond[\mathsf{serve}(a) \wedge \mathsf{serve}(b)]$

c. √ Andy, Billy, and Cindy. $\Diamond[\mathsf{serve}(a) \wedge \mathsf{serve}(b) \wedge \mathsf{serve}(c)]$

Third, Fox makes use of the scope ambiguity of a distributor within the question nucleus, which however, cannot extend to questions with predicates admitting only collective readings. As shown by the minimal pair in (2.46), repeated from (1.86) in section 1.6.3, the predicate *formed a team* supports only a collective reading. Likewise, the corresponding $\Diamond$-declarative of (2.46a) also admits only a collective reading, as seen in (2.47a).

(2.46) (Context: *The kids ABCD formed two teams in total: AB formed one; CD formed one.*)

a. # The kids **formed a team**. (collective)

b. √ The kids **formed teams**. (covered)

(2.47) (Context: *The kids ABCD can form two teams in total: AB can form one; CD can form one.*)

a. # The kids **can form a team**. (collective)

b. √ The kids **can form teams**. (covered)

Nevertheless, the $\Diamond$-question (2.48) does exhibit a mention-some/mention-all ambiguity. Since the predicate *can form a team* cannot license covered or distributive readings, there cannot be any distributor present in the question nucleus. Hence, we need an analysis of the mention-some/mention-all ambiguity that is independent from whether a distributor is present.

(2.48) Who can form a team?

a. A and B.\ (mention-some)

b. AB can form one, and CD can form one.\ (mention-all)

Last, Fox has not discussed the derivation of mention-all answers taking disjunctive forms, which however are more commonly used than the conjunctive ones. In section 2.6.3, I will offer an analysis of disjunctive mention-all based on empirical observations with the Mandarin particle *dou*.

(2.49) Who can chair the committee?

a. John and Mary. (conjunctive mention-all)

b. John or Mary. (disjunctive mention-all)

2.6. Proposal

In this section, I firstly refine Fox's (2013) treatment of mention-some and then argue for two structural methods to derive mention-all readings. In particular, conjunctive mention-all is derived by interpreting the higher-order *wh*-trace above the existential modal, and disjunctive mention-all is derived by employing a covert O_{DOU}-operator above the existential modal.

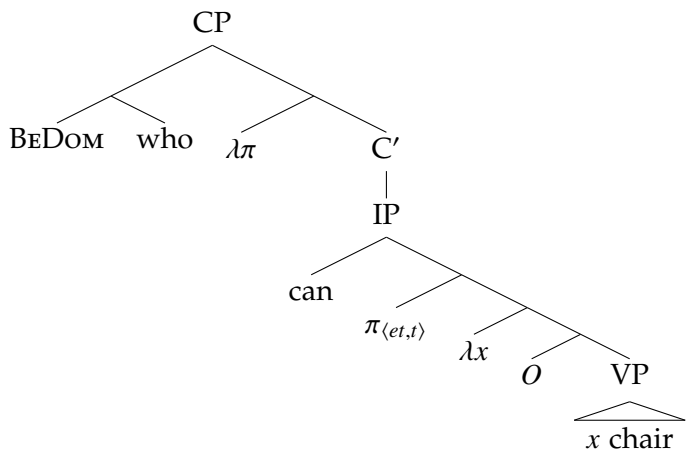
2.6.1. Deriving mention-some

I adopt Fox's (2013) view that any max-informative true answer counts as a complete true answer. Adapting the definition of $\textsc{Ans}_{Fox}$ in (2.35) to the proposed hybrid categorial approach, I define the Ans-operator as in (2.50): Ans applies to the topical property **P** and the evaluation world, returning the set of max-informative true propositions in the range of **P**.

(2.50) $\textsc{Ans}(\mathbf{P})(w) = \{\mathbf{P}(\alpha) : \alpha \in \mathrm{Dom}(\mathbf{P}) \wedge w \in \mathbf{P}(\alpha) \wedge \forall\beta \in \mathrm{Dom}(\mathbf{P})[w \in \mathbf{P}(\beta) \rightarrow \mathbf{P}(\beta) \not\subset \mathbf{P}(\alpha)]\}$

My treatment of mention-some is close to Fox's (2013) treatment in the sense that it also relies on the narrow scope interpretation of the *wh*-item. But my treatment involves two different features related to the structure of question nucleus, as illustrated in (2.51).

(2.51) Who can chair the committee?



First, the *wh*-phrase (in company with the BeDom-operator) takes a mandatory local QR (from x to π) before it moves to the spec of the interrogative CP. These movements create two *wh*-traces, namely, an individual trace x and a higher-order trace π. Second, the existential modal embeds an exhaustivity O-operator associated with the individual *wh*-trace x.

The local QR of the *wh*-phrase rules in generalized conjunctions and disjunctions as possible answers. As we have seen in (1.98), the semantic type of a topical property is determined by the semantic type of the highest *wh*-trace: if the *wh*-item directly moves from the base position to spec of the interrogative CP, the topical property is a property of individuals and hence only individuals of type e can be possible short answers; in contrast, if the *wh*-item firstly takes a local QR, the domain of the topical property ranges over generalized conjunctions and disjunctions of type $\langle et, t\rangle$. The motivation for ruling in higher-order answers will be explained in chapter 3: briefly, if a question does not have a strongest true answer, then it would be undefined unless the domain of its topical property includes generalized conjunctions.

The insertion of a local O-operator is motivated by cases like (2.45), repeated below. The contrast between (2.52a) and (2.52b-c) suggests that mention-some answers involve local exhaustivity: in (2.52), a good mention-some answer needs to specify the all the members of a possible committee. Intuitively, (2.52b) means 'it is possible to have only Andy and Billy serve on the committee.'

(2.52) Who can serve on the committee?

(Context: *The committee can be made up of Andy and Billy, and it can be made of Andy, Billy, and Cindy.*)

a. # Andy.\ $\Diamond O[\textsf{serve}(a)]$

b. √ Andy and Billy.\ $\Diamond O[\textsf{serve}(a \oplus b)]$

c. √ Andy, Billy and Cindy.\ $\Diamond O[\textsf{serve}(a \oplus b \oplus c)]$

Following the *grammatical view of exhaustifications* (Chierchia 2006, 2013; Fox 2007; Chierchia et al. 2012; Fox and Spector to appear; among others), I capture the local exhaustivity by inserting a covert O-operator below the existential modal and associating it with the individual *wh*-trace. This O-operator has a meaning close to the exclusive focus particle *only*; it affirms the prejacent and negates the alternatives that are not entailed by the prejacent.

(2.53) $O(p) = \lambda w[p(w) = 1 \wedge \forall q \in \textsc{Alt}(p)[p \not\subseteq q \rightarrow q(w) = 0]]$
(The prejacent p is true, and any alternative of p that is not entailed by p is false.)

The alternatives associated with the individual *wh*-trace t_{wh} are items of the same semantic type as t_{wh}. The alternative set is composed point-wise, analogous to the focus value of a focus-containing expression (Rooth 1992).

(2.54) **Alternatives of *wh*-trace**

a. *Terminal Node*
$\textsc{Alt}(t_{wh}) = \{a : \textsc{type}(a) = \textsc{type}(t_{wh})\}$

b. *Point-wise Functional Application*
$\textsc{Alt}(f(t_{wh})) = \{f(a) : a \in \textsc{Alt}(t_{wh})\}$

Inserting an O-operator rules out the infelicitous answer (2.52a): under the common knowledge that a committee consists of multiple members, it is impossible to have only Andy serve on the committee. Moreover, as a non-monotonic operator, this O-operator creates a non-monotonic environment with respect to the individual *wh*-trace, which therefore makes (2.52b) semantically independent from (2.52c) and preserves (2.52b) as a max-informative true answer.

More generally speaking, the insertion of an O-operator ensures that all the individual answers are semantically independent, and the presence of an existential modal ensures that these answers are NOT mutually exclusive. Hence, mention-some is available in $\Diamond$-questions. In comparison, as shown in the following, if the existential modal is dropped or replaced with a universal modal, these locally exhaustified answers become mutually exclusive:

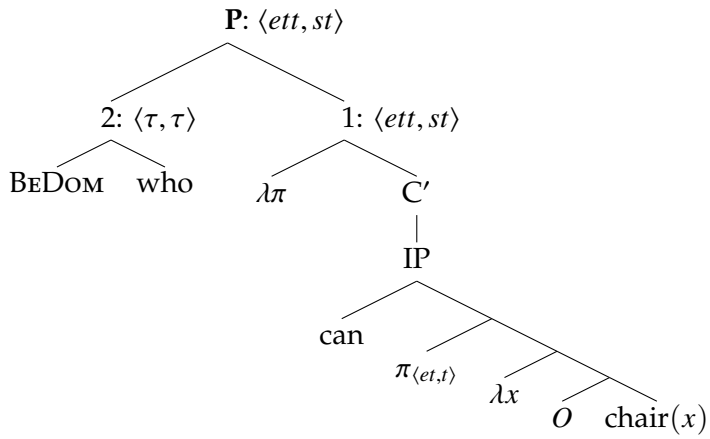
(2.55) a. $\Diamond O[\textsf{serve}(a \oplus b \oplus c)] \wedge \Diamond O[\textsf{serve}(a \oplus b)] \neq \bot$

b. $O[\textsf{serve}(a \oplus b \oplus c)] \wedge O[\textsf{serve}(a \oplus b)] = \bot$

c. $\Box O[\textsf{serve}(a \oplus b \oplus c)] \wedge \Box O[\textsf{serve}(a \oplus b)] = \bot$

See (2.56) for a concrete example of deriving the topical property for a mention-some reading.

(2.56) Who can chair the committee?
(Context: *Only Andy and Billy can chair the committee; single-chair only.*)



a. $[\![\text{IP}]\!] = {}^\wedge\Diamond\pi(\lambda x.O[\textit{chair}(x)])$ (question nucleus)

b. $[\![1]\!] = \lambda\pi_{\langle et,t\rangle}.{}^\wedge\Diamond\pi(\lambda x.O[\textit{chair}(x)])$

c. $[\![\text{who}]\!] = \lambda f_{\langle\tau,t\rangle}.\exists\alpha_\tau[\dagger\textit{people}_@(\alpha) \wedge f(\alpha)]$

d. $[\![\textsc{BeDom}]\!] = \lambda\mathcal{P}\lambda\theta.\iota P[[\text{Dom}(P) = \text{Dom}(\theta) \cap \textsc{Be}(\mathcal{P})] \wedge \forall\alpha \in \text{Dom}(P)[P(\alpha) = \theta(\alpha)]]$

e. $[\![2]\!] = \lambda\theta.\iota P[[\text{Dom}(P) = D_{\langle et,t\rangle} \cap \dagger\textit{people}_@] \wedge \forall\alpha \in \text{Dom}(P)[P(\alpha) = \theta(\alpha)]]$

f. $\mathbf{P} = \lambda\pi_{\langle et,t\rangle}[\dagger\textit{people}_@(\pi) = 1.{}^\wedge\Diamond\pi(\lambda x.O[\textit{chair}(x)])]$ (root denotation)

g. $\textsc{Ans}(\mathbf{P})(w) = \{{}^\wedge\Diamond O[\textit{chair}(a)], {}^\wedge\Diamond O[\textit{chair}(b)]\}$ (max-informative true answers)

The meaning of (2.56) proceeds as follows:

(i) At Node 1, abstracting over the question nucleus generates a chairing-property defined for any generalized quantifier, as in (2.56a-b).

(ii) *Who* is an existential quantifier living on the set †*people*, as in (2.56c). This set consists of not only atomic and sum individuals in $\textit{people}_@$ but also conjunctions and disjunctions over $\textit{people}_@$. At Node 2, BeDom shifts *who* into a domain restrictor, as in (2.56d-e).

(iii) Composing Node 1 and Node 2 by Functional Application returns the topical property **P**, as in (2.56f). It is a partial chairing-property defined for generalized quantifiers of type $\langle et, t\rangle$ that are conjunctions and disjunctions over human individuals. The answer space yielded by **P** is illustrated in Figure 2.1. Here and throughout the thesis, in illustrations of answer spaces, arrows indicate entailments, shading marks the true answers, and underlining marks the max-informative true answers.

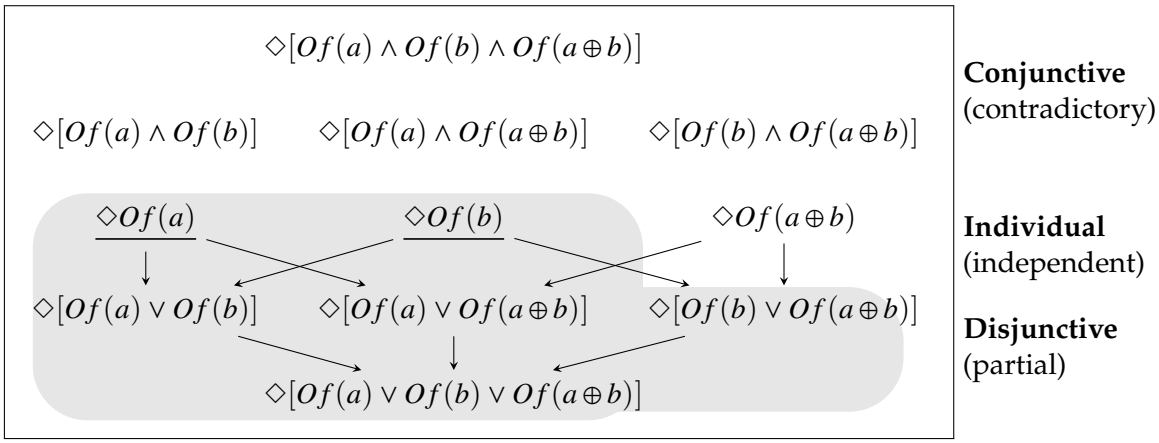


Figure 2.1: Answer space of (2.56), where $f = [\![\text{chair the committee}]\!]$

This answer space involves three types of answers, namely, conjunctive answers (row 1-2), individual answers (row 3), and disjunctive answers (row 4-5). The conjunctive answers are all contradictory, due to the presence of the local O-operator. The individual answers are all semantically independent, and hence each true individual answer counts as a max-informative true answer. Disjunctive answers are asymmetrically entailed by some individual answers. Moreover, as illustrated in Figure 2.2, a disjunctive answer is semantically equivalent to the disjunction of the corresponding individual answers; hence, disjunctive answers are always partial: whenever a disjunctive is true, there must be a true individual answer that asymmetrically entails this disjunctive answer.

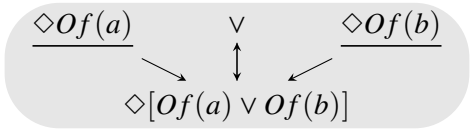


Figure 2.2: Disjunctive answers versus individual answers in mention-some

The overall shape of the answer space is independent from whether the predicate *chair the committee* takes a distributive or collective reading; due to the non-monotonicity of the O-operator, $\Diamond Of(a \oplus b)$ is semantically independent from $\Diamond Of(a)$ and $\Diamond Of(b)$.

In sum, among the three types of answers, only individual answers can be max-informative. This prediction captures the characteristics of the types of non-exhaustivity in mention-some, which cannot explained in a pragmatic approach (§2.4.1): (i) in discourse, without carrying an ignorance-mark, only individual answers can be mention-some answers, while conjunctive and disjunctive answers tend to get an exhaustive reading; and (ii) in indirect questions, mention-some readings are always "mention-one".

(iv) Applying the Ans-operator to the topical property **P** and the evaluation world w returns the set of max-informative true answers in w, as in (2.56g). Each of these max-informative true answers counts as a complete true answer. Applying f_{CH} picks out one of the max-informative true answers. Note that Ans and f_{CH} are semantically active but not syntactically present.

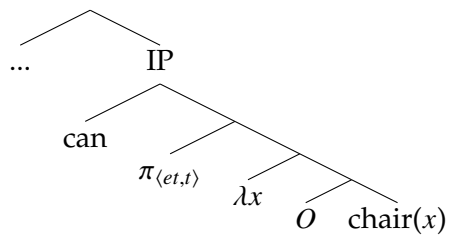
2.6.2. Conjunctive mention-all

Conjunctive mention-all answers are derived by moving the higher-order *wh*-trace π above the existential modal. Since the value of π can be a generalized conjunction, this approach is essentially the same as Fox's (2013) idea of global distributivity, but it has the advantage of being applicable to questions with collective predicates.

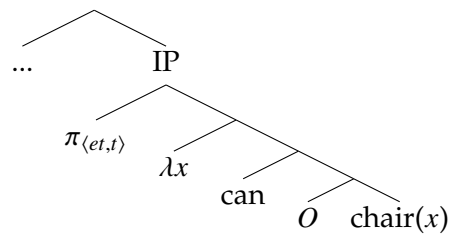
As a simple illustration, the two LFs in (2.57) for the question nucleus differ only with respect to the scope of the higher-order *wh*-trace π relative to the modal *can*.

(2.57) Who can chair the committee?

a. $\Diamond > \pi$



b. $\pi > \Diamond$



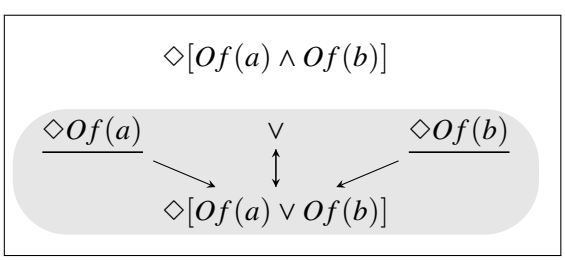
The two LFs yield the topical properties in (2.58a) and (2.58b), respectively. The answer space yielded by these two topical properties are illustrated in (2.59a) and (2.59b), respectively. For simplicity, I ignore the answers that involve the plural individual $a \oplus b$.

(2.58) a. $\lambda\pi_{\langle et,t\rangle}[\dagger\textsf{people}_{@}(\pi) = 1.{}^\wedge\Diamond\pi(\lambda x.O[\textsf{chair}(x)])]$ $\Diamond > \pi$

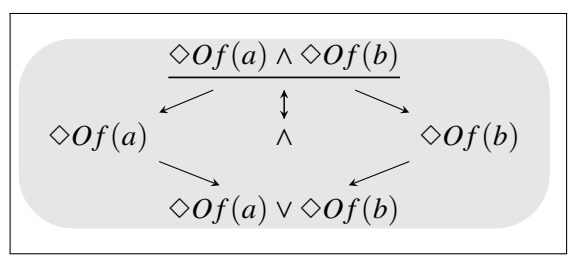
b. $\lambda\pi_{\langle et,t\rangle}[\dagger\textsf{people}_{@}(\pi) = 1.{}^\wedge\pi(\lambda x.\Diamond O[\textsf{chair}(x)])]$ $\pi > \Diamond$

(2.59) (Context: *Only Andy and Billy can chair the committee, and only single-chair is allowed.*)

a. $\Diamond > \pi$: mention-some



b. $\pi > \Diamond$: conjunctive mention-all



The answer space in (2.59a) can have multiple max-informative true answers and hence yields a mention-some reading; moreover, the conjunctive answer is contradictory. In contrast, the answer space in (2.59b) is closed under conjunction and hence yields a mention-all reading; moreover, the conjunctive answer is the unique max-informative true answer and hence serves as a conjunctive mention-all answer.

2.6.3. Disjunctive mention-all

Recall that mention-all answers of a $\Diamond$-question can take a disjunctive form. Moreover, as shown in (2.60), an elided disjunction can take an existential reading or a free choice reading, used as a

partial answer and a mention-all answer, respectively.

(2.60) Who can chair the committee?

a. John or Mary.../ I don't know which. (partial: existential)
$\rightsquigarrow$ *Either John or May can chair the committee, but I don't know which.*

b. John or Mary.\ (mention-all: free choice)
$\rightsquigarrow$ *Both John and Mary can chair the committee. No one else can.*

I argue that the mention-some/mention-all ambiguity of a $\Diamond$-question correlates with the existential/free-choice ambiguity of the corresponding disjunctive answers: a $\Diamond$-question takes a mention-all reading if its disjunctive answers take free choice readings.

2.6.3.1. Evidence from Mandarin particle *dou*

The functions of the Mandarin particle *dou* suggest a parallel between the mention-all readings of $\Diamond$-questions and the free choice interpretations of disjunctions. In a $\Diamond$-question, similar to the cases of German *alles* and English *all*, presence of *dou* above the existential modal blocks mention-some, as shown in (2.61). Square brackets '[•]' encloses the items associated with *dou*. Following Beck and Rullmann (1999), I descriptively call this use an "exhaustivity-marker."

(2.61) a. (**Dou**) [shui] keyi jiao jichu hanyu?
DOU who can teach Intro Chinese
Without *dou*: 'Who can teach Intro Chinese?'
With *dou*: 'Who all can teach Intro Chinese?'

b. Women (**dou**) keyi zai [nali] mai dao kafei?
we DOU can at where buy get coffee
Without *dou*: 'where can we get coffee?'
With *dou*: 'where all can we get coffee?'

Under the exhaustivity-marker use, *dou* ought to appear on the right side of the subject if the subject is not a *wh*-item, as seen in (2.61b). This fact suggests that *dou* is posited within IP. Moreover, *dou* must c-command the *wh*-item at the surface structure, as exemplified in (2.62): *dou* functions as an exhaustivity-marker when appearing above *shenme* 'what', and as a distributor when appearing below *shenme* 'what'.

(2.62) (Context: *John can give all the apples to Mary; he can also give some of the cookies to Mary.*)

a. Yuehan **dou** keyi ba [shenme] gei Mali?
John DOU can BA what give Mary
'What all is John allowed to give to Mary?" (exhaustivity-marker)
Proper reply: 'The apples or some of the cookies.'

b. Yuehan keyi ba [shenme] **dou** gei Mali?
John can BA what DOU give Mary
'What *x* is such that John can give all of *x* to Mary?' (distributor)
Proper reply: 'The apples.'

Given that Mandarin is a *wh*-in-situ language and that *wh*-items take covert movement at LF (Huang 1982), I conjecture that at LF *dou* is interpreted somewhere within the question nucleus (i.e., inside IP) that c-commands the *wh*-trace. Hence, the surface structures and logical forms of (2.61a-b) are as follows.

(2.63) Surface structure

a. $[_{CP}\ [_{IP}$ DOU [who can teach Intro Chinese]]]

b. $[_{CP}\ [_{IP}$ we$_j$ DOU [t_j can get coffee at where]]]

(2.64) Logical Form

a. $[_{CP}$ who$_i$ C^0 $[_{IP}$ DOU [t_i can teach Intro Chinese]]]

b. $[_{CP}$ where$_i$ C^0 $[_{IP}$ DOU [we can get coffee at t_i]]]

Despite the similarity between *dou* and *alles/all* in questions, *dou* should not be analyzed simply as a distributor or a quantifier (compare Lin 1998, Jie Li 1995, Xiaoguang Li 1997).[32] In declaratives, *dou* has more functions than *alles/all*: in a general way of classification, *dou* can be used as a distributor, a universal free choice item (∀-FCI)-licenser, and a scalar marker. For the issues that are concerned with in this section, let us focus on its ∀-FCI-licenser use: in a ◇-declarative, associating *dou* with a pre-verbal disjunction evokes a universal free choice inference, as exemplified in (2.65).

(2.65) a. [Yuehan huozhe Mali] (**dou**) keyi jiao hanyu.
John or Mary DOU can teach Chinese
Without *dou*: 'Either John or Mary can teach Chinese.' (existential)
With *dou*: 'Both John and Mary can teach Chinese.' (free choice)

b. Women zai [Xingbake huozhe Maidanglao] (**dou**) keyi mai dao kafei.
we at Starbucks or McDonalds DOU can buy get coffee
Without *dou*: 'From either S or M, we can get coffee.' (existential)
With *dou*: 'From both S and M, we can get coffee.' (free choice)

Chapter 7 motivates and presents a uniform semantics of *dou* to capture its various uses. I define *dou* as a pre-exhaustification exhaustifier that operates on *sub-alternatives*.

(2.66) $[\![dou]\!](p) = \exists q \in \textsc{Sub}(p).\lambda w[p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)[O(q)(w) = 0]]$

[32] Xiaoguang Li (1997) assumes that, under the exhaustivity-marker use, *dou* is associated with a covert adverbial denoting multiple events and quantifies over events. This analysis cannot predict the unavailability of mention-some in ◇-questions like (ia). If here *dou* were associated with a covert quantificational adverbial over events, then (ia) should admit pair-list mention-some or individual mention-some readings, as observed in (ib). For example, if Starbucks is always accessible to John while J.P. Licks is sometimes accessible to John, "Starbucks" is a proper answer to (ib) but not to (ia).

(i) a. Yuehan **dou** keyi qu [nali] mai kafei?
John DOU can go where buy coffee?
'Where all can John buy coffee?" (mention-all)

b. Yuehan [mei-ci] **dou** keyi qu nali mai kafei?
John each-time DOU can go where buy coffee?
'Each time, where can John can buy coffee?' (pair-list mention-some)
'John always can buy coffee from where?' (individual mention-some)

a. Presupposition: p has a sub-alternative.

b. Assertion: p is true; for each sub-alternative of p, its exhaustification is false.

Sub-alternatives are simply the complements of Fox's (2007) *innocently (I)-excludable alternatives*; in other words, sub-alternatives are the ones that are not I-excludable and distinct from the prejacent. For the purpose of this section, it is enough to know that the sub-alternatives of a conjunction/disjunction are its conjuncts/disjuncts. See chapter 7 for more details.

(2.67) a. **Innocently (I)-excludable alternatives** (Fox 2007)

$\textsc{IExcl}(p) = \bigcap\{A : A \text{ is a maximal subset of } \textsc{Alt}(p) \text{ s.t. } A^{\neg} \cup \{p\} \text{ is consistent}\}$,

where $A^{\neg} = \{\neg q : q \in A\}$

(q is I-excludable to p iff q is included in every maximal set of alternatives of p such that the exclusion of this set is consistent with p.)

b. **Sub-alternatives**

$\textsc{Sub}(p) = (\textsc{Alt}(p) - \textsc{IExcl}(p)) - \{p\}$

(The set of alternatives that are not I-excludable and are distinct from the prejacent)

The computation in (2.68) illustrates the derivation of the universal free choice inference in (2.65a): the prejacent clause is a disjunction;[33] the sub-alternatives of a disjunction are the disjuncts; employing *dou* affirms the prejacent and negates the exhaustification of each disjunct, yielding a conjunctive inference.[34] (See also §7.5.2.)

[33]Notice that the disjunction takes scope above the existential modal. We are, unfortunately, unable to check the semantic consequences of associating *dou* with a disjunction across an existential modal, because *dou* has to be associated with an preceding item when it functions as ∀-FCI-licenser in declaratives.

(i) a. * Ni **dou** keyi mai [pingguo huozhe binggan].
You DOU can buy apples or cookie
Intended: 'You can buy apples or cookies.'

b. Ni [pingguo huozhe binggan] **dou** keyi mai.
You apples or cookie DOU can buy
Intended: 'You can buy apples and you can buy cookies.'

Given that universal FC and existential FC inferences are semantically equivalent in ◇-declaratives, as exemplified in (ii), one might wonder why we cannot interpret the disjunction in (2.68) below the existential modal.

(ii) a. Anyone can be invited (by you). universal FC

b. You can invite anyone. existential FC

This interpretation is not possible because associating *dou* with a pre-verbal disjunction exhibits a modal obviation which is only observed in the case of ∀-FCI-licensing. Compare the following English and Mandarin examples: (see §7.5.2.3 for an explanation of this modal obviation effect.)

(iii) Anyone *(can)/*must be invited.

(iv) a. * Ni [pingguo huozhe binggan] **dou** mai -le.
You apples or cookie DOU can buy

b. * Ni [pingguo huozhe binggan] **dou** must mai.
You apples or cookie DOU must buy

[34]Readers who are familiar with the grammatical view of exhaustifications might find the proposed definition of *dou* similar to the operation of recursive exhaustification proposed by Fox (2007) and the pre-exhaustification operator $O_{\text{D-Exh}}$-operator used by Chierchia (2006, 2013). See section 2.7 for a comparison.

(2.68) [John or Mary] **dou** can teach Intro Chinese.

a. Prejacent: $\Diamond f(j) \vee \Diamond f(m)$ ($f = [\![\text{teach Intro Chinese}]\!]$)

b. $\textsc{Sub}(\Diamond f(j) \vee \Diamond f(m)) = \{\Diamond f(j), \Diamond f(m)\}$

c. $[\![\textbf{dou}]\!][\Diamond f(j) \vee \Diamond f(m)]$
$= [\Diamond f(j) \vee \Diamond f(m)] \wedge \neg O\Diamond f(j) \wedge \neg O\Diamond f(m)$
$= [\Diamond f(j) \vee \Diamond f(m)] \wedge [\Diamond f(j) \rightarrow \Diamond f(m)] \wedge [\Diamond f(m) \rightarrow \Diamond f(j)]$
$= [\Diamond f(j) \vee \Diamond f(m)] \wedge [\Diamond f(j) \leftrightarrow \Diamond f(m)]$
$= \Diamond f(j) \wedge \Diamond f(m)$

2.6.3.2. Deriving disjunctive mention-all

Based on the observations with the Mandarin particle *dou*, I propose that disjunctive mention-all answers are derived by employing a covert $O_{\textsc{dou}}$-operator above the existential modal. This $O_{\textsc{dou}}$-operator is a non-presuppositional counterpart of the Mandarin particle *dou*.[35]

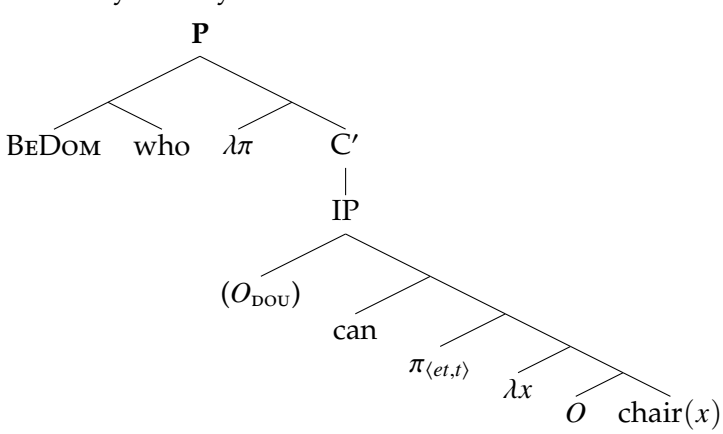
(2.69) $O_{\textsc{dou}}(p) = \lambda w[p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)[O(q)(w) = 1]]$
(The prejacent p is true, and the exhaustification of each sub-alternative of p is false.)

Briefly speaking, applying an $O_{\textsc{dou}}$-operator above the existential modal turns a disjunctive answer into a free choice statement, making the answer space closed under conjunction and yielding a mention-all reading. A concrete example is given in (2.70).

(2.70) Who can chair the committee?

a. Andy or Billy. I don't know who exactly. (partial)

b. Andy or Billy.\ (mention-all)



In this LF, an $O_{\textsc{dou}}$-operator is optionally present within the question nucleus and associated with the higher-order *wh*-trace π across the existential modal *can*. With absence/presence of the global $O_{\textsc{dou}}$-operator, this LF yields the topical property in (2.71a)/(2.71b) and the answer space in (2.72a)/(2.72b). Again, arrows indicate entailments, shading marks the true answers, and underlining marks the max-informative true answers.

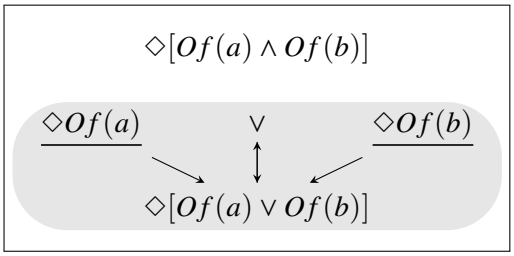
[35]The additive presupposition of *dou* comes from the economy condition that an overt operator cannot be used vacuously. Hence, the covert counterpart should not have this presupposition.

(2.71) a. $\mathbf{P} = \lambda\pi_{\langle et,t\rangle}[\dagger\textsf{people}_{@}(\pi) = 1.\hat{}\Diamond\pi(\lambda x.O[\textsf{chair}(x)])]$ without O_{DOU}

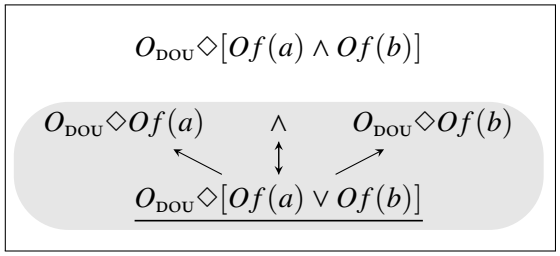
b. $\mathbf{P} = \lambda\pi_{\langle et,t\rangle}[\dagger\textsf{people}_{@}(\pi) = 1.\hat{}O_{\text{DOU}}\Diamond\pi(\lambda x.O[\textsf{chair}(x)])]$ with O_{DOU}

(2.72) (Context: *Only Andy and Billy can chair the committee, and only single-chair is allowed.*)

a. Without O_{DOU}: mention-some



b. With O_{DOU}: disjunctive mention-all



In both answer spaces, the conjunctive answers are contradictory. In (2.72a), the disjunctive answer is asymmetrically entailed by the individual answers and is semantically equivalent to the **disjunction** of the individual answers; hence, here the disjunctive answer is partial while the individual ones are complete. While in (2.72b), with the application of the O_{DOU}-operator, the disjunctive answer takes a free choice interpretation and is semantically equivalent to the **conjunction** of the individual answers, as computed in (2.73); hence, with the presence of DOU, the disjunctive answer is complete while the individual ones are partial.

(2.73) $O_{\text{DOU}}\Diamond[Of(a) \vee Of(b)]$
$= \Diamond[Of(a) \vee Of(b)] \wedge \neg O\Diamond Of(a) \wedge \neg O\Diamond Of(b)$
$= \Diamond[Of(a) \vee Of(b)] \wedge [\Diamond Of(a) \rightarrow \Diamond Of(b)] \wedge [\Diamond Of(b) \rightarrow \Diamond Of(a)]$
$= \Diamond[Of(a) \vee Of(b)] \wedge [\Diamond Of(a) \leftrightarrow \Diamond Of(b)]$
$= \Diamond Of(a) \wedge \Diamond Of(b)$

2.6.3.3. Disjunctive answers in non-modalized questions

In non-modalized questions, disjunctions take only existential readings and must be used as partial answers.

(2.74) Who came?

a. Andy or Billy .../ I don't know which.

b. # Andy or Billy.\

If the answer space of (2.74) is like (2.75a), then the partiality of disjunctive answers can be predicted easily. The disjunctive answer is semantically equivalent to the disjunction of two individual answers, which are strictly stronger. Hence, a disjunctive answer can never be a max-informative true answer: whenever it is true, there must be a stronger answer that is simultaneously true. Nevertheless, a problem arises once we allow the presence of an O_{DOU}-operator: as the answer space (2.75b) shows, O_{DOU} strengthens a disjunctive answer and makes it semantically equivalent to the corresponding conjunctive answer, as computed in (2.76).

(2.75) a. Without O_{DOU} b. With O_{DOU}

$$\begin{tikzcd}[column sep=small] & f(a) \wedge f(b) \arrow[dl] \arrow[d] \arrow[dr] & \\ f(a) \arrow[dr] & \vee \arrow[d, leftrightarrow] & f(b) \arrow[dl] \\ & f(a) \vee f(b) & \end{tikzcd}$$

$$\begin{tikzcd}[column sep=small] & O_{\text{DOU}}[f(a) \wedge f(b)] \arrow[dl] \arrow[d, leftrightarrow] \arrow[dr] & \\ O_{\text{DOU}}f(a) & \wedge \arrow[d, leftrightarrow] & O_{\text{DOU}}f(b) \\ & O_{\text{DOU}}[f(a) \vee f(b)] \arrow[ul] \arrow[ur] & \end{tikzcd}$$

(2.76) $O_{\text{DOU}}[f(a) \vee f(b)]$
$= [f(a) \vee f(b)] \wedge \neg Of(a) \wedge \neg Of(b)$
$= [f(a) \vee f(b)] \wedge [f(a) \rightarrow f(b)] \wedge [f(b) \rightarrow f(a)]$
$= [f(a) \vee f(b)] \wedge [f(a) \leftrightarrow f(b)]$
$= f(a) \wedge f(b)$

Then, given that O_{DOU} can turn the denotation of any disjunctive answer into a conjunctive inference, why is it that a disjunctive answer cannot be used as a complete answer of a non-modalized question? In the following, I show that applying O_{DOU} to a non-modalized disjunctive answer always causes a contradiction. Consider the following two LFs, each of which involves an O_{DOU}-operator associated with the higher-order *wh*-trace π, where the only difference is that (2.77a) involves a local exhaustifier associated with the individual *wh*-trace x.

(2.77) Who came?

a. [$_{\text{CP}}$ BeDom(who) $\lambda\pi$ [$_{\text{IP}}$ O_{DOU} π λx [$_{\text{VP}}$ O [x came]]]] $O_{\text{DOU}}[Of(a) \vee Of(b)]$

b. [$_{\text{CP}}$ BeDom(who) $\lambda\pi$ [$_{\text{IP}}$ O_{DOU} π λx [$_{\text{VP}}$ x came]]] $O_{\text{DOU}}[f(a) \vee f(b)]$

First, disjunctive answers derived based on the LF (2.77b) have a contradictory truth condition, as computed in (2.78).[36]

(2.78) $O_{\text{DOU}}[Of(a) \vee Of(b)]$
$= [Of(a) \vee Of(b)] \wedge \neg OOf(a) \wedge \neg OOf(b)$
$= [Of(a) \vee Of(b)] \wedge \neg Of(a) \wedge \neg Of(b)$
$= \bot$

Second, under the LF (2.77a), applying O_{DOU} to a plain disjunction yields a conjunctive inference, which however contradicts the scalar implicature of this disjunction, as shown in (2.79).

(2.79) $O_{\text{DOU}}[f(a) \vee f(b)]$ is deviant because:

[36] In (2.78), $OOf(a)$ and $OOf(b)$ are reduced to $Of(a)$ and $Of(b)$, respectively, due to the following equation:

(i) $OOf(a) = Of(a) \wedge \neg Of(b) = Of(a) \wedge \neg[f(b) \wedge \neg f(a)] = Of(a) \wedge [\neg f(b) \vee f(a)]$
$= [Of(a) \wedge \neg f(b)] \vee [Of(a) \wedge f(a)] = Of(a) \vee Of(a)$
$= Of(a)$

Note that here the O_{DOU}-operator works differently from Fox's (2007) recursive exhaustification: O_{DOU} yields a contradiction; Fox's recursive exhaustification on the other hand is semantically vacuous because the pre-exhaustified alternatives are not innocently excludable. See example (ii) in footnote 38.

$$\left.\begin{array}{ll} \text{Scalar implicature:} & \neg[f(a) \wedge f(b)] \\ O_{\text{DOU}}[f(a) \vee f(b)] = & f(a) \wedge f(b) \end{array}\right\} \text{Contradictory}$$

The deviance of strengthening a non-modalized disjunction via O_{DOU} is supported by the fact in (2.80), namely that associating the Mandarin particle *dou* with a disjunction in a non-modalized sentence causes ungrammaticality (see §7.5.2.3).

(2.80) [Yuehan huozhe Mali] (***dou**) jiao jichu hanyu.
John or Mary DOU teach intro Chinese
'John or Mary (*dou) teach Introductory Chinese.'

By contrast, applying O_{DOU} to a disjunctive answer of a $\Diamond$-question does not yield a contradiction. First, due to the presence of the existential modal, the truth condition of a disjunctive answer is not contradictory, which is therefore free from the problem in (2.78). Second, as shown in the following, due to the presence of the local exhaustifier, the scalar implicature of a disjunctive answer is tautological, and thus does not suffer the problem in (2.79):

(2.81) $O_{\text{DOU}}\Diamond[f(a) \vee f(b)]$ is not deviant because:

$$\left.\begin{array}{ll} \text{Scalar implicature:} & \neg\Diamond[Of(a) \wedge Of(b)] = \top \\ O_{\text{DOU}}\Diamond[Of(a) \vee Of(b)] = & \Diamond Of(a) \wedge \Diamond Of(a) \end{array}\right\} \text{Consistent}$$

2.7. Comparing the exhaustifiers in deriving free choice

This section compares the following three exhaustifiers which have been proposed for the derivation of free choice inferences: the O_{DOU}-operator for sub-alternatives proposed in this analysis, the recursive exhaustifier O_R proposed by Fox (2007), and the $O_{\text{D-EXH}}$-operator for domain (D-)alternatives proposed by Chierchia (2006, 2013).

The operation of "recursive exhaustification" (abbreviated as 'O_R' henceforth) proposed by Fox (2007) has two major characteristics: first, exhaustification negates only alternatives that are innocently excludable; second, exhaustification is applied recursively. The definition of innocently excludable alternatives is repeated below:[37]

(2.82) **Innocently excludable alternatives** (Fox 2007)

[37] The set of innocently excludable alternatives is also commonly defined as in (i). For example, in a disjunction $p \vee q$, the disjuncts are not innocently excludable because $(p \vee q) \wedge \neg p \rightarrow q$.

(i) $\text{IEXCL}(p) = \{q : q \in \text{ALT}(p) \wedge \underline{\neg\exists q' \in \text{EXCL}(p)[p \wedge \neg q \rightarrow q']}\}$, where $\text{EXCL}(p) = \{q : q \in \text{ALT}(p) \wedge p \not\subseteq q\}$
(The set of alternatives p such that the inference of affirming p and negating q does not entail any excludable alternatives of p)

Definition (i), however, is inadequate. For example, the scalar sentence (ii) is the strongest among the alternatives and thus has no excludable alternative, and thus vacuously satisfies the condition underlined in (i); therefore, definition (i) predicts that every alternative of (ii) is I-excludable, which is clearly problematic.

(ii) EVERY student came.

$\textsc{IExcl}(p) = \bigcap\{A : A$ is a maximal subset of $\textsc{Alt}(p)$ s.t. $A^{\neg} \cup \{p\}$ is consistent$\}$,
where $A^{\neg} = \{\neg q : q \in A\}$

(the intersection of the maximal sets of alternatives of p s.t. the exclusion of each such set is consistent with p.)

See (2.83) for a concrete example. The first exhaustification negates the scalar alternative and the focus alternatives; the D-alternatives are not negated in this round, because they are innocently excludable: $\Diamond(p \vee q) \wedge \neg\Diamond p \wedge \neg\Diamond q = \bot$. The second exhaustification negates the pre-exhaustified domain alternatives.

(2.83) **Recursive exhaustifications** (Fox 2007)
$O_R\Diamond[p \vee q]$

a. The first exhaustification:
$O\Diamond[p \vee q] = \Diamond[p \vee q] \wedge \neg\Diamond[p \wedge q] \wedge \neg\Diamond r$

b. The second exhaustification:
$O'O\Diamond[p \vee q]$
$= O\Diamond[p \vee q] \wedge \neg O\Diamond(p) \wedge \neg O\Diamond(q)$
$= O\Diamond[p \vee q] \wedge [\Diamond p \rightarrow \Diamond q] \wedge [\Diamond q \rightarrow \Diamond p]$
$= [\Diamond[p \vee q] \wedge \neg\Diamond[p \wedge q] \wedge \neg\Diamond r] \wedge [\Diamond p \leftrightarrow \Diamond q]$
$= \Diamond p \wedge \Diamond q \wedge \neg\Diamond[p \wedge q] \wedge \neg\Diamond r$

For an easier comparison with O_{DOU}, I simplify the definition of O_R as (7.42a): O_R affirms the prejacent, negates the exhaustification of each sub-alternative, and negates the innocently excludable alternatives.[38] It can be easily seen that O_{DOU} is semantically weaker than O_R: both O_{DOU} and O_R

[38] In particular cases, the definition for O_R in (7.42a) yields inferences different from what Fox's proposal would expect: if the exhaustification of a sub-alternative is still not innocently excludable, the exhaustification of this sub-alternative would not be negated by O_R under Fox's original definition. For instance, in (i), if we use definition (7.42a), affirming the prejacent and negating the exhaustification of each sub-alternative yield a contradiction. In contrast, if we follow Fox's definition strictly, the D-alternatives $O\phi_\exists$ and $\phi_\forall$ are not innocently excludable even if pre-exhaustified; hence applying O_R does not exhaustify the D-alternatives and does not yield a contradiction.

(i) John read (only) some or all of the books.
a. Prejacent: $O\phi_\exists \vee \phi_\forall$
b. $\textsc{Sub}(O\phi_\exists \vee \phi_\forall) = \{O\phi_\exists, \phi_\forall\}$
c. By definition (7.42), applying O_R yields a contradiction:
$[O\phi_\exists \vee \phi_\forall] \wedge \neg OO\phi_\exists \wedge \neg O\phi_\forall = [O\phi_\exists \vee \phi_\forall] \wedge \neg[\phi_\exists \wedge \neg\phi_\forall] \wedge \neg\phi_\forall = [O\phi_\exists \vee \phi_\forall] \wedge \neg\phi_\exists = \bot$
d. By Fox's original definition, O_R would be applied vacuously:
$O_R[O\phi_\exists \vee \phi_\forall] = O\phi_\exists \vee \phi_\forall$

The same contrast arises in sentence (ii), where a disjunctive coordinates two exhaustified propositions. Here the disjuncts $O\phi_a$ and $O\phi_b$ are not innocently excludable even if pre-exhaustified.

(ii) (Among Andy and Billy,) only Andy came or only Billy came.
a. Prejacent: $O\phi_a \vee O\phi_b$
b. $\textsc{Sub}(O\phi_a \vee O\phi_b) = \{O\phi_a, O\phi_b\}$
c. By definition (7.42), applying O_R yields a contradiction:
$[O\phi_a \vee O\phi_b] \wedge \neg OO\phi_a \wedge \neg OO\phi_b = [O\phi_a \vee O\phi_b] \wedge \neg O\phi_a \wedge \neg O\phi_b = \bot$

affirm the prejacent and negate the exhaustification of the sub-alternatives, but O_{DOU} does not negate the innocently excludable alternatives.

(2.84) a. $O_R(p) = p \wedge \forall q \in \textsc{Sub}(p)[\neg O(q)] \wedge \forall q' \in \textsc{IExcl}(p)[\neg q']$
b. $O_{\text{DOU}}(p) = p \wedge \forall q \in \textsc{Sub}(p)[\neg O(q)]$

Chierchia (2006, 2013) proposes an $O_{\text{D-EXH}}$-operator for D-alternatives to derive free choice inferences. I summarize this idea as follows. First, the lexicon of a disjunction carries a grammatical feature [+D], which activates a set of D-alternatives and must be checked off by a c-commanding O_{D} or $O_{\text{D-EXH}}$-operator. Second, in semantics, employing O_{D} negates the D-alternatives, while employing $O_{\text{D-EXH}}$ negates the exhaustification of each D-alternative.

(2.85) **Exhaustifiers for D-alternatives** (Chierchia 2006, 2013)
a. $O_{\text{D}}(p) = p \wedge \forall q \in \text{D-Alt}(p)[\neg q]$
b. $O_{\text{D-EXH}}(p) = p \wedge \forall q \in \text{D-Alt}(p)[\neg O(q)]$

The choice between O_{D} and $O_{\text{D-EXH}}$ is arbitrary unless employing one of them leads to a contradiction. Compare the following two sentences for a demonstration. In checking off the [+D] feature of the disjunctive *or*, the $\Diamond$-sentence (2.86) must use $O_{\text{D-Exh}}$ while the $\Box$-sentence (2.87) must use O_{D}, giving rise to a contradiction otherwise.[39]

(2.86) You can read some or all of the books.
a. $\Diamond[O\phi_\exists \vee_{[+\text{D}]} \phi_\forall]$ prejacent
b. $\Diamond[O\phi_\exists \vee \phi_\forall] \wedge \neg\Diamond O\phi_\exists \wedge \neg\Diamond\phi_\forall = \bot$ #applying O_{D}
c. $\Diamond[O\phi_\exists \vee \phi_\forall] \wedge \neg O\Diamond O\phi_\exists \wedge \neg O\Diamond\phi_\forall = \Diamond O\phi_\exists \wedge \Diamond\phi_\forall$ OKapplying $O_{\text{D-Exh}}$
(You can read some of the books, and you can read all of the books.)

(2.87) You must read some or all of the books.
a. $\Box[O\phi_\exists \vee_{[+\text{D}]} \phi_\forall]$ prejacent
b. $\Box[O\phi_\exists \vee \phi_\forall] \wedge \neg\Box O\phi_\exists \wedge \neg\Box\phi_\forall = \Box\phi_\exists \wedge \Diamond O\phi_\exists \wedge \Diamond\phi_\forall$ OKapplying O_{D}
(You must read some or all of the books, you can read some of them, and you can read all of them.)
c. $\Box[O\phi_\exists \vee \phi_\forall] \wedge \neg O\Box O\phi_\exists \wedge \neg O\Box\phi_\forall = \Box O\phi_\exists \wedge \Box\phi_\forall = \bot$ #applying $O_{\text{D-Exh}}$

A major difference is that $O_{\text{D-EXH}}$ targets D-alternatives while O_{DOU} targets sub-alternatives. D-alternatives are defined grammatically; they grow point-wise from disjuncts or sub-domains.

d. By Fox's original definition, O_R would be applied vacuously:
$O_R[O\phi_a \vee O\phi_b] = O\phi_a \vee O\phi_b$

[39]The disjunct $\phi_\exists$ is locally exhaustified due to the well-known *Hurford's Constraint* (Hurford 1974): a sentence that contains a disjunctive phrase of the form 'S or T' is infelicitous if S entails T or T entails S.

(i) $O\phi_\exists = \phi_\exists \wedge \neg\phi_\forall$ (You read some but not all of the books.)

I use (2.86) and (2.87) to demonstrate Chierchia's system, so as to avoid the complexities from scalar implicatures of disjunctions. The scalar implicature of $O\phi_\exists \vee \phi_\forall$, namely, $\neg[O\phi_\exists \wedge \phi_\forall]$, is a tautology.

Sub-alternatives are defined purely semantically; they are not innocently excludable and are distinct from the prejacent. Therefore, if a D-alternative is innocently excludable, it will be used by $O_{\text{D-EXH}}$ but not by O_{DOU}; if a sub-alternative is not grammatically derived from a disjunct or a sub-domain, it will be used by O_{DOU} but not by $O_{\text{D-EXH}}$.

For a simple illustration of this difference, let us revisit the two modalized sentences above. In (2.86), the D-alternatives are not innocently excludable and hence O_{DOU} yields the same effect as $O_{\text{D-EXH}}$ does. In (2.87), on the other hand, the D-alternatives are innocently excludable and are not sub-alternatives: $[\Box[O\phi_\exists \vee \phi_\forall] \wedge \neg\Box O\phi_\exists] \not\rightarrow \Box\phi_\forall$. Then, as schematized in (2.88a), applying O_{DOU} is vacuous; when needed, we can further apply a regular O-operator to use up the D-alternatives as in (2.88b), which yields the desired existential free choice inference. Note that the presence of DOU in (2.88b) is optional.

(2.88) You must read some or all of the books.

a. $O_{\text{DOU}}\Box[O\phi_\exists \vee \phi_\forall] = \Box[O\phi_\exists \vee \phi_\forall]$

b. $O[O_{\text{DOU}}\Box[O\phi_\exists \vee \phi_\forall]] = \Box[O\phi_\exists \vee \phi_\forall] \wedge \neg\Box O\phi_\exists \wedge \neg\Box\phi_\forall = \Box\phi_\exists \wedge \Diamond O\phi_\exists \wedge \Diamond\phi_\forall$

In comparison, Fox's (2007) O_R-operator negates innocently excludable alternatives and pre-exhaustified sub-alternative, and hence the interpretations of (2.86) and (2.87) cannot be handled with a single O_R.

(2.89) a. You can read some or all of the books.
$O_R\Diamond[O\phi_\exists \vee \phi_\forall] = \Diamond[O\phi_\exists \vee \phi_\forall] \wedge \neg O\Diamond O\phi_\exists \wedge \neg O\Diamond\phi_\forall = \Diamond O\phi_\exists \wedge \Diamond\phi_\forall$

b. You must read some or all of the books.
$O_R\Box[O\phi_\exists \vee \phi_\forall] = \Box[O\phi_\exists \vee \phi_\forall] \wedge \neg\Box O\phi_\exists \wedge \neg\Box\phi_\forall = \Box\phi_\exists \wedge \Diamond O\phi_\exists \wedge \Diamond\phi_\forall$

Table 2.2 summarizes the three approaches of free choice in modalized sentences.

	Proposed	Chierchia	Fox
You can read some or all of the books.	O_{DOU}	$O_{\text{D-EXH}}$	O_R
You must read some or all of the books.	$O(+O_{\text{DOU}})$	O_{D}	O_R

Table 2.2: Comparison of exhaustifiers

In section 2.6.3, I have shown that in $\Diamond$-questions applying an O_{DOU}-operator above the existential modal derives disjunctive mention-all answers. This approach coincides with the fact that the presence of the Mandarin particle *dou* above the existential modal blocks mention-some. What will happen if we instead use O_R or $O_{\text{D-EXH}}$?

These two exhaustifiers are of course not covert counterparts of the Mandarin particle *dou*. The O_R-operator invokes an exclusive inference, which is not observed with *dou*. For example, 'John and Mary **dou** came' does <u>not</u> suggest that <u>only</u> John and Mary came. The $O_{\text{D-EXH}}$-operator always operates on D-alternatives; therefore, it cannot capture the other functions of *dou*, such as the distributor use and the scalar marker use. See chapter 7 for discussions of these uses.

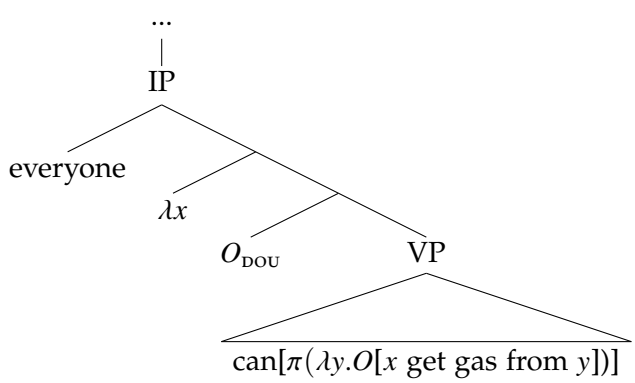
Put aside the facts of *dou* for a moment. Can we use these two exhaustifiers to derive disjunctive mention-all answers? Consider the question in (2.90), where a $\Diamond$-construction is embedded under a

universal quantifier.[40] Intuitively, the disjunctive answer given by Speaker B is a true mention-all answer, meaning that everyone can get gas from A and can get gas from B.

(2.90) (Context: *As for the considered gas stations ABC, A and B are accessible to everyone, but C is only accessible to John; each station has very limited stock and cannot serve all the people.*)
Speaker A: 'Where can everyone get gas?'
Speaker B: 'Station A or station B.'

The proposed analysis predicts the following LF for the question nucleus: an O_{DOU}-operator is inserted right above the existential modal and is associated with the higher-order *wh*-trace π.

(2.91) Where can everyone get gas?



The disjunctive answer 'Station A or station B' is interpreted as in (2.92):

(2.92) $\forall x \in \mathit{hmn}_{@} O_{\text{DOU}} \Diamond [Of(x,a) \vee Of(x,b)]$
$= \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,a) \wedge \Diamond Of(x,b)]$
(Everyone is such that he can get gas from A and he can get gas from B.)

Employing Chierchia's (2006, 2013) $O_{\text{D-EXH}}$-operator also yields the desired semantics for (2.90), but this idea suffers some conceptual problems. On the positive side, employing $O_{\text{D-EXH}}$ yields the desired free choice inference regardless of whether it is applied below or above the universal quantifier. This is so because the $O_{\text{D-EXH}}$-operator always negates the pre-exhaustified D-alternatives, regardless of whether the domain alternatives are innocently excludable.

(2.93) a. $\forall x \in \mathit{hmn}_{@} O_{\text{D-EXH}} \Diamond [Of(x,a) \vee Of(x,b)]$
$= \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,a) \wedge \Diamond Of(x,b)]$

b. $O_{\text{D-EXH}} \forall x \in \mathit{hmn}_{@} \Diamond [Of(x,a) \vee Of(x,b)]$
$= \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,a) \wedge \Diamond Of(x,b)] \wedge$
$\neg O \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,a)] \wedge \neg O \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,b)]$
$= \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,a) \wedge \Diamond Of(x,b)] \wedge$
$\forall x \in \mathit{hmn}_{@} [\Diamond Of(x,a)] \leftrightarrow \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,b)]$
$= \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,a)] \wedge \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,b)]$

[40] With the condition that none of the stations can serve all the people, the existential modal must take scope below the universal quantifier, otherwise the question has no true answer in the given discourse.

On the negative side, the application of $O_{\text{D-EXH}}$ is assumed to be motivated by the syntactic requirement of checking off a [+D] feature: the [+D] feature activates a set of D-alternatives, and must be checked off by a c-commanding O_D or $O_{\text{D-EXH}}$ operator. Under Chierchia's analysis, this [+D] feature is encoded in the lexicon of a disjunction or an existential indefinite (e.g., *any*). Accordingly, to license the presence of O_{D} in the question (2.91), one would have to assume that the *wh*-trace π is lexically encoded with a [+D] feature, which however seems to be quite odd.

Fox's (2007) O_R-operator, on the other hand, yields an overly strong inference. Regardless of whether O_R is applied below or above the universal quantifier *everyone*, it yields an inference that is false in the given discourse. If O_R is applied below *everyone*, it yields the inference that nobody can get gas from C. If O_R is applied above *everyone* as in (2.94b), the D-alternatives are innocently excludable and hence are negated; thus applying O_R would directly negate the true individual answers like "everyone can get gas from station A."

(2.94) a. $\forall x \in \mathit{hmn}_{@} O_R \Diamond [Of(x,a) \vee Of(x,b)]$
$= \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,a) \wedge \Diamond Of(x,b) \wedge \neg \Diamond Of(c)]$
(Everyone is such that he can get gas from A, from B, but not from C.)

b. $O_R \forall x \in \mathit{hmn}_{@} \Diamond [Of(x,a) \vee Of(x,b)]$
$= \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,a) \wedge \Diamond Of(x,b)] \wedge$
$\neg \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,a)] \wedge \neg \forall x \in \mathit{hmn}_{@} [\Diamond Of(x,b)] \wedge ...$
(Every can get gas from A or B, but not everyone can get gas from A, and not everyone can get gas from B, ...)

To solve this problem, Fox has the option of applying O_R locally as in (2.94a) and further assuming that the focus alternative $\Diamond Of(x,c)$ is contextually pruned.

2.8. Summary

This chapter has argued that mention-some readings are a special species of non-exhaustive readings and must be treated grammatically. The proposed treatment of mention-some achieves the advantages of Fox's (2013) analysis and overcomes its insufficiencies. As a desired prediction, any individual answer that specifies one full possible choice can be used as a mention-some answer.

I have also developed two approaches to capture the mention-some/mention-all ambiguity, both of which attribute this ambiguity to a structural ambiguity within the question nucleus. One approach is based on the scope ambiguity of the higher-order *wh*-trace: interpreting the higher-order *wh*-trace above the existential modal yields a conjunctive mention-all answers. The other approach is based on the optional presence of the covert O_{DOU}-operator: applying a covert O_{DOU}-operator above the existential modal generates disjunctive mention-all. The second approach is inspired by observations with the Mandarin particle *dou*: *dou* functions as an exhaustivity-marker in $\Diamond$-questions and evokes universal free choice inferences in disjunctive declaratives.

Chapter 3

Solving the dilemma between uniqueness and mention-some

This chapter proposes a solution to the dilemma between uniqueness and mention-some. As seen briefly in section 1.6.3 and section 2.5.3, a *wh*-question with a singular or a numeral-modified *wh*-phrase triggers a uniqueness effect, namely, that this question can have only one true answer.

(3.1) a. Which boy went to the party?
$\rightsquigarrow$ *Only one of the boys went to the party.*
b. Which two boys went to the party?
$\rightsquigarrow$ *Only two of the boys went to the party.*

This uniqueness effect is standardly analyzed as a result of the so-called "Dayal's presupposition" (Dayal 1996), which requires a question to have a strongest true answer.

Nevertheless, a dilemma arises between uniqueness and mention-some. Dayal's presupposition predicts that a question is undefined if it does not have a strongest true answer. While in chapter 2, the generalization of mention-some that I adopt from Fox (2013) yields the following prediction: a question takes a mention-some reading iff this question can have multiple max-informative true answer, instead of a strongest true answer. Hence, if we stick to Dayal's presupposition, then mention-some would never be grammatically licensed. Alternatively, if we stick to Fox's generalization of mention-some, then we cannot capture the uniqueness effects of singular and numeral-modified *wh*-items.

In addition to uniqueness, Dayal's presupposition is also needed in interpreting questions with a non-monotonic collective predicate, such as (3.2). Without Dayal's presupposition, Fox's generalization of mention-some would predict (3.2) to be a mention-some question, contra fact.

(3.2) Which boys formed a team? (#mention-some; ^{OK}mention-all)

To solve this dilemma, I propose a repair strategy based on the internally lifted interpretations of short answers. This repair strategy preserves the merits of Dayal's presupposition, and also leaves room for mention-some readings. Briefly speaking, if the topical property of a question is defined for generalized conjunctions, internally lifting a generalized conjunction would force

this conjunction to take a wide scope reading. Conversely, if a topical property is only defined for non-scopal elements (e.g., individuals of type e), this repair strategy makes no difference.

3.1. Dayal's presupposition

In this section, I will start with the merits of this presupposition in analyzing uniqueness effects of singular and numeral-modified *wh*-items (§3.1.1). Then I will discuss a problem of Dayal's analysis in interpreting questions with non-monotonic collective predicates, and address this problem based on higher-order readings (§3.1.2).

3.1.1. Uniqueness effects

As a well-known fact, a singular question is subject to a *uniqueness requirement* (Srivastav 1991), namely, it can have only one true answer. A *wh*-question is tagged as "singular" if the NP-complement of its *wh*-item is morphologically marked as singular. Compare the examples in (3.3) for illustration of this requirement. The continuation in (3.3a) is infelicitous because the singular question implies a uniqueness inference that only one of the boys came, which is inconsistent with the second clause. By contrast, this inconsistency disappears if the singular *wh*-phrase *which boy* is replaced with a plural one *which boys* or a bare *wh*-word *who*, as shown in (3.3b) and (3.3c), respectively.

(3.3) a. 'Which boy came? # I heard that many boys did.'
b. 'Which boys came? I heard that many boys did.'
c. 'Who (among the boys) came? I heard that many boys did.'

As mentioned briefly in section 1.6.3, a numeral-modified question (i.e., a *wh*-question in which the *wh*-complement is numeral-modified) is also subject to a uniqueness requirement. For example, the numeral-modified questions in (3.4a) implies that only two of the boys came, and the one in (3.4b) implies that only two or three of the boys came. Both inferences contradict each of their following clauses.

(3.4) a. 'Which two boys came? # I heard that three boys did.'
b. 'Which two or three boys came? # I heard that five boys did.'

Dayal (1996) provides an elegant solution to capture the uniqueness requirements of singular questions. This solution is also applicable to the case of numeral-modified questions. First of all, she defines a presuppositional answerhood-operator, as schematized in (3.5): $\textsc{Ans}_{Dayal}(Q)(w)$ returns the strongest true answer and presupposes the existence of this strongest true answer. This presupposition of $\textsc{Ans}_{Dayal}$ is usually called "Dayal's presupposition".[41]

[41] Another common way to formulate the definition of $\textsc{Ans}_{Dayal}$ is as in (i): $\textsc{Ans}_{Dayal}(Q)(w)$ asserts the conjunction of all the true answers, the same as $\textsc{Ans}_{Heim}(Q)(w)$ (Heim 1994), and presupposes that this conjunction is a possible answer.

(i) a. $\textsc{Ans}_{Dayal}(Q)(w) = \bigcap\{p : w \in p \in Q\} \in Q.\bigcap\{p : w \in p \in Q\}$
b. $\textsc{Ans}_{Heim}(Q)(w) = \bigcap\{p : w \in p \in Q\}$

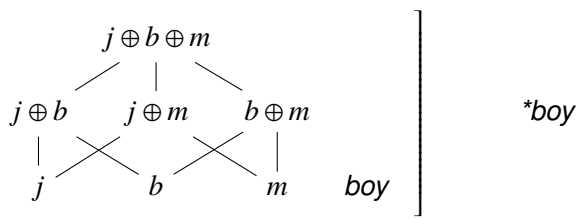
(3.5) **Dayal's answerhood-operator**

$\textsc{Ans}_{Dayal}(Q)(w) = \exists p[w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow p \subseteq q]].$
$\iota p[w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow p \subseteq q]]$

($\textsc{Ans}_{Dayal}(Q)(w)$ is defined iff the set of answers in Q that are true in w has a strongest member; when defined, $\textsc{Ans}_{Dayal}(Q)(w)$ returns this unique strongest true answer.)

Next, Dayal adopts the ontology of individuals from Sharvy (1980) and Link (1983): as exemplified in (3.6), a singular NP *boy* denotes a set of atomics, while a plural NP *boys* denotes a set closed under mereological sum, ranging over both atomic and sum domains. Applied to *wh*-phrases, Dayal gets an existential quantifier that lives on the set of atomic boys for *which boy*, and an existential quantifier that lives on the set consisting of both atomic and sum boys for *which boys*.

(3.6) $\textit{*boy}' = \{\bigoplus X : X \subseteq \textit{boy}\}$, where $\bigoplus X$ refers to the sum of all the members of X.



Finally, adopting Hamblin-Karttunen Semantics, Dayal predicts that the Hamblin set yielded by a plural question (3.7a) is richer than the one yielded by its singular counterpart (3.7b): the former set includes both singular answers (i.e., propositions naming atomic boys) and plural answers (i.e., propositions naming sum boys), while the latter consists of only singular answers. As a consequence, under a discourse where both Andy and Bill came, (3.7a) has a strongest true answer $\textit{came}(a \oplus b)$ while (3.7b) does not. Then employing $\textsc{Ans}_{Dayal}$ in (3.7b) gives rise to a presupposition failure. To avoid this presupposition failure, (3.7b) can only be evaluated in a world where only one of the boys came, which therefore explains its uniqueness requirement.

(3.7) (Context: *Among the considered boys, only Andy and Billy came.*)

a. Which boys came?
   i. $Q = \{\textit{came}(x) : x \in \textit{*boy}_{@}\}$
   ii. $Q_w = \{\textit{came}(a), \textit{came}(b), \textit{came}(a \oplus b)\}$
   iii. $\textsc{Ans}_{Dayal}(Q)(w) = \textit{came}(a \oplus b)$

b. Which boy came?
   i. $Q = \{\textit{came}(x) : x \in \textit{boy}_{@}\}$
   ii. $Q_w = \{\textit{came}(a), \textit{came}(b)\}$
   iii. $\textsc{Ans}_{Dayal}(Q)(w)$ is undefined

Generally speaking, a question constantly fulfills Dayal's presupposition only if its answer space satisfies the following condition:[42]

[42]This condition is necessary but not yet sufficient. For instance, in accounting for the negative island effect in the

(3.8) **Condition to fulfill Dayal's presupposition constantly**
$\forall p \in Q \forall q \in Q[[p \cap q \neq \varnothing] \rightarrow (p \cap q) \in Q]$
(For any two propositions in Q, if they are not mutually exclusive, then their conjunction is also in Q.)

Two categories of questions satisfy this condition. One category is formed by the questions whose possible answers are all mutually exclusive, such as yes-no questions and questions taking only exhaustified answers, as exemplified in (3.9a) and (3.9b), respectively. Those questions can have only a unique true answer.

(3.9) a. Did John come?
b. Only John came or only Mary came?

The other category is formed by the ones whose answer space is closed under mereological conjunction formation, such as the plural question in (3.7a). Questions falling in this category can have multiple true answers. An answer space Q is closed under conjunction iff the conjunction of any propositions in Q is also a member of Q.

3.1.2. Questions with collective predicates

Dayal (1996) has considered only *wh*-questions with distributive predicates. In a question of this sort, as we saw above in (3.7), its answer space is closed under conjunction as long as the NP-complement of the *wh*-phrase denotes a set closed under sum.

Nevertheless, this generalization does not extend to the case of questions with non-monotonic collective predicates. If *which boys* quantifies over $^*\mathsf{boy}$, as Dayal assumes, then the Hamblin set yielded by (3.10) would be like (3.10a). This set, however, does not have a strongest true member under the discourse that the considered boys formed multiple independent teams. Hence, Dayal's analysis incorrectly predicts a uniqueness requirement for the question (3.10).

(3.10) Which boys formed a team?
(Context: *the considered boys formed two teams in total: ab formed one, and cd formed one.*)
a. $Q = \{\mathsf{form}(x) : x \in {}^*\mathsf{boy}_{@}\}$
b. $Q_w = \{\mathsf{form}(a \oplus b), \mathsf{form}(c \oplus d)\}$
c. $\textsc{Ans}_{Dayal}(Q)(w)$ is undefined (#uniqueness)

This undesired prediction can be avoided using my account of *wh*-items (see §1.6.3). Under this account, the Hamblin set can also include conjunctive answers like $\mathsf{form}(a \oplus b) \wedge \mathsf{form}(c \oplus d)$. First, the live-on set of *wh*-NP is closed under conjunction and disjunction iff this NP is closed under sum, by virtue of a †-operation in the *wh*-determiner.

---

degree question (i), Fox and Hackl (2007) analyze the true answer set of this question as an infinite set, which satisfies the constraint in (3.8) but does not have a strongest member.

(i) How fast didn't John drive?
$Q_w = \{\neg \mathsf{run}(j, d) : d > d_0\}$ where d_0 is John's actual driving speed.

(3.11) *wh*-**determiner**

$[\![\text{wh-}]\!] = \lambda A \lambda f.\exists x \in \dagger A[f(x)]$, where

$$\dagger = \lambda A. \begin{cases} \textsc{min}\{X : A \subseteq X \wedge \forall Y \neq \varnothing[Y \subseteq X \rightarrow \bar{\bigvee} Y \in X \wedge \bar{\bigwedge} Y \in X]\} & \text{if } {}^*A = A \\ A & \text{otherwise} \end{cases}$$

(For any set A, if A is closed under sum, then $\dagger A$ is the minimal superset of A that is closed under generalized conjunction and disjunction; otherwise $\dagger A = A$)

Accordingly, the live-on set of a plural or number-neutral *wh*-item consists of not only individuals but also generalized disjunctions and conjunctions. For instance, the live-on set of *which boys* is †*boy′, which consists of not only the individual domain *boy′ but also generalized conjunctions and disjunctions over *boy′.

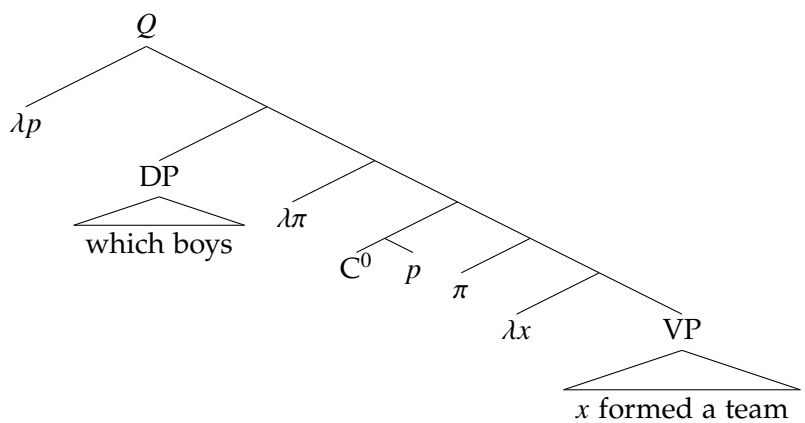
(3.12) $\textsc{Be}([\![\text{which boys}'_{@}]\!]) = \dagger {}^*\mathit{boy}_{@} = \left\{ \begin{array}{l} a, b, \ldots\ a \oplus b, \ldots \\ a \bar{\wedge} b, a \bar{\vee} b, a \bar{\wedge} a \oplus b, \ldots \\ (a \bar{\wedge} b) \bar{\vee} b, \ldots \end{array} \right\}$

Second, items that are of the same semantic type as the highest *wh*-trace can be used to form propositional answers. For instance, as illustrated in (3.13a) using a Karttunen-style way of composition, if *which boys* undergoes a local QR from x to π before moving to the spec of CP, then the Hamblin set will be derived based on generalized conjunctions and disjunctions over **boy*. The obtained Hamblin set (3.13b) is closed under conjunction. Applying $\textsc{Ans}_{Dayal}$ returns the following conjunctive answer: *ab formed a team and cd formed a team*.

(3.13) Which boys formed a team?

(Context: *The considered boys formed two teams in total. ab formed one, and cd formed one.*)

a.



b. $Q = \{\pi(\lambda x.\mathit{form}(x)) : \pi_{\langle et,t\rangle} \in \dagger {}^*\mathit{boy}_{@}\}$

c. $Q_w = \left\{ \begin{array}{l} \mathit{form}(a \oplus b) \\ \mathit{form}(c \oplus d) \\ \mathit{form}(a \oplus b) \wedge \mathit{form}(c \oplus d) \\ \mathit{form}(a \oplus b) \vee \mathit{form}(c \oplus d) \end{array} \right\}$

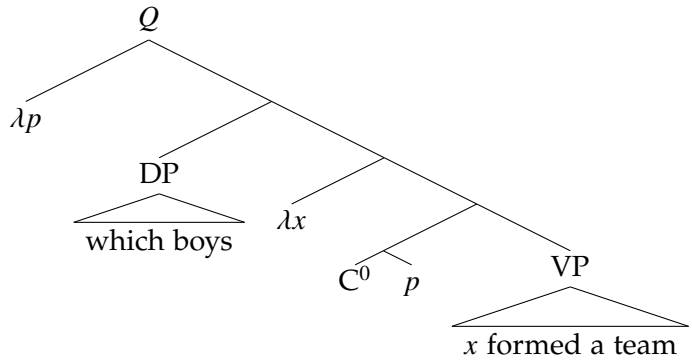
d. $\textsc{Ans}_{Dayal}(Q)(w) = \mathit{form}(a \oplus b) \wedge \mathit{form}(c \oplus d)$ (√ mention-all)

By contrast, if *which boys* does not take a local QR before the *wh*-movement, as illustrated in the LF (3.14a), then only individual boys can be used to form propositional answers. The resulted Hamblin

set is not closed under conjunction and does not support Dayal's presupposition, just like we just saw in (3.10).

(3.14) Which boys formed a team?
(Context: *The considered boys formed two teams in total. ab formed one, and cd formed one.*)

a.



b. $Q = \{\mathit{form}(x) : x_e \in \dagger{}^{*}\mathit{boy}_{@}\}$

c. $Q_w = \{\mathit{form}(a \oplus b), \mathit{form}(c \oplus d)\}$

d. $\textsc{Ans}_{Dayal}(Q)(w)$ is undefined

Thinking about this issue from a different perspective, we can also say that Dayal's presupposition motivates the local QR in (3.13a). With this local QR, this question takes a higher-order reading (3.15b), which yields an answer space closed under conjunction; without this local QR, the question takes an individual reading (3.15a), which yields an answer space not closed under conjunction.

(3.15) Which boys formed a team?

a. *Individual reading*
'What is an item x such that x is a plural boy and x formed a team?'
$Q = \{\mathit{form}(x) : x_e \in \dagger{}^{*}\mathit{boy}_{@}\}$ (Q is not closed under conjunction)

b. *Higher-order reading*
'What is a generalized quantifier π such that π is a conjunction or disjunction over boys and that π formed a team?'
$Q = \{\pi(\lambda x.\mathit{form}(x)) : \pi_{\langle et,t\rangle} \in \dagger{}^{*}\mathit{boy}_{@}\}$ (Q is closed under conjunction)

3.2. The dilemma

A dilemma arises between Dayal's presupposition and the generalization of mention-some adopted from Fox (2013): Dayal predicts that a question is undefined if it does not have a strongest true answer; while Fox predicts that a question takes a mention-some reading iff it can take multiple max-informative true answers instead of a unique strongest true answer.

If we follow Dayal's presupposition, then every question must be interpreted exhaustively, and hence mention-some can never be grammatically licensed. For an illustration, let us revisit the mention-some question (2.37), repeated below. For the purpose of this section, it does not matter whether we use Fox's (2013) derivation of mention-some (see §2.5.2), which predicts the true answer set (3.16a), or the proposed derivation (see §2.6.1), which predicts the true answer set

(3.16b). Both sets have two max-informative members but no strongest member. Employing Dayal's presuppositional answerhood-operator (3.5) based on one of these sets yields a presupposition failure.

(3.16) Who can chair the committee?
(Context: *Only Andy and Billy can chair the committee, and only single-chair is allowed.*)

a. $Q_w = \{\Diamond \mathit{chair}(a), \Diamond \mathit{chair}(b)\}$ (following Fox 2013)

b. $Q_w = \left\{ \begin{array}{l} \Diamond O\mathit{chair}(a), \Diamond O\mathit{chair}(b), \\ \Diamond O\mathit{chair}(a) \vee \Diamond O\mathit{chair}(b) \end{array} \right\}$ (following my proposal)

c. $\textsc{Ans}_{Dayal}(Q)(w)$ is undefined

To avoid this presupposition failure, we would have to make the answer space of (3.16) closed under conjunction using whichever strategies (see §2.6.2 and §2.6.3 for possible strategies); but then only mention-all readings can be grammatically produced. Hence, due to Dayal's presupposition, we would have to attribute the availability of mention-some to pragmatic factors. Nevertheless, as I argued in section 2.4.1, the pragmatic view of mention-some faces a couple of empirical problems.

Alternatively, if we stick to Fox's generalization of mention-some and discard Dayal's presupposition, we would have to face the following unwelcome consequences: (a) unable to capture the uniqueness requirements in singular and numeral-modified questions; and (b) overly predicting mention-some readings.

Recall that Fox (2013) uses a weaker definition of completeness (see §2.5.1): a true answer is complete as long as it is max-informative, namely, not asymmetrically entailed by any of the true answers. On this definition of completeness, a question takes a mention-some reading iff it can have multiple max-informative true answers. Applying this generalization to the singular question (3.17), however, we predict an unwelcome mention-some reading, because both of the true answers are max-informative. Hence, Fox's generalization of mention-some predicts that singular questions are mention-some questions, which is apparently incorrect.

(3.17) Which boy came?
(Context: *Among the boys, only John and Bill came.*)

a. $Q_w = \{\mathit{came}(j), \mathit{came}(b)\}$

b. $\textsc{Ans}_{Fox}(Q)(w) = \{\mathit{came}(j), \mathit{came}(b)\}$ (× mention-some)

Moreover, discarding Dayal's presupposition also causes problems in interpreting questions with non-monotonic collective predicates. Recall that the question (3.15), repeated below, yields an answer space closed under conjunction only under its higher-order reading. In case the boys formed multiple teams, employing Dayal's presupposition yields a desired result: it blocks the individual reading due to presupposition failure, and yields a mention-all answer based on the answer space created under the higher-order reading. Without Dayal's presupposition, however, we cannot block the individual reading. Then, as shown in (3.18a), applying Fox's generalization of mention-some predicts a mention-some reading, contra fact.

(3.18) Which boys formed a team?
(Context: *The considered boys formed two teams in total. ab formed one, and cd formed one.*)

a. What is an item x such that x is a plural boy and x formed a team?
   i. $Q = \{\mathit{form}(x) : x_e \in \dagger{}^*\mathit{boy}_{@}\}$
   ii. $Q_w = \{\mathit{form}(a \oplus b), \mathit{form}(c \oplus d)\}$
   iii. $\textsc{Ans}_{Dayal}(Q)(w)$ is undefined
   iv. $\textsc{Ans}_{Fox}(Q)(w) = \{\mathit{form}(a \oplus b), \mathit{form}(c \oplus d)\}$ (× mention-some)

b. What is a generalized quantifier π such that π is a conjunction or disjunction over boys and that π formed a team?
   i. $Q = \{\pi(\lambda x.\mathit{form}(x)) : \pi_{\langle et,t\rangle} \in \dagger{}^*\mathit{boy}_{@}\}$
   ii. $Q_w = \left\{ \begin{array}{l} \mathit{form}(a \oplus b),\ \mathit{form}(c \oplus d) \\ \mathit{form}(a \oplus b) \wedge \mathit{form}(c \oplus d) \\ \mathit{form}(a \oplus b) \vee \mathit{form}(c \oplus d) \end{array} \right\}$
   iii. $\textsc{Ans}_{Dayal}(Q)(w) = \mathit{form}(a \oplus b) \wedge \mathit{form}(c \oplus d)$ (√ mention-all)
   iv. $\textsc{Ans}_{Fox}(Q)(w) = \{\mathit{form}(a \oplus b) \wedge \mathit{form}(c \oplus d)\}$ (√ mention-all)

To sum up the dilemma, Dayal's presupposition and Fox's generalization of mention-some are inconsistent. If we stick to Dayal' presupposition, then mention-some can never be grammatically licensed; if we abandon Dayal's presupposition and follow Fox's generalization of mention-some, then the following two types of questions would be incorrectly predicted to be mention-some questions: (i) questions that are subject to uniqueness requirements, and (ii) questions with non-monotonic collective predicates.

3.3. Fox (2013) on uniqueness

To solve the dilemma between uniqueness and mention-some, Fox (2013) adds two assumptions to his initial proposal (see §2.5 for his initial proposal). First, contrary to the case of singular *wh*-questions, number-neutral *wh*-questions can obtain propositional answers based on generalized conjunctions and disjunctions. Motivation for this assumption has been explained in section 1.6. Briefly speaking, this assumption was firstly made to capture the contrast of the following two questions: the disjunction can be interpreted as scoping below the universal modal in (3.19) but not in (3.20).

(3.19) a. What does John have to read?
   b. *Syntax* or *Morphology*. (^{OK}*or* > *have to*; ^{OK} *have to* > *or*)

(3.20) a. Which book does John have to read?
   b. *Syntax* or *Morphology*. (^{OK}*or* > *have to*; # *have to* > *or*)

Due to Spector (2007), the narrow scope reading of an elided disjunction arises when the underlying question takes the following higher-order reading: 'for which increasing generalized quantifier G is such that John has to read G?' To obtain this reading, the *wh*-item needs to be quantifying over of set of increasing generalized quantifiers. For instance, in (3.19), *what* is semantically ambiguous, it either lives on a set of individuals $^*\mathit{thing}_{@}$, or a set of increasing generalized quantifiers over

**thing*$_{@}$.[43] Fox adopts this idea and assumes that a singular *wh*-phrase lives on a set of atomic individuals, which therefore predicts the absence of the narrow scope reading of the disjunction in (3.20). Extending this idea to $\Diamond$-questions, Fox predicts the following contrast: compared with the case of (3.21a), (3.21b) has one more true answer based on the generalized disjunction $j \bar{\vee} m$.

(3.21) (Context: *the committee can and can only be chaired by either John or Mary.*)

a. Which professor can chair the committee?
$Q_w = \{\Diamond \mathit{chair}(j), \Diamond \mathit{chair}(m)\}$

b. Who can chair the committee?
$Q_w = \{\Diamond \mathit{chair}(j), \Diamond \mathit{chair}(m), \Diamond \mathit{chair}(j \bar{\vee} m)\}$

Second, Fox proposes that a question is defined iff it has a possible answer whose *innocently exclusive (IE)-exhaustification* is true. This requirement is weaker than Dayal's presupposition and therefore, leaves some space for mention-some.

(3.22) $\textsc{Ans}_{Fox}(Q)(w)$ is defined iff $\exists p \in Q[w \in \text{IE-Exh}(p, Q)]$
(There exists a possible answer p such that the inference of IE-exhaustifying p with respect to the set of possible answers is true.)

Compared with traditional exhaustification, IE-exhaustification negates only innocently excludable alternatives (Fox 2007), as defined in (3.23). The definition of innocently excludable alternatives is repeated below. An proposition q is innocently excludable to p with respect to Q iff q satisfies the following two conditions: (i) q is in Q; (ii) $p \wedge \neg q$ is consistent with negating any other proposition in Q that is not entailed by p.

(3.23) **Innocently exclusive exhaustification**
$\text{IE-Exh}(p, Q) = \lambda w[p(w) = 1 \wedge \forall q \in \textsc{IExcl}(p, Q)[q(w) = 0]]$

(3.24) **Innocently excludable alternatives**
$\textsc{IExcl}(p, Q) = \{q : q \in Q \wedge \neg\exists q' \in \textsc{Excl}(p)[p \wedge \neg q \rightarrow q']\}$
where $\textsc{Excl}(p) = \{q : q \in Q \wedge p \not\subseteq q\}$

The presupposition of $\textsc{Ans}_{Fox}$ is satisfied in (3.21b) but not in (3.21a), due to the distinction with respect to the availability of the higher-order disjunctive answer. In (3.21b), among the three true answers, the individual answers are not innocently excludable to the disjunctive answer, because affirming the disjunctive answer and negating one of the individual answer entails the other individual answer (formally: $[\Diamond \mathit{chair}(j \bar{\vee} m) \wedge \neg\Diamond \mathit{chair}(j)] \rightarrow \Diamond \mathit{chair}(m)]$); hence, IE-exhaustifying $\Diamond \mathit{chair}(j \bar{\vee} m)$ does not yield the negation of any of the true answers. In contrast, (3.21a) has no answer whose IE-exhaustification is true: IE-exhaustifying $\Diamond \mathit{chair}(j)$ yields the negation of the other true answer $\Diamond \mathit{chair}(m)$, and vice versa.

Fox's account of uniqueness, however, yields problematic predictions in questions with quantifiers. The presupposition of $\textsc{Ans}_{Fox}$ is still too strong to rule in individual mention-some readings of questions with universal quantifiers. Consider the question (3.26) for a concrete example. Due

[43] What I proposed in section 1.6.4 is slightly difference from Spector's and Fox's assumptions.

to the scope ambiguity of the universal quantifier, this question has two types of mention-some readings, as paraphrased below.

(3.25) Where can everyone get gas?

a. Individual mention-some reading:
'Tell me one of the places where everyone can get gas.'

b. Pair-list mention-some reading:
'For each individual, tell me one of the places where he can get gas.'

Let us focus on the individual mention-some reading. Extending Fox's analysis to this question, we obtain a Hamlin set as in (3.26a). The true answer set (3.26b) consists of two individual answers and a disjunctive answer.

(3.26) Where can everyone get gas?
(Context: *Only station A and station B are accessible to everyone; everyone is only allowed to go to one gas place. Moreover, AB both have a limited stock, and thus not everyone can get gas from them*[44])

a. $Q = \{\forall y \in \textit{hmn}_{@}[\Diamond \textit{get-gas}(y, x)] : x \in \textit{*place}\}$

b. $Q_w = \left\{ \begin{array}{l} \forall y \in \textit{hmn}_{@}[\Diamond \textit{get-gas}(y, a)] \\ \forall y \in \textit{hmn}_{@}[\Diamond \textit{get-gas}(y, b)] \\ \forall y \in \textit{hmn}_{@}[\Diamond \textit{get-gas}(y, a \bar{\vee} b)] \end{array} \right\}$

c. $\text{IE-Exh}[\forall y \in \textit{hmn}_{@}[\Diamond \textit{get-gas}(y, a \bar{\vee} b)]] \Rightarrow \neg \forall y \in \textit{hmn}_{@}[\Diamond \textit{get-gas}(y, a)]$
$\Rightarrow \neg \forall y \in \textit{hmn}_{@}[\Diamond \textit{get-gas}(y, b)]$

d. $\textsc{Ans}_{Fox}(Q)(w)$ is undefined Problem!

Unlike the case in (3.21a), here the true individual answers are innocently excludable to the true disjunctive answer. Thus, as schematized in (3.21c), IE-exhaustifying the disjunctive answer negates the individual ones, yielding the following false inference: some but not all of the people can get gas from A, the others can get gas from B. Therefore, the presupposition of Ans_{Fox} defined in (3.22) predicts that (3.26) is undefined in the given discourse, contra fact.

This problem also extends to the following questions:

(3.27) a. Where can half of your friends get gas?

b. Where can most of your friends get gas?

3.4. Proposal

We have seen a couple of good reasons to keep Dayal's presupposition. In the case that a question takes a mention-some reading, we need a repair strategy to salvage the presupposition failure. I propose that, in search of the strongest true answer, short answers can be interpreted as if they took a wide scope, or say, scope reconstruction can be neglected. In a $\Diamond$-question, interpreting the short

[44] The latter condition rules out the reading where *everyone* scopes below *can*. For instance, the following proposition is false: $\Diamond \forall y \in \textit{hmn}_{@}[\textit{get-gas}(y, a \bar{\vee} b)]$

answers with a wide scope yields conjunctive mention-all, which easily fulfills Dayal's presupposition. Technically, this wide scope interpretation can be obtained via the type-shifting operation called *internal lift*: internally lifting a generalized quantifier yields a wide scope interpretation of this quantifier (Shan and Barker 2006, Barker and Shan 2014, Charlow 2014).

3.4.1. Scope ambiguity and type-lifting

There are, quite generally, two ways to model quantifier scope ambiguity. One way is to determine quantifier scope syntactically by quantifier raising (May 1985). The other way conceives this scope ambiguity semantically as a result of type-shifting. Representative type-shifting operations are argument raising for verbs (Hendriks 1993), function-argument flip flop (Partee and Rooth 1983), and the continuation passing style (CPS) transforms used in continuation-based works (Shan and Barker 2006, Barker and Shan 2014, Charlow 2014).

In the tradition of Montague grammar, a type-shifting operation LIFT turns a proper name like *John* (of type e) into a generalized quantifier (of type $\langle et, t\rangle$): $\textsc{Lift}([\![\text{John}]\!]) = \lambda P_{\langle e,t\rangle}.P(j)$. With the development of type theories, LIFT is conceived as a more liberal operation. For instance, Partee and Rooth (1983) generalize LIFT as an operation called "argument-to-function flip flop," which can be applied successively. The semantics of LIFT is generalized as in (3.28) due to Partee (1986): LIFT turns an item of type τ to a higher-order item of type $\langle \tau t, t\rangle$.

(3.28) $\textsc{Lift}(m_\tau) = \lambda k_{\langle \tau,t\rangle}.k(m)$ $\qquad \tau \Rightarrow \langle \tau t, t\rangle$

In the case of type-lifting a generalized quantifier, the continuation-based grammar (Barker 2002; Barker and Shan 2014; Shan 2004; Shan and Barker 2006, among others) allows LIFT to be applied externally or internally, as defined in (3.29a) and (3.29b), respectively. Following Charlow (2014), I use '↑' for external lift, which is simply the classic LIFT, and '↑↑' for internal lift. Crucially, internally lifting an expression to a higher type can allow it to take wider scope, including scoping over elements that precede it.

(3.29) $m = \lambda k.m(\lambda v.k(v))$

a. *External lift*
$m^{\uparrow} = \lambda Q.Q(\lambda k.m(\lambda v.k(v)))$

b. *Internal lift*
$m^{\uparrow\uparrow} = \lambda Q.m(\lambda v.Q(\lambda k.k(v)))$

I will not get to the actual system of the continuation-based grammar, but simply borrow its idea of internal lift for achieving wide scope readings of generalized quantifiers. Consider the sentence (3.30) for illustration. For the sake of simplicity, I use the extensional type t as oppose to the intensional type $\langle s, t\rangle$, and consider *John must invite* a predicate taking the generalized quantifier *someone* as an argument. In (3.30c), applying *John must invite* to the generalized quantifier *someone* yields a surface scope reading (*must* > *someone*): 'John must invite someone, and the choice is up to him.'

(3.30) John must invite someone.

a. $[\![\text{someone}]\!] = \lambda P.\exists x[P(x)]$ $\qquad \langle et, t\rangle$

b. $[\![\text{John must invite}]\!] = \lambda\pi.\Box\pi(\lambda x.\text{invite}'(j,x))$ $\langle ett,t\rangle$

c. $[\![\text{John must invite}]\!]([\![\text{someone}]\!]) = \Box\exists x[\text{invite}'(j,x)]$ $(\Box > \exists)$

Now consider the consequences of applying external or internally lift to *someone*. In (3.30d-e), both type-lifting operations raise the semantic type of *someone* from $\langle et,t\rangle$ to $\langle ettt,t\rangle$, and hence *someone* becomes a function that takes *John must invite* as an argument. Nevertheless, as schematized in (3.30f-g), composing the two type-lifted forms of *someone* with *John must invite* yield inferences of distinct scopal orders: applying *someone*$^{\uparrow}$ maintains the narrow scope reading for *someone* relative to *must*, while applying *someone*$^{\uparrow\uparrow}$ yields a wide scope reading for *someone* relative to *must*.

d. $[\![\text{someone}]\!]^{\uparrow} = \lambda Q.Q(\lambda P.\exists x[P(x)])$ $\langle ettt,t\rangle$

e. $[\![\text{someone}]\!]^{\uparrow\uparrow} = \lambda Q.\exists x[Q(\lambda P.P(x)])$ $\langle ettt,t\rangle$

f. $[\![\text{someone}]\!]^{\uparrow}([\![\text{John must invite}]\!])$
$= [\lambda Q.Q(\lambda P.\exists x[P(x)])](\lambda\pi.\Box\pi(\lambda x.\text{invite}'(j,x)))$
$= \Box\exists x[\text{invite}'(j,x)]$ $(\Box > \exists)$

g. $[\![\text{someone}]\!]^{\uparrow\uparrow}([\![\text{John must invite}]\!])$
$= [\lambda Q.\exists x[Q(\lambda P.P(x))]](\lambda\pi.\Box\pi(\lambda x.\text{invite}'(j,x)))$
$= \exists x[\Box\text{invite}'(j,x)]$ $(\exists > \Box)$

3.4.2. Preserving mention-some

Recall that the proposed hybrid categorial approach defines the root denotation of a question as a topical property **P**. The domain of **P** is the set of possible short answers, and the range of **P** is the Hamblin set. Adapting to the hybrid categorial approach, I schematize Dayal's presupposition as follows. The strongest true proposition in a Hamlin set is now the strongest true proposition in the range of **P**.

(3.31) **Dayal's presupposition** (adapted)
$\textsc{Ans}_{Dayal}(\mathbf{P})(w)$ is defined only if
$\exists\alpha \in \text{Dom}(\mathbf{P})[w \in \mathbf{P}(\alpha) \wedge \forall\beta \in \text{Dom}[w \in \mathbf{P}(\beta) \rightarrow \mathbf{P}(\alpha) \subseteq \mathbf{P}(\beta)\}]]$
(there is an item α in the domain of **P** such that $\mathbf{P}(\alpha)$ is the strongest true proposition in the range of **P**.)

Note that here the Ans-operator has a direct access to the short answers, namely, the items in the domain of **P**. This accessibility makes it possible for the Ans-operator to interact with short answers.

In the previous chapters, I have adopted Fox's generalization of mention-some:

(3.32) **Fox's generalization of mention-some**
A question takes a mention-some reading only if it can have multiple max-informative true answers.

To salvage the conflict between Fox's generalization and Dayal's presupposition, I propose that, in search of the strongest true answer, short answers can be interpreted as if they took a wide scope.

Technically, scope flexibility can be achieved by type-shifting, as we just saw in section 3.4.1. Using this technique, I weaken Dayal's presupposition as follows, which allows the strongest true answer to be obtained based on a type-lifted variant of a short answer.

(3.33) **⇑-shifter**

$$\alpha^{\Uparrow} = \begin{cases} \alpha^{\uparrow\uparrow} & \text{if } \alpha^{\uparrow\uparrow} \text{ is defined} \\ \alpha & \text{otherwise} \end{cases}$$

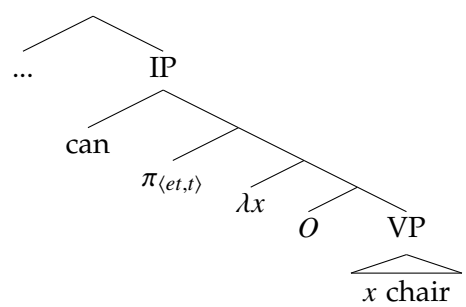
(3.34) **Presupposition of the Ans-operator**
$\textsc{Ans}(\mathbf{P})(w)$ is defined only if
$\exists\alpha \in \mathrm{Dom}(\mathbf{P})[w \in \mathbf{P}(\alpha^{\Uparrow}) \wedge \forall\beta \in \mathrm{Dom}(\mathbf{P})[w \in \mathbf{P}(\beta^{\Uparrow}) \rightarrow \mathbf{P}(\alpha^{\Uparrow}) \subseteq \mathbf{P}(\beta^{\Uparrow})]]$
(there is an item α in the domain of $\mathbf{P}$ such that, based on a type-lifted variant of α, $\mathbf{P}$ yields a true proposition that entails all the true answers.)

Clearly, if the original answer space of a question already contains a strongest true answer, this weakening strategy makes no difference .

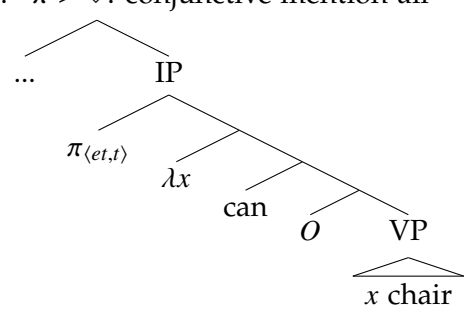
In questions taking mention-some readings, the required strongest true answer can always be obtained based on the internal-lifted variant of a generalized conjunction. Before getting into the solution, let me remind you how we derived the ambiguity between mention-some and mention-all (see §2.6.2): a ◇-question like (3.35) takes a mention-some reading when the higher-order *wh*-trace π takes scope below the existential modal *can*, and a conjunctive mention-all reading otherwise.

(3.35) Who can chair the committee?

a. $\Diamond > \pi$: mention-some



b. $\pi > \Diamond$: conjunctive mention-all



In (3.35b), the wide scope reading of higher-order answers is syntactically derived by quantifier raising. But, just like the case in (3.30), this wide scope reading can also be obtained semantically by internally lifting the higher-order answers. Thus, given the topical property of a mention-some reading, we can retrieve the conjunctive mention-all answer by internally lifting the higher-order short answers.

To be more concrete, see (3.36) for a demonstration. We start with a topical property for the mention-some reading, which is compositionally derived based on the LF in (3.35a). The domain of this property is a set of generalized conjunctions and disjunctions over human individuals. Compare the derivations in (3.36e) and (3.36f): while composing with the same property $\mathbf{P}$, a basic conjunction $a \wedge b$ yields a contradiction, and the internal-lifted conjunction $(a \bar{\wedge} b)^{\Uparrow}$ yields a conjunctive mention-all answer.

(3.36) Who can chair the committee?
(Context: *Only Andy and Billy can chair; only single-chair is allowed.*)

a. $\mathbf{P} = \lambda\pi_{\langle et,t\rangle}[\dagger\mathsf{people}_{@}(\pi) = 1.{}^{\wedge}\Diamond\pi(\lambda x.\mathsf{Ochair}(x))]$

b. $\mathrm{Dom}(\mathbf{P}) = D_{\langle et,t\rangle} \cap \dagger\mathsf{people}_{@} = \{a^{\uparrow}, b^{\uparrow}, a\bar{\vee}b, a\bar{\wedge}b, ...\}$

c. $a\bar{\wedge}b = \lambda P[(a\bar{\wedge}b)(\lambda x.P(x))] = \lambda P[P(a) \wedge P(b)]$

d. $(a\bar{\wedge}b)^{\Uparrow} = \lambda\theta[(a\bar{\wedge}b)(\lambda x.\theta(\lambda P.P(x)))]$
$= \lambda\theta[\theta(\lambda P.P(a)) \wedge \theta(\lambda P.P(b))]$
$= \lambda\theta[\theta(a^{\uparrow}) \wedge \theta(b^{\uparrow})]$

e. $\mathbf{P}(a\bar{\wedge}b) = \Diamond[\mathsf{Ochair}(a) \wedge \mathsf{Ochair}(b)]$ $(\Diamond > \wedge)$

f. $(a\bar{\wedge}b)^{\Uparrow}(\mathbf{P}) = [(\lambda\pi.\Diamond\pi(\lambda x.\mathsf{Ochair}(x)))(a^{\uparrow})] \wedge [(\lambda\pi.\Diamond\pi(\lambda x.\mathsf{Ochair}(x)))(b^{\uparrow})]$
$= [\Diamond a^{\uparrow}(\lambda x.\mathsf{Ochair}(x))] \wedge [\Diamond b^{\uparrow}(\lambda x.\mathsf{Ochair}(x))]$
$= \Diamond\mathsf{Ochair}(a) \wedge \Diamond\mathsf{Ochair}(b)$ $(\wedge > \Diamond)$

g. $\textsc{Ans}(\mathbf{P})(w) = \{{}^{\wedge}\Diamond\mathsf{Ochair}(a), {}^{\wedge}\Diamond\mathsf{Ochair}(b)\}$

From Figure 3.1, it can be nicely seen that a true proposition obtained based on $(a\bar{\wedge}b)^{\Uparrow}$ entails all the true answers, even though the original answer space (the squared part) does not have a strongest true answer. Hence, the presupposition of Ans defined in (3.34) is satisfied. Employing Ans picks out the max-informative true propositions in the original answer space, yielding a set of mention-some answers.

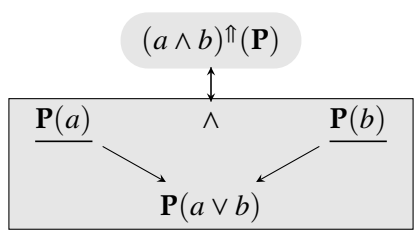


Figure 3.1: The answer space of (3.36) under a mention-some reading
where $\mathbf{P} = \lambda\pi_{\langle et,t\rangle}[\dagger\mathsf{people}_{@}(\pi) = 1.{}^{\wedge}\Diamond\pi(\lambda x.\mathsf{Ochair}(x))]$

3.4.3. Preserving the merits of Dayal's presupposition

Type-shifting a non-scopal expression has no scopal effect. For instance, in (3.37), whichever type-lifting operation is employed, the obtained inference is *Andy came*.[45]

(3.37) Andy came.

a. $[\![\text{Andy}]\!] = a$

b. $[\![\text{came}]\!]([\![\text{Andy}]\!]) = \mathsf{came}(a)$

c. $[\![\text{Andy}]\!]^{\uparrow} = \lambda P.P(a)$

d. $[\![\text{Andy}]\!]^{\uparrow}([\![\text{came}]\!]) = \mathsf{came}(a)$

[45] As Simon Charlow (pers. comm.) points out, the internal-lift operation is not defined on a proper name. But it is possible to internally lift a lifted proper name: $(a^{\uparrow})^{\uparrow\uparrow} = \lambda\theta.a(\lambda x.\theta(\lambda P.P(x))) = \lambda\theta.\theta(a^{\uparrow})$.

e. $(\llbracket \text{Andy} \rrbracket^{\uparrow})^{\uparrow\uparrow} = \lambda\theta.a(\lambda x.\theta(\lambda P.P(x))) = \lambda\theta.\theta(a^{\uparrow})$

f. $(\llbracket \text{Andy} \rrbracket^{\uparrow})^{\uparrow\uparrow}(\llbracket \text{came} \rrbracket^{\uparrow}) = \text{came}^{\uparrow}(a^{\uparrow}) = \mathit{came}(a)$

Hence, in the case that the topical property of a question is defined for only non-scopal items (such as individuals of type e), or say, this question takes an individual reading, the repair strategy would not add any proposition to the original answer space. The merits of Dayal's presupposition are thus preserved.

3.4.3.1. Uniqueness requirements

The singular *wh*-phrase *which boy* lives on a set consisting of only atomic boys (see §1.6.3), which is therefore the only possible domain for the topical property of (3.39). Type-shifting an atomic element, whichever operation is employed, does not change the corresponding propositional answer. For instance, let a stand for the atomic boy *Andy*, $\mathbf{P}(a)$ and $a^{\uparrow}(\mathbf{P})$ both return the singular answer that *a came*. Hence, the proposed repair strategy makes no change to the answer space. In the case that multiple boys came, the presupposition of Ans is not satisfied, which therefore explains the uniqueness requirement. This analysis also extends to numeral-modified questions.

(3.38) $\textsc{Be}(\llbracket \text{which boy}_{@} \rrbracket) = \dagger\mathit{boy}_{@} = \mathit{boy}_{@}$

(3.39) Which boy came?
(Context: *Among the boys, only Andy and Billy came.*)

a. $\mathbf{P} = \lambda x_e[\mathit{boy}_{@}(x) = 1.{}^{\wedge}\mathit{came}(x)]$

b. $\text{Dom}(\mathbf{P}) = \{a, b, ...\} = \mathit{boy}_{@}$

c. true answers: $\{{}^{\wedge}\mathit{came}(a), {}^{\wedge}\mathit{came}(b)\}$

d. $\textsc{Ans}(\mathbf{P})(w)$ is undefined

3.4.3.2. Questions with non-monotonic collective predicates

As seen in example (3.18), re-formulated below using the proposed hybrid categorial approach, in case that a question has a non-monotonic collective predicate, its individual reading gives rise to an unwelcome mention-some interpretation and must be ruled out.

(3.40) Which boys formed a team?
(Context: *The considered boys formed two teams in total. ab formed one, and cd formed one.*)

a. **Individual reading** $\rightsquigarrow$ mention-some #
'What is an item x such that x is a plural boy and x formed a team?'

i. $\mathbf{P} = \lambda x_e[\dagger{}^{*}\mathit{boy}_{@}(x) = 1.{}^{\wedge}\mathit{form}(x)]$

ii. $\text{Dom}(\mathbf{P}) = \dagger{}^{*}\mathit{boy}_{@} \cap D_e = {}^{*}\mathit{boy}_{@}$

iii. True answers: $\{\mathit{form}(a \oplus b), \mathit{form}(c \oplus d)\}$

b. **Higher-order reading** $\rightsquigarrow$ mention-all $\surd$
'What is a generalized quantifier π such that π is a conjunction or disjunction over boys and that π formed a team?'

i. $\mathbf{P} = \lambda\pi_{\langle et,t\rangle}[\dagger{}^{*}\mathsf{boy}_{@}(\pi) = 1.\hat{}\pi(\lambda x.\mathsf{form}(x))]$

ii. $\mathrm{Dom}(\mathbf{P}) = \dagger{}^{*}\mathsf{boy}_{@} \cap D_{\langle et,t\rangle} = \{a^{\uparrow}, b^{\uparrow}, a \barwedge b, ...\}$

iii. True answers: $\{\mathsf{form}(a \oplus b), \mathsf{form}(c \oplus d), \mathsf{form}(a \oplus b) \wedge \mathsf{form}(c \oplus d)\}$

Since the proposed repair strategy makes no difference to individual readings, the presupposition of Ans in (3.34) has the same effects as Dayal's presupposition: in case that the considered boys formed multiple teams, (3.40) cannot obtain an exhaustive answer based on individual boys; hence the individual reading is ruled out due to presupposition failure.

3.4.4. Weak island effects

The proposed analysis for preserving mention-some relies on the scope ambiguity of generalized quantifiers. In a $\Diamond$-question, to obtain a mention-some reading without violating the presupposition of the Ans-operator, the topical property needs to be defined for generalized conjunctions, or equivalently, this question needs to take a higher-order reading. Moreover, the derivation of a higher-order reading involves scope reconstruction (see §1.6.4), which is sensitive to weak islands. For these reasons, I predict that the distribution of mention-some readings is subject to weak island constraints.

The sensitivity to weak island effects is illustrated in the following examples, taken from Spector (2007). In these examples, the narrow scope readings of the elided disjunctions are blocked due to negative islands and factive islands.

(3.41) Speaker A: "Which books didn't Jack read?"
Speaker B: "The French novels or the Russian novels."

a. # NOT [Jack either read the French novels or Russian novels]

b. √ Jack either didn't read the French novels or didn't read Russian novels.

(3.42) Speaker A: "Which books did Mary discover that Jack read?"
Speaker B: "The French novels or the Russian novels."

a. # Mary discovered [that Jack either read the French novels or the Russian novels].
(This inference could be true in the following scenario: Jack read the French novels but not the Russian ones, and Mary discovered that Jack read either the French novels or the Russian novels without knowing that he in fact read the French ones.)

b. √ Either Mary discovered that Jack read the French novels or she discovered that he read the Russian novels.
(This inference presupposes that Jack actually read both the French novels and the Russian novels.)

Extending this idea to modalized questions, we correctly predict the unavailability of mention-some in (3.43), which involves a negative island.

(3.43) Who doesn't have to serve on the committee? (# mention-some)
(Context: *Neither Andy nor Billy have to serve on the committee.*)

a. # [$_{\text{CP}}$ BeDom(who) λx [$_{\text{IP}}$ **not** [have to [x serve on the comm]]]]

b. * [$_{CP}$ BeDom(who) $\lambda\pi$ [$_{IP}$ **not** [have to [π λx [x serve on the comm]]]]]
c. √ [$_{CP}$ BeDom(who) $\lambda\pi$ [$_{IP}$ π λx [**not** [have to [x serve on the comm]]]]]
d. √ [$_{CP}$ BeDom(who) λX [$_{IP}$ each(X) λx [**not** [have to [x serve on the comm]]]]]

The LF (3.43a) yields an individual reading, which however violates the presupposition of the Ans-operator in the given discourse. The LF (3.43b) is similar to the proposed LF for mention-some readings of ◇-questions (see the LF for mention-some in (2.56)); but it is syntactically ill-formed because it involves scope reconstruction across a negative island. The rest two LFs (3.43c-d) are well-formed but yield mention-all readings.

3.5. Anti-presuppositions of plural questions

A plural ◇-question rejects a mention-some answer that names only one atomic individual. Compare the questions in (3.44) and (3.45). If the committee needs one chair but multiple members, mention-some answers of (3.44) and (3.45), if they are available, would be based on atomic individuals and groups of individuals, respectively. With this difference, (3.45) admits both mention-some and mention-all answers, but (3.44) accepts only the mention-all answer (3.44b) and requires the non-exhaustive answer (3.44a) to be ignorance-marked.

(3.44) Which professors can chair the committee?
(Context: *The committee can and can only be chaired by either John or Mary.*)
a. # John.\
a' John..../
b. John and/or Mary.\

(3.45) Which professors can form the committee?
(Context: *The committee can and can only be formed by any two professors among John, Mary, and Sue.*)
a. John+Mary.\
b. John+Mary, John+Sue, and/or Mary+Sue.\

The contrast above is more salient in embedding contexts. Compare the two following indirect questions. (3.46a) requires John to know the mention-all answer of (3.44); while (3.46b) only requires John to know a mention-some answer of of (3.45).

(3.46) a. John knows which professors can chair the committee.
b. John knows which professors can form the committee.

Sauerland et al. (2005) make use of the principle of Maximize Presupposition (Heim 1991) to derive inferences evoked by plurals.

(3.47) **Maximize Presupposition** (Heim 1991)
Out of two sentences which are presuppositional alternatives and which are contextually equivalent, the one with the stronger presuppositions must be used if its presuppositions are met in the context.

Based on this principle, Sauerland et al. (2005) argue that singulars are more presuppositional than plurals, and thus that a plural-morpheme implicates an "anti-presupposition" that the singular counterpart is undefined.

Following this idea, I propose that a plural *wh*-phrase implicates an anti-presupposition, namely, that the corresponding singular question is undefined. Further, in spirit of question-answer congruence, I propose that a proper answer of a plural question needs to entail the anti-presupposition of this question. On this account, the plural question (3.44) rejects mention-some because a mention-some answer names only one individual and does not entail the anti-presupposition that the singular question 'which professor can chair the committee' is undefined. In contrast, (3.45) admits mention-some because its mention-some answers do entail the anti-presupposition that the singular question 'which professor can form the committee' is undefined.

3.6. Summary

This chapter has been centered on the dilemma between uniqueness and mention-some, and more broadly, the conflict between Dayal's presupposition and Fox's (2013) generalization of mention-some. With Dayal's presupposition, mention-some readings can never be grammatically licensed. Without Dayal's presupposition, Fox's generalization predicts undesired mention-some readings for the following questions: (a) questions that are subject to uniqueness requirements (e.g., *which boys came?*); and (b) questions with non-monotonic collective predicates (e.g., *which boys formed a team?*).

Fox (2013) offers a solution to this dilemma based on Spector's (2007, 2008) diagnostic of higher-order answers and the idea of innocent exclusion (Fox 2007). This solution, however, fails in predicting individual mention-some readings of $\Diamond$-questions with quantifiers (e.g., *where can everyone get gas?*).

I propose that, in search of the strongest true answer, short answers with scopal effects can be interpreted as if they took a wide scope. Technically, I weaken Dayal's presupposition by allowing the strongest true answer to be obtained based on a type-lifted variant of a short answer.

In the case of a non-scopal item, type-lifting makes no difference. Therefore, if a question takes an individual reading (i.e., the short answers are all individuals of type e), this repair strategy makes no difference. Therefore my solution preserves the merits of Dayal's presupposition in interpreting questions with uniqueness requirements and questions with non-monotonic collective predicates.

By contrast, in the case of a generalized quantifier, applying internal lift (Shan and Barker 2006) yields a wide scope reading of this quantifier. Hence, if a question takes a higher-order reading (i.e., the short answers are generalized quantifiers), it can always obtain a strongest true answer based on a generalized conjunction. Mention-some readings are thus preserved in $\Diamond$-question admitting higher-order readings. Moreover, since the derivation of a higher-order reading involves scope reconstruction, this account further predicts that the availability of mention-some is subject to weak island constraints.

Following Sauerland et al. (2005), I propose that a plural question implicates an anti-presupposition that the corresponding singular question is undefined. This proposal predicts the fact that a plural $\Diamond$-question (e.g., *which professors can chair the committee?*) rejects a mention-some answer that names only one atomic individual.

Chapter 4

Variations of exhaustivity and sensitivity to false answers

4.1. Introduction

There have been a plenty of studies on the interpretations of indirect questions, especially on the variations of exhaustivity.[46] Most of the studies take weak exhaustivity as the baseline and generate other forms of exhaustivity (i.e., intermediate exhaustivity and strong exhaustivity) using a strengthening operation, such as employing a strong answerhood-operator or strengthening the root denotation. Nevertheless, to unify mention-some and mention-all readings of questions, we have replaced weak exhaustivity with max-informativity. This move requires us to re-consider the derivational procedures of other forms of exhaustivity.

The main goal of this chapter is to characterize the condition of *false answer* (*FA-*)*sensitivity* involved in interpreting indirect questions. For example, for the sentence in (4.1) to be true, John shall not believe any false answers to *who came*.

(4.1) John knows who came.

Previous accounts of FA-sensitivity consider only the case of indirect mention-all questions and treat FA-sensitivity as a result of strengthening weak exhaustivity (Klinedinst and Rothschild 2011, Spector and Egré 2015b, Uegaki 2015). George (2011, 2013) observes that, however, FA-sensitivity is also involved in interpreting indirect mention-some questions, which therefore calls for a uniform treatment of FA-sensitivity across mention-all and mention-some. Moreover, I observe that the content of FA-sensitivity is richer than what the previous accounts thought: it is concerned with not only potential complete answers, but also the answers that are always partial, such as false disjunctive answers and false denials.

The rest of this chapter is organized as follows. Section 4.2 introduces some basic concepts and facts about indirect questions, including the typology of question-embedding predicates and the

[46]Representative studies are list in the following: Karttunen (1977), Groenendijk and Stokhof (1982, 1984), Heim (1994), Ginzburg (1995), Beck and Rullmann (1999), Lahiri (2002), Beck and Sharvit (2002), Sharvit (2002), Guerzoni and Sharvit (2007), George (2011, 2013), Klinedinst and Rothschild (2011), Nicolae (2013, 2015), Spector and Egré (2015a), Kriz (2015), Xiang (2016a), Uegaki (2015), Cremers and Chemla (2016), Cremers (2016), Theiler et al. (2016).

forms of exhaustivity involved in interpreting indirect mention-all questions. Section 4.3 discusses two facts that challenge the current dominant view of FA-sensitivity, including:

(i) Indirect mention-some questions have readings sensitive to false answers;
(ii) FA-sensitivity is also concerned with all types of false answers, not just the answers that are potentially complete.

Section 4.4 reviews and argues against the exhaustification-based account by Klinedinst and Rothschild (2011). Section 4.5 presents my analysis of Completeness and FA-sensitivity. I treat them as two independent conditions. Moreover, I argue that the embedded question should not be flattened into a proposition, otherwise we cannot recover all the relevant answers of the embedded question. Section 4.6 discusses other two puzzling issues:

(i) How is FA-sensitivity interacted with factivity? Why is it that questions embedded under emotive factives (e.g., *surprise*) do not seem to be FA-sensitive?
(ii) Why is it that questions embedded under *agree* (*with*/*on*) cannot take mention-some readings?

Section 4.7 presents experimental evidence for the claim that FA-sensitivity is concerned with false denials. Moreover, the results of the experiments show asymmetries of false beliefs that vary by question type. I provide a principled explanation to these asymmetries. Section 4.8 summarizes the lines of approaches to strong exhaustivity, and shows how those approaches can be adapted to the proposed framework.

4.2. Background

4.2.1. Interrogative-embedding predicates

There is a rich literature on the interpretations of indirect questions and the semantics of interrogative-embedding predicates. (See fn. 46 for a list of representative studies.) The following tree illustrates the typology of interrogative-embedding predicates, adapted from (Lahiri 2002: chap. 6), Spector and Egré 2015b, and Uegaki (2015).

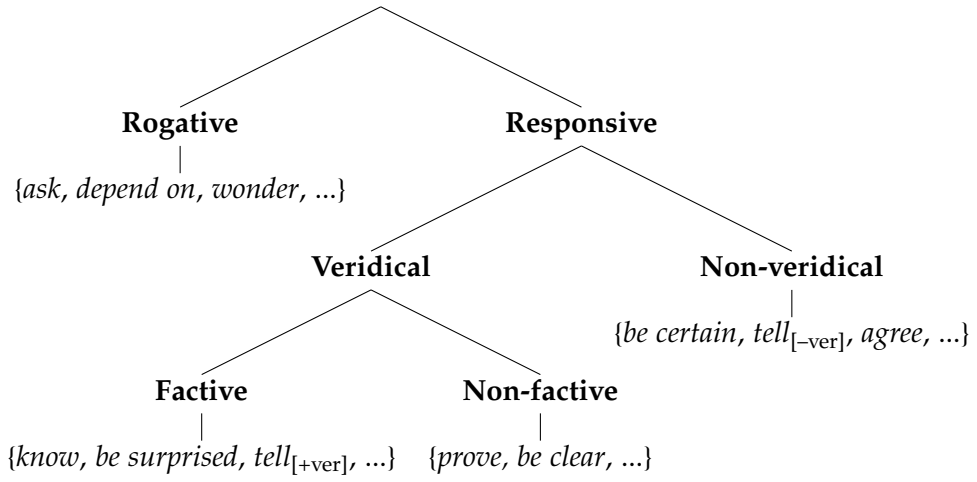


Figure 4.1: Typology of interrogative-embedding predicates

Rogative versus responsive Following (Lahiri 2002: chap. 6), we firstly classify interrogative-embedding predicates into two major classes, namely, *rogative predicates* and *responsive predicates*. Rogative predicates are only compatible with interrogative complements, while responsive predicates are also compatible with declarative complements.

(4.2) a. John knows that Mary left.
b. * John asked me that Mary left.

Veridicality We further divide responsive predicates into two groups, based on veridicality with respect to interrogative complements. Compare the following minimal pair:

(4.3) a. John knows who left.
$\rightsquigarrow$ *For some true answer p as to who left, John knows p.*
b. John is certain about who left.
$\rightsquigarrow$ *For some possible answer p as to who left, John is certain about p.*

(4.3a) implies that John knows a complete true answer as to who left, while (4.3b) only suggests that John is sure about the truth of a possible answer as to who left. Hence, we say that *know* is veridical, while *be certain* is non-veridical.

Communication verbs as factives A few more things need to be clarified for communication verbs (e.g., *tell*, *predicate*). Karttunen (1977) claims that *tell* is non-veridical with respect to declarative complements, but that it can be veridical with respect to interrogative complements. For instance, (4.4a) does not imply that what John told us is true (i.e., it does not imply that Mary indeed left), while (4.4b) intuitively suggests that John told us some true answer as to who left. Based on this contrast, Karttunen concludes that the verb *tell* is non-veridical by itself, and that the veridicality of *tell* in (4.4b) comes from the interrogative complement. Hence, Karttunen argues that a question denotes a set of true propositions.

(4.4) a. John told us that Mary left.
$\not\rightsquigarrow$ *Mary left.*
b. John told us who left.
$\rightsquigarrow$ *For some true answer p as to who came, John told us p.*

Contrary to Karttunen (1977), Spector and Egré (2015b) argue that declarative-embedding *tell* does admit a factive/veridical reading. Compare the examples in (4.5): while the indirect question in (4.5a) by itself does not necessarily imply the truth of the declarative complement, embedding it under negation or in a polar question strongly suggests the truth of the declarative complement. These facts suggest that the declarative-embedding *tell* also has a factive reading, and that the veridicality of interrogative-embedding *tell* comes from *tell*, not the interrogative complement. Following Spector and Egré (2015b), I classify communication verbs that take veridical readings as factives.

(4.5) a. Sue told Jack that Fred is the culprit. $\not\rightsquigarrow$ *Fred is the culprit.*

b. Sue didn't tell Jack that Fred is the culprit. $\rightsquigarrow$ *Fred is the culprit.*

c. Did Sue tell Jack that Fred is the culprit? $\rightsquigarrow$ *Fred is the culprit.*

A veridical predicate is not necessarily factive (Egré 2008, Uegaki 2015). For instance, *prove* is veridical with respect to both interrogative and declarative complements, but it is not factive. The following examples are taken from (Uegaki 2015: chap. 4).

(4.6) a. John proved which academic degree he has.
$\rightsquigarrow$ *For some true answer p as to which academic degree John has, John proved p.*

b. John proved that he has a PhD.
$\rightsquigarrow$ *John has a PhD.*

c. John didn't prove that he has a PhD.
$\not\rightsquigarrow$ *John has a PhD.*

4.2.2. Forms of exhaustivity

Earlier works have noticed two forms of exhaustivity involved in interpreting indirect mention-all questions, namely, *weak exhaustivity* (Karttunen 1977) and *strong exhaustivity* (Groenendijk and Stokhof 1982, 1984). Consider the indirect question (4.7) for illustration. This example is just to illustrate the range of theoretically possible readings. At this point, I am not committed to any empirical claim about the available readings of the sentence in (4.7).

(4.7) John knows who came.
(Context: *Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)

a. John knows that *a* and *b* came. **WE**

b. John knows that *a* and *b* came; and John knows that *c* did **not** come. **SE**

c. John knows that *a* and *b* came; and **not** [John believes that *c* came]. **IE**

The weakly exhaustive (WE) reading only requires John to know the mention-all answer as to *who came*: for any individual *x*, if *x* came, then John knows that *x* came. While the strongly exhaustive (SE) reading also requires John to know the mention-all answer as to *who didn't come*: for any individual *x*, if *x* didn't come, then John knows that *x* didn't come. Recent works (Klinedinst and Rothschild 2011, Spector and Egré 2015a, Uegaki 2015, Cremers and Chemla 2016) start to consider an intermediate form of exhaustivity: stronger than WE but weaker than SE, the *intermediately exhaustive* (IE) reading requires John to know the mention-all answer as to *who came* and to have no false belief as to *who came*. I call this "no false belief" condition "be sensitive to false answers," and abbreviate it as "false answer (FA-)sensitivity" henceforth.

Several different empirical claims have been made as to which embedding predicates license which forms of exhaustivity. For now, I only consider veridical responsive predicates, which can be classified into the following four groups.

(4.8) **Veridical responsive predicates**

a. Cognitive factives: *know*, *remember*, *discover*, ...

b. Emotive factives: *be surprised*, *be pleased*, *be annoyed*, ...

c. Communication verbs: *tell*, *predict*, ...

d. Non-factives: *be clear*, *prove*, ...

It is commonly believed that SE readings are licensed by cognitive factives (Groenendijk and Stokhof 1982, 1984) but are difficult for other veridical responsive predicates (Heim 1994; Beck and Rullmann 1999; Guerzoni and Sharvit 2007; Nicolae 2013, 2015; Uegaki 2015). Nevertheless, a recent experimental work by Cremers and Chemla (2016) found evidence that supports the availability of SE readings with the communication verb *predict*.

As for the distribution of WE readings, there are basically two positions, different with respect to whether WE readings can be licensed by cognitive factives: one position (Groenendijk and Stokhof 1984, George 2011, Uegaki 2015) believes that WE readings can be licensed by most veridical responsive predicates except cognitive factives; the other position (Karttunen 1977, Heim 1994, Guerzoni and Sharvit 2007, Klinedinst and Rothschild 2011) believes that WE readings are also available under cognitive factives. For instance, Guerzoni and Sharvit (2007) argue that the consistency of (4.9) would be left unexplained if *know* licenses only SE readings.

(4.9) Jack knows who came, but he does not know who did not come.

Nevertheless, for authors taking either position, the readings that they claim to be WE might be actually IE. Lahiri (2002: 149) firstly discusses the possible confusion between WE and IE for *know*. He argues that WE readings are too weak for *know*, based on the following example due to J. Higginbotham. This sentence cannot be true (on any conceivable reading) if John happens to believe that all numbers between 10 and 20 are prime.

(4.10) John knows which numbers between 10 and 20 are prime.

Cremers and Chemla (2016) experimentally validate the existence of IE readings for *know* and *predict*. Moreover, they indicate that it is difficult to establish the existence of WE readings for *know* at least, because what appears to be WE readings might be actually SE or IE readings with covert domain restrictions. The only "seeming" exceptions with respect to the availability of IE readings are emotive factives. For instance, as shown in (4.11), a *surprise*-sentence is true as long as the attitude holder is surprised at the WE answer of the embedded question.

(4.11) (Context: *Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)
John is surprised at who came.

a. $\rightsquigarrow$ John is surprised that Andy and Billy came.

b. $\not\rightsquigarrow$ John isn't surprised that Cindy came.

In section 4.6.1, I will show that the FA-sensitivity condition (i.e., the condition that distinguishes IE from WE) collapses under the strong factive presupposition of *surprise*, which therefore makes IE undistinguishable from WE. If all of these claims are right, then there is no independent WE reading for indirect questions.

I summarize my take on the distributional pattern of each exhaustive reading as follows:

(4.12) a. WE is not an independent reading;

b. IE is widely available;

c. SE is available at least under cognitive factives and communication verbs.

4.3. Two facts on FA-sensitivity

4.3.1. FA-sensitivity under mention-some

George (2011, 2013) observes that indirect mention-some questions also have readings sensitive to false answers, in parallel to the IE readings of indirect mention-all questions. For a concrete example, consider the scenario described in (4.13): Italian newspapers are available at Newstopia but not PaperWorld; both John and Mary know a true mention-some answer as to where one can buy an Italian newspaper (viz., at Newstopia), but Mary also believes a false answer, namely, that one can buy an Italian newspaper at PaperWorld. Intuitively, there is a prominent reading under which (4.13a) is true while (4.13b) is false.

(4.13) Scenario:

Are Italian newspapers available at ...	*Newstopia?*	*PaperWorld?*
Facts	*Yes*	*No*
John's belief	Yes	?
Mary's belief	Yes	Yes

a. John knows where one can buy an Italian newspaper. [Judgment: TRUE]

b. Mary knows where one can buy an Italian newspaper. [Judgment: FALSE]

George takes this fact as an argument against the reductive view of interrogative-embedding *know*. On the reductive view, the meaning of a [x knows Q] construction can be paraphrased based on x's knowledge of facts or declaratives relevant to Q. The sensitivity to false answers in indirect mention-some questions shows that 'which answers of Q x knows' does not suffice to resolve 'whether x knows Q.' Klinedinst and Rothschild (2011) and Uegaki (2015) argue that the ordinary value of [x knows Q] can still be defined in terms of x's declarative-knowledge relevant to Q, namely, 'x knows a complete true answer of Q,' and that the FA-sensitivity condition is a logical consequence of exhaustifying this reduced inference. I will review and argue against this exhaustification-based approach in section 4.4.

It remains controversial, however, whether the reading described above for (4.13a-b) is exhaustive in any sense (see §4.4.2). To be theory neutral, for both mention-all questions and mention-some questions, I call the readings that are sensitive to false answers "FA-sensitive readings." I divide the truth conditions of an FA-sensitive reading into two parts, namely, *Completeness* and *FA-sensitivity*, roughly described in (4.14) based on the factive *know*.

(4.14) John knows Q.

a. John knows a complete true answer of Q. **Completeness**

b. John does not believe any false answers of Q. **FA-sensitivity**

4.3.2. FA-sensitivity to partial answers

What types of false answers are involved in the condition of FA-sensitivity? Previous studies consider only answers that are potentially complete and characterize FA-sensitivity accordingly. Nevertheless, as I will show in the following, FA-sensitivity is concerned with all types of false answers, not just those that can be complete. Regardless of how Completeness is defined, the answers in the following example can never be complete:[47]

(4.15) Who came?

a. Andy or Billy. $\phi_a \vee \phi_b$ Disjunctive partial

b. Andy didn't. $\neg\phi_a$ Negative partial

Consider, for example, the sentences in (4.16) and (4.17) satisfy the Completeness condition but are intuitively false in the given scenarios. These facts suggest that the FA-sensitivity condition is concerned with *false disjunctive* answers.

(4.16) John knows who came. [Judgment: FALSE]

Fact: *a* came, while *b* and *c* didn't come.

John's belief: *a* someone else came, <u>who might be *b* or *c*.</u>

(4.17) John knows where we can get gas. [Judgment: FALSE]

Fact: *a* sells gas, while *b* and *c* do not.

John's belief: *a* and somewhere else sell gas, <u>which might be *b* or *c*.</u>

Moreover, interpretations of indirect mention-some questions show that FA-sensitivity is also concerned with *false denials*, which are always partial and are even excluded from any possible Hamblin set. George (2011, 2013) has discussed false answers that are *over-affirming* (OA), namely, overly affirming a possible answer that is false in the evaluation world. For example, Mary incorrectly believes that Italian newspapers are available at store B. Correspondingly, we should also check false answers that are *over-denying* (OD), namely, overly denying a possible answer that is true in the evaluation world. For example, Sue incorrectly believes that Italian newspapers are unavailable at store C.

(4.18)

Are Italian newspapers available at ...	*A?*	*B?*	*C?*	FA-type
Facts	*Yes*	*No*	*Yes*	
John's belief	Yes	?	?	
Mary's belief	Yes	**Yes**	?	OA
Sue's belief	Yes	?	**No**	OD

a. John knows where one can buy an Italian newspaper. TRUE

[47] Under the assumed definition of Completeness, adopted from Fox (2013), a proposition p is a potential complete answer of Q only if there is a world w such that p is a max-informative true answer of Q in w. Formally:

(i) p is a potential complete answer of Q only if $\exists w[p \in \textsc{Ans}([\![\text{Q}]\!])(w)]$.

b. Mary knows where one can buy an Italian newspaper. FALSE

c. Sue knows where one can buy an Italian newspaper. TRUE/FALSE?

The truth value of (4.18c) reflects whether FA-sensitivity is concerned with over-denying: if over-denying is involved in FA-sensitivity, then there should be a reading under which (4.18a) is true while (4.18c) is false. It is however a bit hard to judge the truth value of (4.18c). (See explanations in §4.7.3.) In section 4.7, I provide experimental evidence to show that over-denying is indeed involved in FA-sensitivity: cases like (4.18c) received significantly less acceptances than cases like (4.18a).

It is worthy noting that, based on mention-all questions, we cannot tell whether FA-sensitivity is concerned with over-denying. Consider (4.19) for illustration, the requirement of avoiding over-denying can be understood in two ways. One way is to treat this requirement as simply a logical consequence of Completeness: if John has no conflicting belief, then (4.19c) follows (4.19a). The other way is to treat this requirement as part of FA-sensitivity and group it together with the condition (4.19b), because both (4.19b-c) are concerned with false answers.

(4.19) John knows who came.

a. if x came, John believes that x came.

b. if x didn't come, not [John believes that x came]. Avoiding OA

c. if x came, not [John believes that x didn't come]. Avoiding OD

Previous accounts of FA-sensitivity (Klinedinst and Rothschild 2011, Uegaki 2015, Roelofsen et al. 2014) take the former option. In a mention-some question, however, the requirement of avoiding over-denying is not entailed by Completeness. Hence, to unify the analyses of mention-all and mention-some questions, it is more plausible to take the latter option.

4.4. The exhaustification-based approach and its problems

4.4.1. The exhaustification-based approach

Klinedinst and Rothschild (2011) derive IE readings based on exhaustifications. The core idea of their approach is as follows: exhaustifying the Completeness condition (4.20a) yields an inference entailing the FA-sensitivity condition (4.20b).[48]

(4.20) John knows who came.

a. If x came, then John knows that x came. **Completeness**

b. If x didn't come, then not [John believes that x came]. **FA-sensitivity**

Klinedinst & Rothschild assume that the ordinary value of sentence (4.20) is its WE inference, and that the IE reading is derived by exhaustifying this WE inference at the matrix level.[49] The LFs for WE and IE readings are thus as follows:

[48] Klinedinst and Rothschild (2011) consider only the existence of IE readings for communication verbs like *tell* and *predict*. But Cremers and Chemla (2016) have experimentally validated the existence of IE readings for the cognitive factive *know*. This section uses *know* to demonstrate Klinedinst & Rothschild's idea, so as to avoid confusions from the ambiguity of *tell* on veridicality.

[49] Klinedinst and Rothschild (2011) derive SE readings by placing an O-operator immediately above the embedded

(4.21) a. John knows [who came] **WE**

b. O [John knows [who came]] **IE**

The O-operator has a meaning akin to the exclusive particle *only*: it affirms the prejacent proposition and negates all the alternatives of the prejacent that are not entailed by the prejacent. (Chierchia et al. 2012, among others)

(4.22) $O(p) = \lambda w[p(w) = 1 \wedge \forall q \in \textsc{Alt}(p)[p \not\subseteq q \rightarrow q(w) = 0]]$
(The prejacent p is true, while the alternatives that are not entailed by the p are false.)

Klinedinst & Rothschild define the denotation of the embedded interrogative Q as a function that maps each possible world to the mention-all answer of Q in that world, as in (4.23a). The ordinary value of the indirect question is thus the WE inference, namely, that John knows the true mention-all answer to Q, as in (4.21b). Employing exhaustification globally affirms this WE inference and negates all the propositions of the form "John believes ϕ" where ϕ is a possible mention-all answer to Q and is not entailed by the true mention-all answer to Q,[50] yielding the following exhaustified inference: among all the possible mention-all answers of Q, John only believes the TRUE mention-all answer of Q.

(4.23) O [$_S$ John knows [$_Q$ who came]]

a. $[\![\text{Q}]\!] = \lambda w \lambda w'.\forall x[\mathit{came}_w(x) \rightarrow \mathit{came}_{w'}(x)]$

b. $[\![\text{S}]\!] = \lambda w.\mathit{know}_w(j, \lambda w'.\forall x[\mathit{came}_w(x) \rightarrow \mathit{came}_{w'}(x)])$ **WE**
(John knows the true mention-all answer to *who came*.)

c. $\textsc{Alt}(\text{S}) = \{q \mid \exists w''[q = \lambda w.\mathit{believe}_w(j, \lambda w'.\forall x[\mathit{came}_{w''}(x) \rightarrow \mathit{came}_{w'}(x)])]\}$
($\{q \mid \exists w''[q =$ John believes the mention-all answer to *who came*$_{w''}$]$\}$.)

d. $[\![O(\text{S})]\!] = \lambda w[[\![\text{S}]\!](w) = 1 \wedge \forall q \in \textsc{Alt}(\text{S})[[\![\text{S}]\!] \not\subseteq q \rightarrow q(w) = 0]]$ **IE**
(John only believes the TRUE mention-all answer to *who came*.)

To adapt this account to the proposed hybrid categorial approach of question semantics developed in chapter 1, we just need to define the embedded interrogative as a topical property and obtain the WE inference via employing an Ans-operator. A schematized derivation is given in the following. For simplicity, the proposition $\mathit{came}(x)$ is abbreviated as ϕ_x. For a schematization following Hamblin-Karttunen Semantics, see Uegaki (2015) and Xiang (2016a).

(4.24) O [$_S$ John knows [$_Q$ who came]]
(Context: *Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)

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interrogative, as illustrated in (i). This implementation requires additional assumptions, because here the prejacent of O-operator denotes a function from possible worlds to propositions (of type $\langle s, st\rangle$), not a proposition. See more details on the derivation of SE in section 4.8.

(i) John knows [O [who came]]

[50] Note that the alternatives are of the form "John believes ϕ," not "John knows ϕ." As observed by Spector and Egré (2015a), in paraphrasing the FA-sensitivity condition of a question with a cognitive factive, the factive needs to be replaced with its non-factive counterpart. See my explanation in section 4.6.1.

a. $[\![\text{Q}]\!] = \lambda x.\phi_x$

b. $\textsc{Ans}([\![\text{Q}]\!])(w) = \{\phi_x : w \in \phi_x \wedge \forall y[w \in \phi_y \rightarrow \phi_y \not\subset \phi_x]\} = \{\phi_{a\oplus b}\}$

c. $[\![\text{S}]\!] = \lambda w.\exists\phi \in \textsc{Ans}([\![\text{Q}]\!])(w)[\textit{know}_w(j,\phi)] = \textit{know}(j,\phi_{a\oplus b})$ **WE**

(John knows a true complete answer of Q.)

d. $\textsc{Alt}(\text{S}) = \{\lambda w.\exists\phi \in \alpha[\textit{believe}_w(j,\phi)] \mid \exists w'[\alpha = \textsc{Ans}([\![\text{Q}]\!])(w')]\}$

$= \{\lambda w.\exists\phi \in \textsc{Ans}([\![\text{Q}]\!])(w')[\textit{believe}_w(j,\phi)] \mid w' \in W\}$

$= \left\{ \begin{array}{l} \textit{believe}(j,\phi_a), \textit{believe}(j,\phi_b), \textit{believe}(j,\phi_c), \\ \textit{believe}(j,\phi_{a\oplus b}\}, \textit{believe}(j,\phi_{b\oplus c}\}, \textit{believe}(j,\phi_{a\oplus c}\} \\ \textit{believe}(j,\phi_{a\oplus b\oplus c}) \end{array} \right\}$

(John believes ϕ, where ϕ is a potential complete answer of Q.)

e. $[\![O(\text{S})]\!] = \textit{know}(j,\phi_{a\oplus b}) \wedge \neg\textit{believe}(j,\phi_c)$ **IE**

(John only believes the TRUE complete answer of Q.)

4.4.2. Extending the exhaustification-based account to mention-some

In an indirect mention-some question, there are two possible positions to place an O-operator: one of such positions is immediately above the scope part of the existential closure, as in (4.25a), and the other is above the existential closure, as in (4.25b).

(4.25) John knows [$_{\text{Q}}$ where we can get gas].

a. *Local exhaustification*

$\exists\phi$ [ϕ is a true mention-some answer of Q] [O [John knows ϕ]]

b. *Global exhaustification*

O [$\exists\phi$ [ϕ is a true mention-some answer of Q] [John knows ϕ]]

In the paragraphs that follow, I show that neither of the options derives the desired the FA-sensitivity inference.

Local exhaustification is apparently infeasible. If the embedded question Q takes a mention-some reading, this operation yields the following truth conditions: (i) John knows a mention-some answer of Q, and (ii) John doesn't believe any answer that is not entailed by this mention-some answer. The exhaustification condition (ii) is clearly too strong. For example, in case that there are three accessible stations and John knows two of them, the sentence (4.25) would be predicted to be false, contra fact.

The option of global exhaustification seems to have a better chance of yielding the desired FA-sensitivity inference. As Danny Fox and Alexandre Cremers point out (pers. comm.) to me independently, employing *innocent exclusion* (Fox 2007) globally yields an inference that is very close to the FA-sensitivity condition. As seen in section 3.3, while the regular exhaustifier O negates all the excludable alternatives (i.e., the alternatives that are not entailed by the prejacent of the exhaustifier), the innocently exclusive exhaustifier IE-Exh negates only the "innocently" (I-)excludable alternatives. For a proposition p, one of its alternatives q is I-excludable only if q is included in every maximal set of alternatives such that the exclusion of this set is consistent with p.

(4.26) **Innocent Exclusion** (Fox 2007)

a. **Innocently (I-)excludable alternatives**
$\text{IExcl}(p) = \bigcap\{A : A \text{ is a maximal subset of } \text{Alt}(p) \text{ s.t. } A^{\neg} \cup \{p\} \text{ is consistent}\}$,
where $A^{\neg} = \{\neg q : q \in A\}$
(The intersection of the maximal sets of alternatives of p such that the exclusion of each such set is consistent with p)

b. **Innocently (I-)exclusive exhaustifier**
$\text{IE-Exh}(p) = \lambda w[p(w) = 1 \wedge \forall q \in \text{IExcl}(p)[q(w) = 0]]$
(The prejacent p is true, and the I-excludable alternatives of p are false.)

Using innocent exclusion avoids negating propositions of the form "John believes ϕ" where ϕ is a true mention-some answer or a disjunctive answer that involves at least one true mention-some answer as a disjunct. Consider (4.27) for a concrete example. For simplicity, the proposition 'we can get gas from place x' is abbreviated as ϕ_x.

(4.27) John knows [$_{\text{Q}}$ where we could get gas].
(Context: *Among the considered places abc, only a and b sell gas.*)

a. IE-Exh [$_{\text{S}}$ $\exists\phi$ [ϕ is a true mention-some answer of Q] [John knows ϕ]]

b. $[\![\text{S}]\!] = \lambda w.\exists\phi \in \text{Ans}([\![\text{Q}]\!])(w)[\textit{know}_w(j,\phi)]$
$= \textit{know}(j,\phi_a) \vee \textit{know}(j,\phi_b)$

c. $\text{Alt}(\text{S}) = \{\lambda w.\exists\phi \in \text{Ans}([\![\text{Q}]\!])(w')[\textit{bel}_w(j,\phi)] \mid w' \in W\}$
$$= \left\{\begin{array}{lll} \textit{bel}(j,\phi_a), & \textit{bel}(j,\phi_a) \vee \textit{bel}(j,\phi_b), & \textit{bel}(j,\phi_a) \vee \textit{bel}(j,\phi_b) \vee \textit{bel}(j,\phi_c) \\ \textit{bel}(j,\phi_b), & \textit{bel}(j,\phi_a) \vee \textit{bel}(j,\phi_c), & \\ \textit{bel}(j,\phi_c), & \textit{bel}(j,\phi_b) \vee \textit{bel}(j,\phi_c), & \end{array}\right\}$$

d. $[\![\text{IE-Exh(S)}]\!] = [\textit{know}(j,\phi_a) \vee \textit{know}(j,\phi_b)] \wedge \neg\textit{bel}(j,\phi_c)$

The ordinary value of prejacent clause S is the Completeness condition, namely, that John knows a true mention-some answer of Q, as schematized in (4.27b). Alternatives of S are propositions of the form "John believes some proposition in α" where α is the set of complete true answers of some possible world, as shown in (4.27c). Among these alternatives, only $\textit{bel}(j,\phi_c)$ is innocently excludable.[51] Hence, employing innocent exclusion yields the inference in (4.27d), which affirms the truth of prejacent clause and negates only the innocently excludable alternative $\textit{bel}(j,\phi_c)$. More generally, the final inference can be stated as follows: John knows a true mention-some answer of Q, and he doesn't believe any false mention-some answers of Q.

4.4.3. Problems with the exhaustification-based account

4.4.3.1. FA-sensitivity is concerned with partial answers

So far, the alternative set used by the exhaustification-based account includes only propositions that are based on potential complete answers of the embedded questions. Hence, exhaustifying the

[51] For instance, $\textit{bel}(j,\phi_a)$ is not innocently excludable, because $[\textit{know}(j,\phi_a) \vee \textit{know}(j,\phi_b)] \wedge \neg\textit{bel}(j,\phi_a)$ entails another excludable alternative $\textit{bel}(j,\phi_b)$. In contrast, $\textit{bel}(j,\phi_c)$ is innocently excludable, because $[\textit{know}(j,\phi_a) \vee \textit{know}(j,\phi_b)] \wedge \neg\textit{bel}(j,\phi_c)$ does not entail any of the excludable alternatives.

Completeness condition only yields the requirement of avoiding false answers that are potential complete answers. This requirement is however insufficient. As seen in section 4.3.2, the FA-sensitivity condition is concerned with all types of false answers, including also those that can never be complete, such as false denials and false disjunctives. This insufficiency applies to not only the interpretation of indirect mention-some questions but also the interpretation of indirect mention-all questions.

To derive the desired FA-sensitivity inference, an exhaustification-based account would have to assume a very special set of alternatives. For instance, for the indirect mention-some question in (4.28), the alternative set of of the clause S ought to be like (4.28c). One the one hand, this set includes all the propositions stating that John believes a false answer (including over-affirming (OA), over-denying (OD), and false disjunctive (Disj)). On the other hand, this set must exclude propositions stating that John believes a true mention-all (MA) answer or a mention-intermediate (MI) answer; otherwise, (4.28) would be predicted to be false in a scenario that John knows multiple accessible gas stations, contra fact. I suspect that there is no theory of exhaustification that would generate an alternative set of this sort.

(4.28) John knows where we can get gas.
(w : *Among the four considered places, a and b sell gas; but c and d do not.*)

a. IE-Exh [$_S$ John knows [$_Q$ where we can get gas]]

b. $[\![S]\!] = \mathit{know}(j, \phi_a) \vee \mathit{know}(j, \phi_b)$

c. No way to generate an alternative set as follows:

$$\textsc{Alt}(S) = \left\{ \begin{array}{ll} \mathit{bel}(j, \phi_c), \mathit{bel}(j, \phi_d), \ldots & \text{OA} \\ \mathit{bel}(j, \neg\phi_a), \mathit{bel}(j, \neg\phi_b), \ldots & \text{OD} \\ \mathit{bel}(j, \phi_c \vee \phi_d), \ldots & \text{Disj} \\ \ldots & \\ \cancel{\mathit{bel}(j, \phi_a \wedge \phi_b), \mathit{bel}(j, \phi_{a \oplus b})} \ldots & \cancel{\text{MA/MI}} \end{array} \right\}$$

4.4.3.2. FA-sensitivity is not a scalar implicature

Treating FA-sensitivity as a logical consequence of exhaustifying Completeness amounts to saying that FA-sensitivity is a scalar implicature of Completeness. Nevertheless, FA-sensitivity inferences do not behave like scalar implicatures.

First, unlike scalar implicatures, FA-sensitivity inferences are easily generated even in downward-entailing contexts. Consider scalar implicatures first: in (4.29a), appearing within the antecedent of a conditional, the scalar item *some* does not evoke a scalar implicature unless is stressed (cf. (4.29b)).

(4.29) a. If [Mary invited some of the speakers to the dinner], I will buy her a coffee.
$\not\leadsto$ If Mary invited some but **not all** speakers to the dinner, I will buy ....

b. If [Mary invited SOME of the speakers to the dinner], I will buy her a coffee; but if she invited all of the speakers to the dinner, we would run out of budget.
$\leadsto$ If Mary invited some but **not all** speakers to the dinner, I will buy ....

This is so because strengthening the antecedent weakens the entire conditional and violates the *Strongest Meaning Hypothesis* (Chierchia et al. 2012, Fox and Spector to appear) for exhaustifications:

the use of an exhaustifier is marked if it gives rise to a reading that is equivalent to or weaker than what would have resulted in its absence. In other words, it is marked to use an exhaustification in an environment that is downward-entailing or non-monotonic.

(4.30) **Strongest Meaning Hypothesis**
Let S be a sentence of the form [S ..O(X)...]. Let S_0 be the sentence of the form [S_0 ...X...], i.e., the one that is derived from S by replacing O(X) with X, i.e., by eliminating this particular occurrence of O. Then, everything else being equal, S_0 is preferred to S if S_0 is logically stronger than S.

In (4.31), however, while uttered as the antecedent of a conditional, the indirect question *Mary knows which speakers went to the dinner* still evokes an FA-sensitivity inference.

(4.31) (Context: *Andy and Billy went to the dinner, but Cindy didn't.*)
If Mary knows which speakers went to the dinner, I will buy her a coffee.
$\rightsquigarrow$ If [Mary knows that Andy and Billy went to the dinner] $\wedge$
not [Mary believes that Cindy went to the dinner], I will buy her a coffee.

Second, FA-sensitivity inferences are not cancelable. Compare the following conversations. In (4.32), the scalar implicature 'Mary did not invite all of the speakers to the dinner' can be easily cancelled, while in (4.33), the FA-sensitivity inference 'it is not the case that Mary believes that Cindy went to the dinner' cannot be cancelled.

(4.32) A: "Did Mary invite some of the speakers to the dinner?"
B: "Yes. Actually she invited all of them."

(4.33) (Context: *Andy and Billy went to the dinner, but Cindy didn't.*)
A: "Does Mary know which speakers went to the dinner?"
B: "Yes. #Actually also she believes that Cindy went to the dinner."

One might suggest that FA-sensitivity inferences are special species of scalar implicatures which are mandatorily evoked and exceptionally robust. To assess this assumption, let us compare FA-sensitivity inferences with scalar implicatures that are mandatorily evoked in presence of the overt exhaustifier *only*. In (4.34) and (4.35), for instance, since the scalar item *some* is associated with *only*, its scalar implicature patterns like FA-sensitivity inferences: this scalar implicature can be generated within the antecedent of a conditional and cannot be cancelled.

(4.34) If [Mary invited only SOME_F of the speakers to the dinner], I will buy her a coffee.
$\rightsquigarrow$ If Mary invited some but **not all** speakers to the dinner, I will buy her a coffee.

(4.35) A: "Did Mary invite only SOME_F of the speakers to the dinner?"
B: "Yes. #Actually she invited all of them."

Nevertheless, a contrast between FA-sensitivity inference and obligatory scalar implicature arises in negative sentences. In (4.36b), associating *only* with the focused item over negation evokes a positive implicature (i.e., an indirect scalar implicature): as schematized in (4.36c), *only* negates the negative alternative $\neg\phi_{\text{male}}$, yielding an indirect scalar implicature ϕ_{male}. If FA-sensitivity inferences

were mandatory scalar implicatures, we would predict the negated indirect question (4.37b) to take the analogous LF (4.37c),[52] negate the excludable alternative $\neg \mathit{bel}(m, \phi_c)$, and evoke an indirect scalar implicature $\mathit{bel}(m, \phi_c)$ (i.e., the negation of the FA-sensitivity inference), contra fact.

(4.36) a. Mary **only** invited some FEMALE$_F$ speakers to the dinner.
$\rightsquigarrow$ Mary did not invite any male speakers to the dinner. $\neg\phi_{\text{male}}$

b. Mary **only** did <u>not</u> invite any FEMALE$_F$ speakers to the dinner.
$\rightsquigarrow$ Mary did invite some male speaker(s) to the dinner. ϕ_{male}

c. $O\neg\phi_{\text{female}} = \neg\phi_{\text{female}} \wedge \neg\neg\phi_{\text{male}} = \neg\phi_{\text{female}} \wedge \phi_{\text{male}}$

(4.37) (Context: *Andy and Billy went to the dinner, but Cindy didn't.*)

a. Mary knows which speakers went to the dinner.
$\rightsquigarrow$ not [Mary believes that Cindy went to the dinner. $\neg \mathit{bel}(m, \phi_c)$

b. Mary doesn't know which speakers went to the dinner.
$\not\rightsquigarrow$ Mary believes that Cindy went to the dinner. $\mathit{bel}(m, \phi_c)$

c. O **not** [Mary knows [$_{\text{Q}}$ which speakers went to the dinner]]

4.5. Proposal

I propose that Completeness and FA-sensitivity are two independent conditions. Both of them are mandatorily involved in interpreting any indirect question. In particular, completeness is defined based on a complete true answer, while FA-sensitivity is concerned with all relevant answers, recovered from the partition of the embedded question. For indirect questions with veridical predicates, their FA-sensitive readings are uniformly defined as in (4.38). This analysis accounts for indirect MA questions as well as indirect MS questions.

(4.38) $$[\![x\ V_{[+\text{ver}]}\ \text{Q}]\!]^w = \underbrace{\exists\phi \in \textsc{Ans}([\![\text{Q}]\!])(w)[V'_w(x,\phi)]}_{\textsc{Completeness}} \wedge \underbrace{\forall\psi \in \textsc{Rel}([\![\text{Q}]\!])[w \notin \psi \rightarrow \neg V'_w(x,\psi)]}_{\textsc{FA-sensitivity}}$$

The core ideas of this proposal are independent from whether a question denotes a topical property or a Hamblin set. To be theory-neutral, I use $[\![\text{Q}]\!]$ (where 'Q' is in text mode) for the denotation of Q, and $\textsc{Ans}([\![\text{Q}]\!])(w)$ for the set of max-informative true answers of Q in w. In case that the exact question denotation matters, I use Q (where 'Q' is in math mode) for a Hamblin set, and **P** for a topical property.

4.5.1. Characterizing Completeness

Following Fox (2013), I have defined completeness as max-informativity: a true answer is complete iff it is not asymmetrically entailed by any of the true answers. As shown in section 2.5 and 2.6, this definition works for both mention-all and mention-all readings of questions. If a question takes a mention-some reading, it has a unique max-informative true answer, namely, the mention-all

[52] Note that here the exhaustifier cannot be placed below negation, due to the Strongest Meaning Hypothesis.

answer. If a question takes a mention-some reading, it can have multiple max-informative true answers, each of which is a mention-some answer.

Based on these assumptions, I schematize the Completeness condition of an indirect question of the form 'x V Q' uniformly as follows. The letters x, V, and Q stand for an attitude holder, an interrogative-embedding predicate, and an embedded interrogative, respectively.

(4.39) **Completeness condition**

a. For 'x $V_{[+\text{ver}]}$ Q': $\lambda w.\exists\phi \in \textsc{Ans}(\llbracket \text{Q} \rrbracket)(w)[V'_w(x,\phi)]$
(There is a proposition ϕ such that ϕ is a max-informative true answer of Q in w and that x Vs ϕ in w.)

b. For 'x $V_{[\text{-ver}]}$ Q': $\lambda w.\exists w'\exists\phi \in \textsc{Ans}(\llbracket \text{Q} \rrbracket)(w')[V'_w(x,\phi)]$
(There is a proposition ϕ such that ϕ is a potential max-informative answer of Q and that $V'(x,\phi)$ is true in w.)

In the formalizations above, the set of max-informative true answers $\textsc{Ans}(\llbracket \text{Q} \rrbracket)(w)$ serves as the domain restriction of an existential quantification. If the embedding predicate V is veridical (e.g., factives like *know*, *remember*; non-factive veridical predicates like *prove*, *be clear*), the world argument of the Ans-operator would be co-indexed with that of V. By contrast, if V is non-veridical (e.g., *be certain*, *tell*$_{[\text{-ver}]}$), then the world variable of Ans would be existentially bound at a non-local scopal site, as assumed by Berman (1991), Lahiri (2002), and Spector and Egré (2015a).

4.5.2. Characterizing FA-sensitivity

A proper characterization of FA-sensitivity should capture the following two facts:

(i) FA-sensitivity is involved in interpreting both indirect mention-all questions and indirect mention-some questions (George 2013, 2011; see §4.3.1);

(ii) FA-sensitivity is concerned with all types of false answers, including not only those that are potentially complete, but also those that can never be complete (see §4.3.2).

The current dominant approach (Klinedinst and Rothschild 2011, Uegaki 2015) characterizes FA-sensitivity as a logical consequence of strengthening or exhaustifying the WE inference. As argued in section 4.4, although this approach can be extended to indirect mention-some questions using innocent exclusion, it cannot capture fact **(ii)**.

I argue that FA-sensitivity is independent from Completeness. Regardless of whether the embedded question of the considered indirect question takes a mention-some or mention-all reading, the FA-sensitivity condition can be uniformly schematized as in (4.40). Intuitively, FA-sensitivity is not involved in interpreting an indirect question whose interrogative-embedding predicate is non-veridical. To capture this intuition, we do not need to stipulate a constraint on the distribution of FA-sensitivity, but instead make the evaluation world variable of ϕ existentially bound. Some concrete examples are given in (4.41).

(4.40) **FA-sensitivity condition**

a. For 'x $V_{[+\text{ver}]}$ Q': $\lambda w.\forall\phi \in \textsc{Rel}(\llbracket \text{Q} \rrbracket)[w \notin \phi \rightarrow \neg V'_w(x,\phi)]$
(For any Q-relevant proposition ϕ, whenever ϕ is false, $V'(x,\phi)$ is false.)

b. For 'x $V_{[\text{-ver}]}$ Q': $\lambda w.\exists w'\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[w' \notin \phi \rightarrow \neg V'_w(x,\phi)]$
(For any Q-relevant proposition ϕ, there is a world w' such that $V'(x,\phi)$ is false in w' if ϕ is false in w'.)

(4.41) a. For 'John knows Q': $\lambda w.\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[w \notin \phi \rightarrow \neg \textit{believe}_w(j,\phi)]$
(John has no Q-relevant false belief.)

b. For 'John is certain at Q': $\lambda w.\exists w'\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[w' \notin \phi \rightarrow \neg \textit{certain}_w(j,\phi)]$
(There is world such that everything John is certain about Q is true in this world; or equivalently, everything that John is certain about Q is consistent.)

$\textsc{Rel}([\![\text{Q}]\!])$ stands for the set of propositions that are relevant to the embedded interrogative, called "Q-relevant propositions." Formally, a proposition is Q-relevant iff it equals to the union of some partition cells of Q, as schematized in (4.42). As seen in section 1.3.4, the partition of a question can be derived based on a Hamblin/Karttunen set or a topical property, as defined in (4.43a) and (4.43b), respectively.

(4.42) **Q-relevant propositions**
$\textsc{Rel}([\![\text{Q}]\!]) = \{\bigcup X : X \subseteq \textsc{Par}([\![\text{Q}]\!])\}$
(ϕ is Q-relevant iff ϕ is the union of some partition cells of Q.)

(4.43) **Partition cells**

a. If Q denotes a Hamblin set Q:
$\textsc{Par}([\![\text{Q}]\!]) = \{\lambda w[Q_w = Q_{w'}] : w' \in W\}$, where $Q_w = \{p : w \in p \in Q\}$
(The family of world sets such that every world in each world set yields the same true propositional answers)

b. If Q denotes a topical property $\mathbf{P}$:
$\textsc{Par}([\![\text{Q}]\!]) = \{\lambda w[\mathbf{P}_w = \mathbf{P}_{w'}] : w' \in W\}$, where $\mathbf{P}_w = \{\alpha : \alpha \in \text{Dom}(\mathbf{P}) \wedge w \in \mathbf{P}(\alpha)\}$
(The family of world sets such that every world in each world set yields the same true short answers)

Consider (4.44) for a concrete example of deriving the Q-relevant propositions of a mention-all question. Partition (i) and (ii) are identical. The former is defined based on an equivalence relation between possible worlds with respect to true propositional answers (PAs), while the latter is defined based on an equivalence relation between possible worlds with respect to true short answers (SAs). For instance, the second cell c_2 stands for the set of worlds where only a came, or equivalently, the set of worlds where the Karttunen set Q_w is $\{\phi_a\}$, or equivalently, the set of worlds where the set of true short answers $\mathbf{P}_w$ is $\{a\}$. Q-relevant propositions can be obtained easily from the partition. In particular, the disjunctive answer $\phi_a \vee \phi_b$ is the union of the first three cells, and the negative answer $\neg\phi_a$ is the union of the last two cells.

(4.44) Who came?

a. $Q = \{{}^\wedge\textit{came}(x) : x_e \in {}^\dagger\textit{people}_@\}$

b. $\mathbf{P} = \lambda x_e[{}^\dagger\textit{people}_@(x) = 1.{}^\wedge\textit{came}(x)\}$

c. Andy came. $\phi_a = c_1 \cup c_2$
Andy or Billy came. $\phi_a \vee \phi_b = c_1 \cup c_2 \cup c_3$
Andy didn't. $\neg\phi_a = c_3 \cup c_4$

w: $Q_w = \{\phi_a, \phi_b, \phi_{ab}\}$		c_1	w: only ab came$_w$		w: $\mathbf{P}_w = \{a, b, a \oplus b\}$
w: $Q_w = \{\phi_a\}$	=	c_2	w: only a came$_w$	=	w: $\mathbf{P}_w = \{a\}$
w: $Q_w = \{\phi_b\}$		c_3	w: only b came$_w$		w: $\mathbf{P}_w = \{b\}$
w: $Q_w = \varnothing$		c_4	w: nobody came$_w$		w: $\mathbf{P}_w = \varnothing$

(i) Partition by PA (ii) Partition by SA

If a question that takes a mention-some reading, its Q-relevant propositions can be derived analogously, as exemplified in the following:

(4.45) Where can we get gas? (mention-some)

a. $Q = \{{}^\wedge\Diamond\pi(\lambda x.O[f(x)]) : \pi_{\langle et,t\rangle} \in \dagger\mathit{places}_@\}$

b. $\mathbf{P} = \lambda\pi_{\langle et,t\rangle}[\dagger\mathit{places}_@(\pi) = 1.{}^\wedge\Diamond\pi(\lambda x.O[f(x)])]$

c. Station A. $\phi_a = c_1 \cup c_2$
Station A or B, (I don't know which). $\phi_a \vee \phi_b = c_1 \cup c_2 \cup c_3$
Not station A. $\neg\phi_a = c_3 \cup c_4$

w: $Q_w = \{\Diamond\phi_a, \Diamond\phi_b, \Diamond\phi_{a\bar{\vee}b}\}$		c_1	w: only ab sell$_w$ gas		w: $\mathbf{P}_w = \{a, b, a\bar{\vee}b\}$
w: $Q_w = \{\Diamond\phi_a, \Diamond\phi_{a\bar{\vee}b}\}$	=	c_2	w: only a sells$_w$ gas	=	w: $\mathbf{P}_w = \{a, a\bar{\vee}b\}$
w: $Q_w = \{\Diamond\phi_b, \Diamond\phi_{a\bar{\vee}b}\}$		c_3	w: only b sells$_w$ gas		w: $\mathbf{P}_w = \{b, a\bar{\vee}b\}$
w: $Q_w = \varnothing$		c_4	w: nowhere sells$_w$ gas		w: $\mathbf{P}_w = \varnothing$

(i) Partition by PA (ii) Partition by SA

Although the proposed hybrid categorial approach does not assume the syntactic presence of an Ans-operator, I would like to discuss some consequences with respect to FA-sensitivity if Ans is syntactically present in the LF. Consider the following LFs:

(4.46) a. John knows [Ans$_w$ [$_Q$ who came]]

b. John knows [λw [Ans$_w$ [$_Q$ who came]]]

In (4.46a), depending on the assumed semantics of the Ans-operator, the complement of *know* denotes either a max-informative true answer or a set of max-informative true answers of the embedded question. Since here the Ans-operator has already introduced truth, we cannot form a partition from the complement of *know*, let alone retrieve all the Q-relevant propositions.

In (4.46b), the complement of *know* denotes a function that maps a possible world to the (set of) max-informative true answers of Q in this world. The index w is later saturated by the embedding-predicate (*à la* Groenendijk and Stokhof 1984). With this structure, since the world variable of Ans is alive, we can obtain the partition of Q based on equations with respect to the max-informative true answers of this question, as schematized in the following:

(4.47) $\textsc{Par}([\![Q]\!]) = \{\lambda w[\textsc{Ans}([\![Q]\!])(w) = \textsc{Ans}([\![Q]\!])(w')] : w' \in W\}$

(The family of world sets such that every world in each world set yields the same max-informative true answers)

For example, in (4.48), cell c_2 can be defined as the set of worlds where the question Q has a unique max-informative true answer ϕ_a.

(4.48) Who came?

c_1	w: only $a \oplus b$ came$_w$		w: $\textsc{Ans}([\![\text{Q}]\!])(w) = \{\phi_{a\oplus b}\}$
c_2	w: only a came$_w$	=	w: $\textsc{Ans}([\![\text{Q}]\!])(w) = \{\phi_a\}$
c_3	w: only b came$_w$		w: $\textsc{Ans}([\![\text{Q}]\!])(w) = \{\phi_b\}$
c_4	w: nobody came$_w$		w: $\textsc{Ans}([\![\text{Q}]\!])(w) = \varnothing$

4.6. Other issues

This section will discuss the following puzzling issues on interpreting indirect questions. First, how does FA-sensitivity interact with factivity in questions with a factive embedding predicate? In particular, why is it that indirect questions with emotional factives (cf. cognitive factives) do not seem to be FA-sensitive? Second, why it is that mention-some readings are not licensed by *agree* (*with*/*on*)?

4.6.1. FA-sensitivity and factivity

This section discusses some puzzling issues related to the FA-sensitivity condition in cases where the interrogative-embedding predicate is a factive. As seen below, factives are veridical responsive predicates that trigger factivity effects. When embedding a declarative, a factive presupposes the truth of the embedded declarative. When embedding an interrogative, a factive expresses a relation between the attitude holder and some TRUE answer of the embedded interrogative.

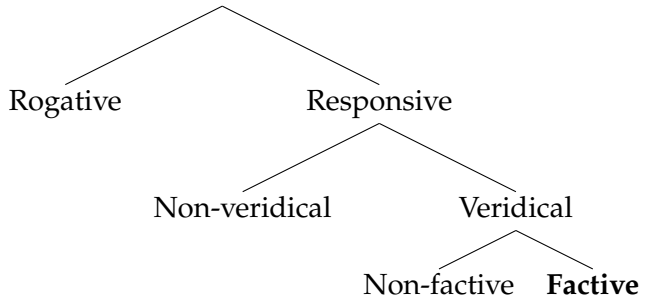


Figure 4.2: The typology of interrogative-embedding predicates

Factives are classified into the three groups. In particular, following Spector and Egré (2015a), I treat communication verbs with veridical readings as factives (see §4.2.1).

(4.49) **Types of factives**

a. Cognitive factives: *know*, *remember*, *discover*, ...

b. Emotive factives: *be surprised*, *be pleased*, ...

c. Communication verbs: $tell_{[+fac]}$, $predict_{[+fac]}$, ...

In what follows, I will first explain the the following two puzzling facts. **Fact 1**: in paraphrasing the FA-sensitivity condition of a question with a cognitive factive, the cognitive factive needs to be replaced with its non-factive counterpart (Spector and Egré 2015a). For instance, in (4.50a), where the embedding predicate is the factive *know*, the FA-sensitivity inference needs to be paraphrased using the non-factive *believe*. **Fact 2**: indirect questions with emotive factives do not seem to be FA-sensitive. For instance, the meaning of the *surprise*-sentence in (4.50b) can be sufficiently defined in terms of the attitude of John with respect to a true answer of the embedded question. In other words, its interpretation is not concerned with the relation between the agent and the false answers of the embedded question.

(4.50) (Context: *Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)

a. John knows who came.
$\not\rightsquigarrow$ *John doesn't* **know** *that c came.*
$\rightsquigarrow$ *John doesn't* **believe** *that c came.*

b. John is surprised at who came.
$\approx \exists\phi$ [ϕ is a true answer as to who came] [John is surprised at ϕ]
$\not\rightsquigarrow$ *John isn't surprised that c came.*

To explain **Fact 1**, let us first consider the consequences if the FA-sensitivity condition of (4.50a) were paraphrased with the factive *know*. The factive presupposition of *know* would have to be accommodated (notated by '$w \in \phi$'), globally or locally relative to negation, as shown in (4.51a) and (4.51b), respectively. Both ways of accommodating the factive presupposition yield an unwelcome consequence: global exhaustification causes a presupposition failure (i.e., a contradiction between the assertion and the presupposition); local accommodation makes the FA-sensitivity condition tautologous. To avoid these consequences, it is better to "deactivate" the factive presupposition of *know*, which yields the desired condition, as seen in (4.51c).[53]

(4.51) FA-sensitivity condition for 'John knows Q':

a. *Global accommodation* $\times$
$\lambda w.\forall\phi \in \textsc{Rel}([\![Q]\!])[w \notin \phi \rightarrow [w \in \phi \wedge \neg \textit{believe}_w(j,\phi)]]$ **Contradiction**
(For any Q-relevant proposition ϕ, whenever ϕ is false, ϕ is true and it is not the case that John believe ϕ.)

[53]Benjamin Spector (pers. comm.) points out to me a deficiency of this explanation: if the factive presupposition of *know* can be freely deactivated, we would expect that *know* never suffers presupposition failure, contra fact. For instance, in a scenario that Andy actually didn't arrive, (ia-i) and (ib-i) suffer presupposition failure, while (ia-ii) and (ib-ii) do not. I don't have a good answer to this problem.

(i) (Context: *Andy didn't arrive.*)

a. i. # John knows that Andy arrived.
ii. John believes that Andy arrived.

b. i. # Perhaps John knows that Andy arrived.
ii. Perhaps John believes that Andy arrived.

b. *Local accommodation* ×
$\lambda w.\forall\phi \in \textsc{Rel}([\![\mathrm{Q}]\!])[w \notin \phi \rightarrow \neg[w \in \phi \wedge \textit{believe}_w(j,\phi)]]$ **Tautology**
(For any Q-relevant proposition ϕ, whenever ϕ is false, then it is not the case that [ϕ is true and John believes ϕ].)

c. *Deactivating factivity* √
$\lambda w.\forall\phi \in \textsc{Rel}([\![\mathrm{Q}]\!])[w \notin \phi \rightarrow \neg\textit{believe}_w(j,\phi)]$
(For any Q-relevant proposition ϕ, if ϕ is false, then John doesn't believe ϕ.)

As for **Fact 2**, I assume that tautologies are more tolerated than contradictions. Hence, in paraphrasing the FA-sensitivity condition, the factive presupposition of an emotive factive is locally accommodated, so as to rescue presupposition failure. Consider (4.52) for illustration. The inference in (4.52a) holds as long as the factive presupposition ϕ_c is accommodated under negation. In contrast, the inference in (4.52b) is not implied, because global accommodation causes presupposition failure.

(4.52) (Context: *Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)
John is surprised at who came.

a. $\rightsquigarrow$ it isn't the case that John is surprised that c came. $\neg[\textit{surprise}(j,\phi_c) \wedge \phi_c]$

b. $\not\rightsquigarrow$ John isn't surprised that c came. $\neg\textit{surprise}(j,\phi_c) \wedge \phi_c$

Broadly speaking, locally accommodating the factive presupposition of an emotive factive turns the FA-sensitivity condition into a tautology, as schematized in (4.53). Or, equivalently, the FA-sensitivity inference collapses under the factive presupposition. This undesired consequence explains why emotive factives "seemingly" cannot license FA-sensitive readings.

(4.53) FA-sensitivity condition for 'John is surprised at Q':
$\lambda w.\forall\phi \in \textsc{Rel}([\![\mathrm{Q}]\!])[w \notin \phi \rightarrow \neg[w \in \phi \wedge \textit{surprise}_w(j,\phi)]]$ **Tautology**
(For any Q-relevant proposition, whenever ϕ is false, it is not the case that [ϕ is true and John is surprised at ϕ].)

Here arises a question: in paraphrasing FA-sensitivity conditions, why is it that the factive presupposition of *be surprised* is accommodated locally, while that the factive presupposition of *know* is deactivated? This contrast correlates with the general distinction between emotive factives and cognitive factives as presupposition triggers, as exemplified in (7.36a): the factive presupposition triggered by the cognitive factive *discover* is defeasible, while that triggered by the emotive factive *regret* is not.

(4.54) a. If someone **regrets** that I was mistaken, I will admit that I was wrong.
$\rightsquigarrow$ *The speaker was mistaken.*

b. If someone **discovers** that I was mistaken, I will admit that I was wrong.
$\not\rightsquigarrow$ *The speaker was mistaken.*

Earlier works have argued that emotive factives are *strong presupposition triggers*, while cognitive factives are *weak presupposition triggers* (Karttunen 1971, Stainaker 1977). Recent theoretical and

experimental works (Romoli 2012, 2015; Romoli and Schwarz 2015) argue that the presuppositions of soft triggers are actually scalar implicatures. The contrast between hard and soft triggers is far beyond the scope of this dissertation, but whatever accounting for this contrast should also explain the contrast between (4.52) and (4.51) with respect to FA-sensitivity.

Factive communication predicates are also weak presupposition triggers. Hence, in paraphrasing FA-sensitivity, they pattern like cognitive factives and need to be replaced with their non-factive/non-veridical counterparts, as exemplified in the following:

(4.55) FA-sensitivity condition of 'John told$_{[+\text{ver}]}$ Mary Q':
$\lambda w.\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[w \notin \phi \rightarrow \neg \textit{told}_{[\text{-ver}],w}(j, m, \phi)]$
(For any Q-relevant proposition, if ϕ is false, then John didn't tell$_{[\text{-ver}]}$ Mary ϕ.)

To sum up this section, the FA-sensitivity condition of an indirect question with a factive interrogative-embedding predicate is schematized as one of the following forms, varying depending on whether the embedding factive is a strong or a weak presupposition trigger:

(4.56) FA-sensitivity condition of 'x $V_{[+\text{fac}]}$ Q':
a. If $V_{[+\text{fac}]}$ is a weak factive presupposition trigger:
$\lambda w.\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[w \notin \phi \rightarrow \neg V'_{[\text{-fac}],w}(x, \phi)]$
b. If $V_{[+\text{fac}]}$ is a strong factive presupposition trigger:
$\lambda w.\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[w \notin \phi \rightarrow \neg[V'_w(x, \phi) \wedge w \in \phi]]$

4.6.2. Collapsing of mention-some under *agree*: Opinionatedness

The non-veridical responsive predicate *agree* also licenses FA-sensitive readings. For instance, for the following sentences to be true, if Mary has a negative belief that Cindy didn't come, John cannot have the contrary positive belief that Cindy came.

(4.57) a. John agrees with Mary on who came.
b. John and Mary agree on who came.

It remains controversial what precisely the truth conditions of (4.57a-b) are. Lahiri (1991, 2002) takes *agree with* sentences as basic and *agree on* sentences as their symmetric counterparts.[54]

[54]Unexpected to Lahiri (2002), the experimental results of Chemla and George (2015) did not show any significant differences between *agree with* and *agree on*. The results suggest that both (4.57a-b) should take the following truth conditions, interpreted as 'John and Mary have the same positive belief as to *who came*.'

(i) a. $\forall x$ [Mary believes that x came $\rightarrow$ John believes that x came]
b. $\forall x$ [**not** [Mary believes that x did came] $\rightarrow$ **not** [John believes that x came]]
$\Rightarrow$ $\forall x$ [Mary believes that x came $\leftrightarrow$ John believes that x came]
(John and Mary have the same positive belief as to *who came*.)

Alexandre Cremers points out (pers. comm.) to me that there is probably no need to draw strong interpretations from the lack of difference between *agree with* and *agree on* in the results. The lack of difference might be simply due to experimental artifact.

Different empirical claims have been made by Beck and Rullmann (1999), Spector and Egré (2015a), (Uegaki 2015: chap. 4), and so on.[55]

(4.58) **Semantics of** *agree with/on* (Lahiri 2002)

a. 'A agrees with B on Q' is true iff
for every p in the Hamblin set of Q: if B believes p, then A believes p;

b. 'A and B agree on Q' is true iff
for every p in the Hamblin set of Q: A believes p iff B believes p.

The semantics given by Lahiri does not capture the condition of FA-sensitivity involved in interpreting *agree*-sentences. Consider the scenario described in the following table. Intuitively, if Mary has a negative belief that c didn't come, John shall not have the corresponding affirmative belief that c came. More generally, John shall not have any belief that contradicts Mary's belief as to who came. In comparison, if Mary is ignorant as to whether d came, it does not matter whether John believes, doubts, or is ignorant as to whether d came.

(4.59) John agrees with Mary on who came.

Did ... came?	*a*	*b*	*c*	*d*
Mary's belief	Yes	Yes	No	?
John's belief can be	Yes	Yes	No/?	Yes/No/?

I schematize the truth conditions of *agree with* sentences as follows. Compared with sentences with a veridical predicate, the Completeness condition in an *agree*-sentence is not concerned with the true answers of the embedded interrogative Q, but rather the answers of Q that Mary believes, written as '$\mathcal{B}^m_w([\![\text{Q}]\!])$.' Likewise, the FA-sensitivity condition is to avoid contradictions to *Mary's belief* relevant to Q, not to avoid contradictions to the *facts* relevant to Q.

(4.60) $\mathcal{B}^m_w([\![\text{Q}]\!]) = Q \cap \{p : \text{DOX}^m_w \subseteq p\}$, where Q is the Hamblin set of Q.
(The set of possible answers of Q that Mary believes in w)

(4.61) John agrees with Mary on Q.

a. $\lambda w.\exists\phi \in \textsc{MaxI}(\mathcal{B}^m_w([\![\text{Q}]\!]))[\textit{believe}_w(j,\phi)]$ **Completeness**
(λw. John believes$_w$ a max-informative proposition in $\mathcal{B}^m_w([\![\text{Q}]\!])$)

b. $\lambda w.\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[\textit{believe}_w(m,\neg\phi) \rightarrow \neg\textit{believe}_w(j,\phi)]$ **FA-sensitivity**
(For any Q-relevant proposition ϕ, if ϕ contradicts Mary's belief, it is not the case that John believes ϕ.)

[55] Beck and Rullmann (1999) discuss only *agree on* sentences. They argue that the truth conditions of *agree on* sentences are also concerned with negative beliefs. They assume that the truth conditions of *agree on* sentences involve both (ia-b). Chemla and George (2015) experimentally validated condition (ia), but showed that (ib) is too strong.

(i) 'A and B agree on Q' is true iff for all p in the Hamblin set of Q,

a. A believes p iff B believes p;

b. A believes $\neg p$ iff B believes $\neg p$;

A more uniform way to characterize the truth conditions is as follows. Take FA-sensitivity for example: 'ϕ contradicts the facts in w' can be viewed as 'the intersection between the intension of ϕ and $\{w\}$ is empty'; likewise, 'ϕ contradicts Mary's belief' can be viewed as 'the intersection between the intension of ϕ and DOX^m_w is empty.'

(4.62) For 'John knows Q':

a. $\lambda w.\exists\phi \in \mathrm{MaxI}(Q \cap \{p : \{w\} \subseteq p\})[\textit{believe}_w(x,\phi)]$ **Completeness**

b. $\lambda w.\forall\phi \in \textsc{Rel}(\llbracket \mathrm{Q} \rrbracket)[[\phi \cap \{w\} = \varnothing] \rightarrow \neg\textit{believe}_w(j,\phi)]$ **FA-sensitivity**

(4.63) For 'John agrees with Mary on Q':

a. $\lambda w.\exists\phi \in \mathrm{MaxI}(Q \cap \{p : \mathrm{DOX}^m_w \subseteq p\})[\textit{believe}_w(x,\phi)]$ **Completeness**

b. $\lambda w.\forall\phi \in \textsc{Rel}(\llbracket \mathrm{Q} \rrbracket)[[\phi \cap \mathrm{DOX}^m_w = \varnothing] \rightarrow \neg\textit{believe}_w(j,\phi)]$ **FA-sensitivity**

What strikes me the most is that $\Diamond$-questions embedded under *agree* do not seem to admit mention-some readings. For example, for the *agree*-sentence in (4.64) to be true, John needs to share **all** the affirmative beliefs that Mary has as to the embedded question, even though this embedded question is a typical mention-some question.

(4.64) John agrees with Mary on who can chair the committee.

To be more concrete, compare the scenarios described in the following two tables. Intuitively, (4.64) is false in both scenarios. The conditions characterized in (4.61) correctly predict (4.64) to be false in Scenario 1 due to the violation of FA-sensitivity: John's belief that *b cannot chair* contradicts Mary's belief that *b can chair*. Nevertheless, so far, is remains puzzling why (4.64) is false also in Scenario 2, where John is ignorant as to whether *b* can chair: (i) John agrees with Mary that *a can chair*, and hence Completeness is satisfied; (ii) John has no belief that contradicts Mary's belief, and hence FA-sensitivity is satisfied.

Can ... chair?	*a*	*b*	*c*	*d*
Mary's belief	Yes	Yes	No	?
John's belief	Yes	**No**	No	?

Table 4.1: Scenario 1 [False]

Can ... chair?	*a*	*b*	*c*	*d*
Mary's belief	Yes	Yes	No	?
John's belief	Yes	**?**	No	?

Table 4.2: Scenario 2 [False]

I propose that *agree* also evokes a condition of *Opinionatedness*, defined as follows:

(4.65) Opinionatedness condition of 'John agrees with Mary on Q':
$\lambda w.\forall\phi \in \textsc{MaxI}(\mathcal{B}^m_w(\llbracket \mathrm{Q} \rrbracket))[\textit{believe}_w(j,\phi) \vee \textit{believe}_w(j,\neg\phi)]$
(For any max-informative belief of Mary on Q, John either believes it or doubts it.)

As seen below, FA-sensitivity together with Opinionatedness entails a universal inference, which happens to be equivalent to a mention-all inference. Hence, the *agree*-sentence in (4.64) cannot take a mention-some reading because the mention-some inference collapses under the universal inference derived from FA-sensitivity and Opinionatedness.

(4.66) a. $\lambda w.\forall\phi \in \text{MaxI}(\mathcal{B}^m_w([\![\text{Q}]\!]))[\neg \textit{believe}_w(j, \neg\phi)]$ **Entailed by FA-sensitivity**
(John does not doubt any of Mary's max-informative beliefs on Q.)

b. $\lambda w.\forall\phi \in \text{MaxI}(\mathcal{B}^m_w([\![\text{Q}]\!]))[\textit{believe}_w(j, \phi) \vee \textit{believe}_w(j, \neg\phi)]$ **Opinionatedness**
(For any max-informative belief of Mary on Q, John either believes it or doubts it.)

$\Rightarrow$ $\lambda w.\forall\phi \in \text{MaxI}(\mathcal{B}^m_w([\![\text{Q}]\!]))[\textit{believe}_w(j, \phi)]$
(For any max-informative belief of Mary on Q, John believes it.)

4.7. Over-denying and asymmetries of FA-sensitivity: Experimental evidence

4.7.1. Design

The primary goal of the following experiments is to identify whether over-denying is involved in the condition of FA-sensitivity. "Exp-MA" stands for reanalyzing Klinedinst & Rothschild's (2011) survey on indirect mention-all questions. "Exp-MS" stands for an analogous experiment on indirect mention-some questions.

Exp-MA Klinedinst and Rothschild (2011) conducted a survey to establish the existence of IE readings.[56] They stipulated that four individuals *abcd* tried out for the swimming team, and that only *a* and *d* made the team. Four sets of predictions (A1-A4 in Table 4.3) were made as to whether each individual made the team. For instance, A1 means that the agent predicted that *d* but not *a* nor *c* made the swimming team and that the agent was uncertain whether *b* made it. Next, they asked the participants to judge whether or not each prediction correctly predicted who made the swimming team. Each combination of responses corresponds to a reading of the indirect mention-all question *x predicted who made the swimming team*. For instance, the participants who chose an IE reading would ideally accept A3 and reject the rest responses, while the participants who chose an SE reading would ideally reject all the responses.

Did ... make the swimming team?	*a*	*b*	*c*	*d*	Answer type
Fact	*Yes*	*No*	*No*	*Yes*	
A1	**No**	?	No	Yes	OD
A2	?	No	No	Yes	MS
A3	Yes	?	No	Yes	MA
A4	Yes	**Yes**	?	Yes	OA

Table 4.3: Design of Exp-MA (Klinedinst and Rothschild 2011)

[56]See Cremers & Chelma (2016) for an extensive experimental investigation on intermediate exhaustivity.

Klinedinst & Rothschild were not particularly interested in over-denying. They removed the participants who accepted A1/A2 (i.e., the participants who were tolerant of incompleteness) from their data analysis. But this survey is also helpful for studying FA-sensitivity. A1 and A4 represent answers with over-denying and answers with over-affirming, respectively: A1 incorrectly predicted that *a* did not make the team, and A4 incorrectly predicted that *b* made the team. A2 and A3 have no false prediction, but A2 violates Completeness. I renamed A1-A4 as OD/MS/MA/OA and re-analyzed the raw data.[57]

Exp-MS Next, I conducted a similar experiment for indirect mention-some questions on MTurk, henceforth called "Exp-MS":[58] among the four liquor stores *abcd* at Central Square, only *a* and *d* sell red wine; Susan asked her local friends where she could buy a bottle of red wine at Central Square and received four responses (A1-A4 in Table 4.4). Participants were asked to identify whether each response correctly answered Susan's question. Note here that A2 satisfies the condition of Completeness, contrary to the case in Exp-MA.

Could Susan buy a bottle of red wine at ...?	*a*	*b*	*c*	*d*	Answer type
Fact	*Yes*	*No*	*No*	*Yes*	
A1	**No**	?	No	Yes	OD
A2	?	No	No	Yes	MS
A3	Yes	?	No	Yes	MA
A4	Yes	**Yes**	?	Yes	OA

Table 4.4: Design of Exp-MS

4.7.2. Results and discussions

The proportions of acceptances by Answer are summarized in the Figure 4.3 and 4.4. *N* stands for the number of participants who satisfied all the filtering criteria.[59]

[57]See here (http://users.ox.ac.uk/~sfop0300/questionsurvey/) for the raw data of Klinedinst & Rothschild's survey. This survey had no fillers. Thus, I excluded only participants who were (i) non-native speakers, (ii) rejected by Amazon Mechanical Turk (MTurk), or (iii) with missing responses. 107 participants (out of 193) were kept in my data analysis. Participants were not chosen based on their responses.

[58]In Exp-MS, the four target items (A1-A4) and two fillers were randomized into 10 lists. I recruited 100 participants on MTurk. All the participants were required to have completed 90 HITs with the number of HITs approved no less than 50. All IP address were tied to the U.S. Based on the filler accuracy (100%), native language (English), and the completion rate (fully completed exactly one HIT), I kept 88 participants out of 100. The randomization process were done using the *turktools* software (Erlewine and Kotek 2016).

[59]In Exp-MA, A1 to A4 received 88, 75, 28, and 55 acceptances (out of 107), respectively. Note that the results might be noisy because the subjects/responses could not be removed based on filler accuracy. In Exp-MS, A1 to A4 received 70, 86, 86, and 50 acceptances (out of 88), respectively.

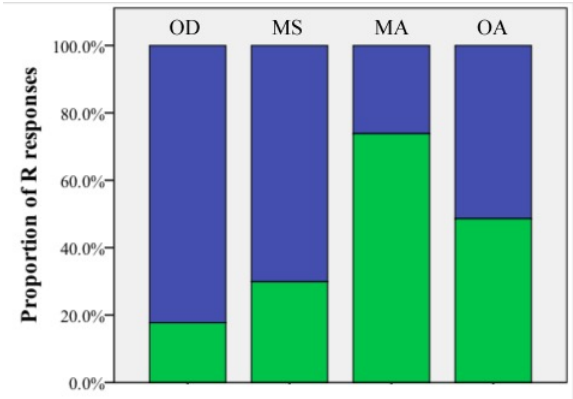


Figure 4.3: Proportion of acceptances by Answer in Exp-MA (N = 107)

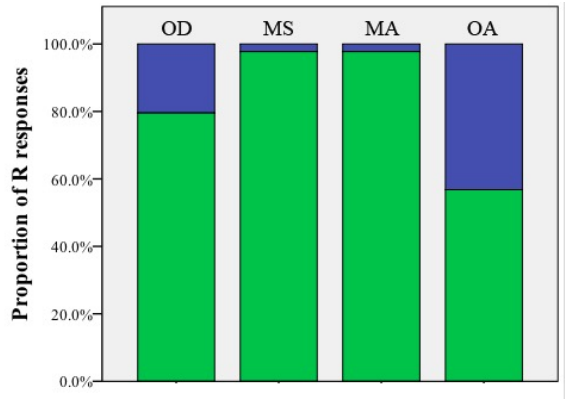


Figure 4.4: Proportion of acceptances by Answer in Exp-MS (N = 88)

FA-sensitivity For every two answers in each experiment, I fitted a logistic mixed effects model predicting responses by Answer.[60] All the models, except the one for MS versus MA in Exp-MS, reported a significant effect. These significant effects, especially the ones for OD versus MS/MA in Exp-MS, show that FA-sensitivity is concerned with both over-affirming and over-denying (viz., false denials).

Asymmetry of FA-sensitivity Compared with OD, OA received significantly more acceptances in Exp-MA ($\hat{\beta}$ = 1.0952, p<.001) but significantly less acceptances in Exp-MS ($\hat{\beta}$ = –0.7324, p<.005). These results suggest the following asymmetry:

(4.67) **Asymmetry of FA-sensitivity**
Compared with over-denying, over-affirming is more tolerated in mention-all questions, but less tolerated in mention-some questions.

What causes this asymmetry? One might suggest that over-denying is less tolerated than over-affirming in mention-all questions simply because over-denying even does not satisfy the Completeness condition. This suggestion yields the following prediction: if a participant was tolerant of incompleteness, then his or her responses would not show any asymmetry with respect to FA-sensitivity. To evaluate this prediction, consider the participants in Exp-MA who were tolerant of incompleteness (i.e., the participants who accepted both MS and MA, N = 28). The distribution of each possible combination of responses given by these subjects is summarized in Table 4.5.

[60] A1 and A4 were coded as –1 and 1, respectively. Fomula: glmer(Choice ~ Item + (1|WorkerId), data = mydata, family = binomial (link="logit"), verbose = TRUE)

A1	A2	A3	A4	*N*
×	√	√	×	11
√	√	√	×	1
×	√	√	√	8
√	√	√	√	8

Table 4.5: Responses in Exp-MA (based on subjects accepting partial answers)

Contrary to the prediction above, however, these participants also rejected OD significantly more than OA (binomial test: 89%, $p<.05$). In other words, over-denying is consistently less tolerated than over-affirming in mention-all questions, regardless of whether Completeness is concerned. In conclusion, the asymmetry of FA-sensitivity varies by question-type (viz., mention-all versus mention-some), not results from a violation of Completeness.

4.7.3. Asymmetries of FA-sensitivity

Experiments above found an asymmetry with respect to FA-sensitivity (at least for indirect questions with communication verbs): over-affirming is more tolerated than over-denying in mention-all questions, but less tolerated than over-denying in mention-some questions. In other words, mention-all questions are more sensitive to over-denying, while mention-some questions are more sensitive to over-affirming. Moreover, I have shown that this asymmetry holds even if the Completeness condition is ignored.

Why it is that false answers are not equally bad? I propose that a false answer is tolerated if it is not misleading. Each response brings an update to the answer space, such as removing the incompatible answers or adding the entailed answers. If the questioner accepts this response, he would take one of the max-informative answers of the updated answer space as a resolution and make decisions accordingly. If a response updates the answer space in a way such that none of the max-informative answers leads to an improper decision, this response could be tolerated, even if it contains false information. For instance, in Exp-MS, is was assumed that red wine is only available in store A and store D. If someone told Susan that she could get red wine from A but not from store D, she would still go to a right place for red wine (i.e., store A). For this reason, overly denying the possibility of getting red wine from store D is tolerated. In contrast, if someone told Susan that she could get red wine from both Store A and store B, she might end up going to a wrong place for red wine (i.e., store B). For this reason, overly affirming the possibility of getting red wine from store B is not tolerated. Hence, OD received more acceptances than OA in Exp-MS.

Could Susan buy red wine at ...?	*a*	*b*	*c*	*d*
Fact	*Yes*	*No*	*No*	*Yes*
OD	**No**	?	No	Yes
OA	Yes	**Yes**	?	Yes

Table 4.6: Scenario of Exp-MS

More generally, for a max-informative answer not leading to an improper decision, it has to

provide enough information that a good answer would do. Whether an answer counts as a "good answer" is determined by both linguistic factors (i.e., whether this answer is a max-informative true answer) and non-linguistic factors (i.e., whether this answer is sufficient for the conversational goal). In a context-neutral case, a max-informative true answer counts as a good answer. Hence, I propose that a false answer is tolerated if it satisfies the *Principle of Tolerance*. This principle relates FA-sensitivity to max-informativity.

(4.68) **Principle of Tolerance**
Assume that a question has a set of true answers Q_w. An answer of this question is tolerated iff this answer updates Q_w into A such that every max-informative member of A entails a max-informative member of Q_w.

In the paragraphs that follow, I elaborate how this principle captures the asymmetry of FA-sensitivity in each type of questions.

FA-sensitivity in Exp-MA: Figure 4.5 illustrates the asymmetry of FA-sensitivity observed in Exp-MA. Arrows indicate entailments. Shading marks the answers that entail the bottom-left answer $f(a)$. Underlining marks the max-informative propositions in each answer space.

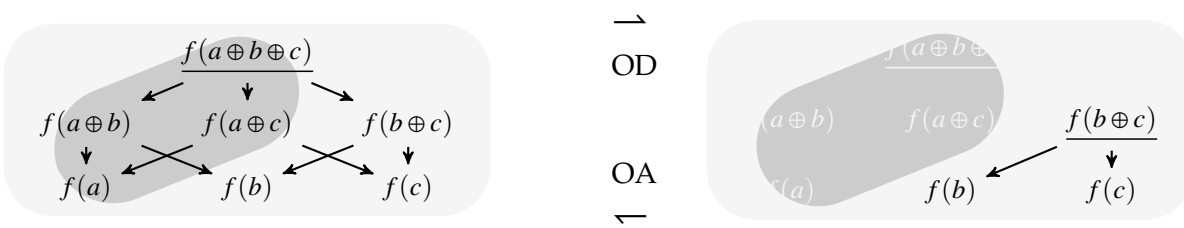


Figure 4.5: OA and OD in "who made the swimming team?"
f = ⟦made the swimming team⟧, abc are relevant individuals

- **Over-affirming is tolerated.** Assume that only the unshaded answers are true, then the question has a unique max-informative true answer $f(b \oplus c)$. Due to the entailment relation among the answers, overly affirming $f(a)$ brings in all the shaded answers. The unique max-informative member of the updated answer space, namely, $f(a \oplus b \oplus c)$, entails the unique max-informative true answer $f(b \oplus c)$.

- **Over-denying is not tolerated.** Assume that all the present answers are true, then the question has a unique max-informative true answer $f(a \oplus b \oplus c)$. Due to the entailment relation among the answers, overly denying $f(a)$ subsequently excludes all the shaded answers. The max-informative member of the updated answer space, namely, $f(b \oplus c)$, does not entail the unique max-informative true answer $f(a \oplus b \oplus c)$.

FA-sensitivity in Exp-MS: Figure 4.6 illustrates the asymmetry of FA-sensitivity observed in Exp-MS. For simplicity, here I only consider individual answers.[61] Due to the non-monotonicity

[61] As seen in Figure 2.1, if a question takes a mention-some reading, its answer space consists of individual answers, disjunctive answers, and conjunctive answers. Only individual answers are potentially max-informative.

of the embedded O-operator (see §2.6.1), all the individual answers are semantically independent; hence, the bottom-left answer is only entailed by itself (shaded).

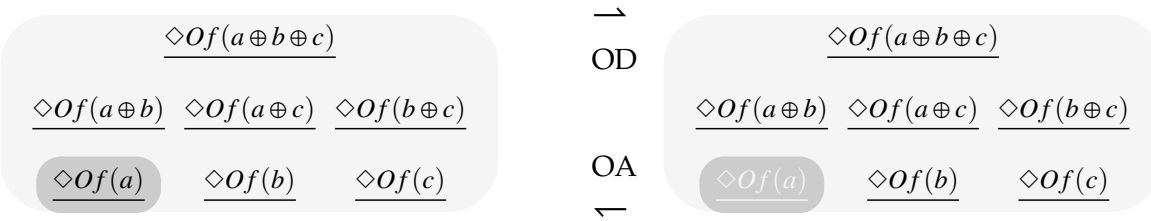


Figure 4.6: OA and OD in "where could Susan get a bottle of red wine?"
f = ⟦Susan gets a bottle of red wine from⟧, abc are relevant places

- **Over-affirming is not tolerated**. Assume that only the unshaded answers are true, then all of the unshaded answers are max-informative true answers. Overly affirming $\diamond Of(a)$ only adds $\diamond Of(a)$ itself to the answer space. $\diamond Of(a)$ is a max-informative member in the updated answer space, but it does not entail any max-informative true answers.

- **Over-denying is tolerated**. If all the present answers are true, then all of them are max-informative true answers. Overly denying $\diamond Of(a)$ only removes $\diamond Of(a)$ itself from the answer space. All the remaining answers are max-informative members of the updated answer space, and each of them entails a max-informative true answer, namely, itself.

4.8. Lines of approaches to the WE/SE distinction

There are, quite generally, three lines of approaches to capture the WE/SE distinction, which I call "answerhood-based approaches," "strengthener-based approaches," and "neg-raising-based approach." This section does not attempt to take a position from the three lines, but just to show how each line of approaches can be adapted or extended to the proposed account of Completeness and FA-sensitivity.

4.8.1. The answerhood-based approaches

In view of the answerhood-based approaches, the WE/SE distinction is treated as a result of employing different answerhood-operators (Heim 1994, Dayal 1996, Beck and Rullmann 1999). The root denotation of a question unambiguously denotes a Hamlin set (or something similar), but it can enter into different answerhood operations. In particular, employing $\textsc{Ans}_{\textsc{we}}$ and $\textsc{Ans}_{\textsc{se}}$ yield WE and SE readings, respectively.

We have seen several $\textsc{Ans}_{\textsc{we}}$-operators, as collected in (4.69). On Heim's and Dayal's accounts, employing the $\textsc{Ans}_{\textsc{we}}$-operator returns the strongest true answer, which is therefore the WE answer. On Fox's account, employing the $\textsc{Ans}_{\textsc{we}}$-operator returns a set of max-informative true answers; if the underlying question takes a mention-all reading, this set is a singleton set and it consists of only the WE answer.

(4.69) a. $\textsc{Ans}_{Heim.\textsc{we}}(Q)(w) = \bigcap\{p : w \in p \in Q\}$ (Heim 1994)

b. $\textsc{Ans}_{Dayal.\textsc{we}}(Q)(w) = \exists p[w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow p \subseteq q]].$ (Dayal 1996)
$\iota p[w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow p \subseteq q]]$

c. $\textsc{Ans}_{Fox.\textsc{we}}(Q)(w) = \{p : w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow q \not\subset p]\}$ (Fox 2013)

Based on whichever $\textsc{Ans}_{\textsc{we}}$-operator in (4.69), we can obtain an $\textsc{Ans}_{\textsc{se}}$-operator via the rule in (4.70): $\textsc{Ans}_{\textsc{se}}(Q)(w)$ returns the set of worlds w' such that the underlying question has the same complete true answer(s) in w and w'.

(4.70) $\textsc{Ans}_{\textsc{se}}(Q)(w) = \lambda w'[\textsc{Ans}_{\textsc{we}}(Q)(w) = \textsc{Ans}_{\textsc{we}}(Q)(w')]$ (Heim 1994)

Adapting this line of approaches to the proposed account of Completeness and FA-sensitivity, we can treat the WE/SE distinction as a variation with respect to the Completeness condition, as exemplified in (4.71a-b). Note that $\textsc{Ans}_{\textsc{we}}([\![\text{Q}]\!])(w)$ denotes a set of propositions and needs to be existentially bound, while $\textsc{Ans}_{\textsc{se}}([\![\text{Q}]\!])(w)$ denotes a proposition. The FA-sensitivity condition is asymmetrically entailed by the Completeness condition for SE; hence, FA-sensitivity collapses under strong exhaustivity.

(4.71) John knows Q.

a. $\lambda w.\exists\phi \in \textsc{Ans}_{\textsc{we}}([\![\text{Q}]\!])(w)[\mathit{know}_w(j,\phi)]$ **Completeness for WE**
(There is a proposition ϕ such that ϕ is a max-informative true answer of Q and that John knows ϕ.)

b. $\lambda w.\mathit{know}_w(j, \textsc{Ans}_{\textsc{se}}([\![\text{Q}]\!])(w))$ **Completeness for SE**
(John knows the SE inference of Q.)

c. $\lambda w.\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[\mathit{know}_w(j,\phi) \rightarrow w \in \phi]$ **FA-sensitivity**
(Everything that John knows relevant to Q is true.)

4.8.2. The strengthener-based approaches

A number of recent works attribute the WE/SE contrast to the absence/presence of a strengthening operator. The strengthening operator, depending on the actual approach, can be applied to the question root (George 2011, Klinedinst and Rothschild 2011) or used within the question nucleus (Nicolae 2013, 2015). The following summarizes the basic idea of each representative analysis:

George (2011: chap. 2) assumes an **X**-operator which is optionally present between the λ-abstract *Abs* and the question-formation operator **Q**. An answerhood-operator unambiguously takes an existential quantification force. Primarily, **Q**(*Abs*) returns a Hamlin set, yielding mention-some;[62] when the **X**-operator is present, **Q**[**X**(*Abs*)] returns a set of exhaustified propositions, yielding SE. (See more details in §2.4.2.)

Klinedinst and Rothschild (2011) assume that a question primarily denotes a WE inference, and hence that the ordinary value of an indirect question is its WE reading. The SE reading arises when a generalized exhaustivity-operator is applied to the embedded question. Note here that the

[62] George (2011) does not take WE as an independent reading, but a special case of mention-some.

exhaustivity-operator is not used in sense of the grammatical view of exhaustifications, because it does not operate on a proposition but instead a function from worlds to proposition sets (of type $\langle s, st \rangle$). (See §4.4.1.)

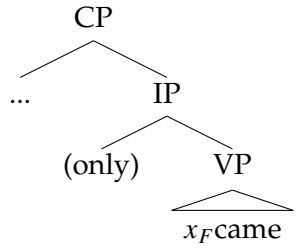
(4.72) a. John knows [who came]. **WE**
b. John knows [O [who came]]. **SE**

Nicolae (2013, 2015) takes insights from the negative polarity item (NPI)-licensing effects in *wh*-questions, and correlates these effects with the distributional pattern of SE readings. Compare the sentences in (4.73) for instance. An emotive factive like *surprise* does not license SE, and the weak NPI *any* cannot be licensed when appearing in a *wh*-question embedded under *surprise*. In contrast, a cognitive factive like *know* licenses SE, and the weak NPI *any* can be licensed when appearing in a *wh*-question embedded under *know*.

(4.73) a. * It **surprised** Angela which boys brought her any gifts.
b. Angela wants to **know** which boys brought her any gifts.

Given the similar distributional patterns of SE and weak NPIs, Nicolae proposes that an SE reading arises when a covert *only* appears within the question nucleus and is associated with the *wh*-trace.[63] For instance, under the WE reading, the root denotation of (4.74) is a set of propositions of the form 'x came', and under the SE reading, it is a set of propositions of the form 'only x came'.

(4.74) Who came?



(4.75) $[\![\text{only}]\!](p) = \lambda w[p(w) = 1.\forall q \in \textsc{Alt}(p)[q(w) = 1 \rightarrow p \subseteq q]]$

[63]This covert *only* assumed by Nicolae (2013, 2015) is slightly different from the covert O-operator assumed by the grammatical view (Chierchia et al. 2012). The overt exclusive particle *only* licenses an NPI in its scope, while a covert exhaustification does not.

(i) a. Only JOHN$_F$ read any books.
b. * O [JOHN$_F$ read any books].

Gajewski (2011) proposes that the licensing of a weak NPI is only concerned with the asserted component of the embedding environment, not the presupposed or the implicated components. This proposal easily captures the contrast in (i): *only* asserts an exhaustivity inference and presupposes the truth of the prejacent (Horn 1969), while O asserts both; therefore, the asserted component of *only* is downward-entailing with respect to the weak NPI *any*, while that of the covert O-operator is non-monotonic with respect to the weak NPI *any*. For Nicolae to make use of the NPI-licensing effect of *only*, she needs an exhaustifier that asserts only the exhaustivity inference. Moreover, she has to assume that the prejacent presupposition of the covert *only* is mandatorily locally accommodated.

The presence of a covert *only* has two consequences. First, it makes all the answers exhaustified and mutually exclusive, which therefore yields an SE reading. Second, it create an NPI-licensing environment, just like the overt *only* would do.

On the strengthener-based line of approaches, the WE/SE distinction is an ambiguity within the root denotation of the embedded question. Hence, these approaches predict that the WE/SE distinction is independent from how we characterize the Completeness condition and the FA-sensitivity condition.

For my interests in mention-some questions, an advantage of Nicolae's approach is that it predicts that SE readings cannot be derived directly from mention-some readings. This prediction captures the fact that mention-some questions hardly can take SE readings unless mention-some readings are contextually blocked. Consider (4.76) for a concrete example. Each square represents an answer space. The shaded answers are the true answers. (4.76a) illustrates the answer space for the mention-some reading. Crucially, when each of the answers is exhaustified, as in (4.76a′), the answer space would have no true answer, which violates the presupposition of the Ans-operator. By contrast, SE readings can be derived from mention-all readings via exhaustifications: in (4.76b′/c′), the conjunctive/disjunctive mention-all answer is the unique true answer and therefore the SE answer.

(4.76) Who can chair the committee?
(Context: *Only Andy and Billy can chair the committee; single-chair only.*)

a. mention-some

$$\begin{array}{ccc} & \Diamond[Of(a) \wedge Of(b)] & \\ \underline{\Diamond Of(a)} & \vee & \underline{\Diamond Of(b)} \\ & \Diamond[Of(a) \vee Of(b)] & \end{array}$$

a′. adding *only* to a

$$\begin{array}{ccc} & only\Diamond[Of(a) \wedge Of(b)] & \\ only\Diamond Of(a) & \wedge & only\Diamond Of(b) \\ & only\Diamond[Of(a) \vee Of(b)] & \end{array}$$

b. conjunctive mention-all

$$\begin{array}{ccc} & \underline{\Diamond Of(a) \wedge \Diamond Of(b)} & \\ \Diamond Of(a) & \wedge & \Diamond Of(b) \\ & \Diamond Of(a) \vee \Diamond Of(b) & \end{array}$$

b′. adding *only* to b

$$\begin{array}{ccc} & \underline{only[\Diamond Of(a) \wedge \Diamond Of(b)]} & \\ only\Diamond Of(a) & \wedge & only\Diamond Of(b) \\ & only[\Diamond Of(a) \vee \Diamond Of(b)] & \end{array}$$

c. disjunctive mention-all

$$O_{\mathbf{dou}}\Diamond[Of(a) \wedge Of(b)]$$

$$O_{\mathbf{dou}}\Diamond Of(a) \quad \wedge \quad O_{\mathbf{dou}}\Diamond Of(b)$$

$$\underline{O_{\mathbf{dou}}\Diamond[Of(a) \vee Of(b)]}$$

c′. adding *only* to c

$$only O_{\text{DOU}}\Diamond[Of(a) \wedge Of(b)]$$

$$only O_{\text{DOU}}\Diamond Of(a) \quad \wedge \quad only O_{\text{DOU}}\Diamond Of(b)$$

$$\underline{only O_{\text{DOU}}\Diamond[Of(a) \vee Of(b)]}$$

On the negative side, however, Nicolae's approach predicts that a question cannot license NPIs if it takes a mention-some reading. This prediction is incompatible with the following examples.

(4.77) a. Where can we get any$_{\text{NPI}}$ coffee?
b. Who can give me any$_{\text{NPI}}$ help?

4.8.3. The neg-raising based approach

Uegaki (2015: chap. 3) makes use of global exhaustification to derive IE readings (*à la* Klinedinst and Rothschild 2011; see §4.4.1) and further derives SE readings from IE readings based on neg-raising.

Consider (4.78) for a concrete example. **First**, an exhaustivity-operator X mandatorily presents in the matrix clause; it affirms the prejacent and negates all the alternatives that are strictly stronger than the prejacent clause, yielding an IE inference, as in (4.78c). **Second**, *know* evokes an excluded middle (EM) inference (4.78c), namely, that the attitude holder is opinionated at every potential complete answer of the embedded question. In the considered sentence, the EM inference says that John is opinionated as to whether *abc* all came, whether *ab* both came. Last, (4.78c-d) together entail the SE inference, as in (4.78e).

(4.78) John knows who came.
(Context: *Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)
a. X [$_{\text{S}}$ John knows who came]
b. $[\![\text{S}]\!] = \textsf{know}(j, \phi_{a\oplus b})$
c. $[\![X(\text{S})]\!] = \textsf{know}(j, \phi_{a\oplus b}) \wedge \neg\textsf{believe}(j, \phi_{a\oplus b\oplus c})$ **IE**
d. $[\textsf{bel}(j, \phi_{a\oplus b}) \vee \textsf{bel}(j, \neg\phi_{a\oplus b})] \wedge [\textsf{bel}(j, \phi_{a\oplus b\oplus c}) \vee \textsf{bel}(j, \neg\phi_{a\oplus b\oplus c})]$ **EM**
e. (c)&(d) $= \textsf{know}(j, \phi_{a\oplus b}) \wedge \textsf{believe}(j, \phi_a \wedge \neg\phi_{a\oplus b\oplus c})$ **SE**
$= \textsf{know}(j, \phi_{a\oplus b}) \wedge \textsf{believe}(j, \neg\phi_c)$

Adapting this idea to the proposed account, we can derive SE by strengthening the FA-sensitivity condition with an excluded middle inference. The definition of excluded middle is slightly different from what Uegaki assumes: like the FA-sensitivity condition, the excluded middle inference is concerned with every Q-relevant proposition, not just those that are potentially complete. As seen in (4.79), the inferences in (4.79b-c) together yield a strengthened (S)-FA-sensitivity condition (4.79d); then the S-FA-sensitivity condition together with the Completeness condition yields the desired SE reading.

(4.79) John knows Q.

a. $\lambda w.\exists\phi \in \textsc{Ans}([\![\text{Q}]\!])(w)[\textit{know}_w(j,\phi)]$ **Completeness**
(There is a max-informative true answer ϕ such that John knows ϕ.)

b. $\lambda w.\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[w \notin \phi \rightarrow \neg\textit{believe}_w(j,\phi)]$ **FA-sensitivity**
(Every Q-relevant proposition that John believes is true.)

c. $\lambda w.\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[\textit{believe}_w(j,\phi) \vee \textit{believe}_w(j,\neg\phi)]$ **EM**
(John is opinionated at every Q-relevant proposition.)

d. (b)&(c) $\Rightarrow \lambda w.\forall\phi \in \textsc{Rel}([\![\text{Q}]\!])[w \notin \phi \rightarrow \textit{believe}_w(j,\neg\phi)]$ **S-FA-sensitivity**
(John doubts at every false Q-relevant proposition.)

4.9. Summary

This chapter started from two understudied facts on FA-sensitivity: (i) FA-sensitivity is observed with indirect mention-some questions (George 2013, 2011), and (ii) FA-sensitivity is concerned with all types of false answers, not just not that are potentially complete. These facts challenge the current dominant account by Klinedinst and Rothschild (2011), which derives FA-sensitivity as a logical consequence of exhaustifying Completeness.

I proposed to treat Completeness and FA-sensitivity as two independent conditions, both of which are mandatorily involved in interpreting an indirect question. In the case of a veridical interrogative-embedding predicate, Completeness is concerned with a true max-informative answer of the embedded question, and FA-sensitivity is concerned with all the false propositions that are relevant to the embedded question. This account works uniformly for both mention-some and mention-all questions.

I have also explained some seemingly exceptional behaviors of emotive factives and the non-veridical predicate *agree*. In the case of an emotive factive, the FA-sensitivity condition collapses under the indefeasible factive presupposition and is therefore, not detectable. In the case of *agree*, FA-sensitivity and Opinionatedness together entail a mention-all inference, and hence *agree* does not license mention-some readings.

Experimental results from Exp-MA and Exp-MS suggested an asymmetry with respect to FA-sensitivity: over-affirming is more tolerated than over-denying in mention-all questions, but less tolerated than over-denying in mention-some questions. I proposed a Principle of Tolerance to explain this asymmetry. This principle relates FA-sensitivity to Completeness/max-informativity.

Chapter 5

Pair-list readings of multi-*wh* questions

5.1. Introduction

Multi-*wh* questions are ambiguous between single-pair readings and pair-list readings. Consider (5.1) for example. Under a single-pair reading, (5.1) presupposes that there is exactly one boy-invite-girl pair and asks the addressee to specify this pair. Under a pair-list reading, (5.1) expects that there are multiple boy-invite-girl pairs and requests the addressee to list all these pairs.

(5.1) Which boy invited which girl?

a. Andy invited Mary. (single-pair)

b. Andy invited Mary, Billy invited Jenny. (pair-list)

Analogously, $\Diamond$-questions with multiple *wh*-items exhibit a single-pair/pair-list contrast, as exemplified in (5.2). Under a single-pair reading, (5.2) presupposes that only one of the boys have access to some coffee places and asks the address to name one of these places. Under a pair-list reading, (5.2) expects that multiple boys have access to some coffee places, and asks the address to list one accessible place for each of these boys.

(5.2) Which boy can get coffee from where?

a. Andy can get coffee from J.P. Licks. (single-pair mention-some)

b. Andy can get coffee from J.P. Licks,
and Billy can get coffee from Peet's. (pair-list mention-some)

This chapter is centered on pair-list readings. See derivations of single-pair readings in section 1.4.

For the derivation of pair-list readings of multi-*wh* questions, two lines of approaches have been proposed in the literature. One line assumes that the pair-list reading of a multi-*wh* question inquires the functional dependency between the sets quantified over by the *wh*-items (Engdahl 1986, 1980; Dayal 1996, 2017), henceforth called a "function-based" line. The other line defines multi-*wh* questions as families of questions (Hagstrom 1998, Fox 2012a, Nicolae 2013, Kotek 2014), henceforth called a "higher-order question" line. This chapter will explore both lines of approaches.

The rest of this chapter is organized as follows. Section 5.2 re-examines the "domain exhaustivity" presupposition (Dayal 1996, 2002). Contra the current dominant view, I argue that pair-list readings

of multi-*wh* questions are not subject to domain exhaustivity, unlike the pair-list readings of ∀-questions. Section 5.3 reviews the two representative lines of approaches, especially the analyses proposed by Dayal (1996, 2017) and Fox (2012a). Section 5.4 presents my analysis. This analysis takes insights from previous function-based approaches, meaning that it treats pair-list readings as a special species of functional readings. Nevertheless, my analysis is more preferable than the "crazy C approach" by Dayal (1996, 2017) in the following respects. First, it does not involve any abnormal assumptions or structure-dependent operations; therefore, I call my analysis a "non-crazy" function-based approach. Second, my analysis overcomes several conceptual or empirical problems with Dayal's analysis: it does not overly predict domain exhaustivity effects with multi-*wh* questions; it can also easily capture the QV effects in quantified indirect multi-*wh* questions. The appendix shows how to adapt the higher-order question approach by Fox (2012a) to the proposed hybrid categorial approach of composing questions.

5.2. The phenomenon: Domain exhaustivity?

The current dominant view, due to Dayal (2017, 2002, 1996), says that pair-list readings of multi-*wh* questions are subject to *domain exhaustivity* (also called domain cover by Dayal (2017)). For example, questions with multiple singular *wh*-phrases (abbreviated as "multi-wh_{SG} questions" henceforth) are said to evoke two presuppositions under pair-list readings, including domain exhaustivity and point-wise uniqueness, as described in the following:

(5.3) **Presuppositions of a multiple wh_{sg}-question** (Dayal 2002)

a. *Domain exhaustivity*
Every member of the set quantified over by the overtly moved *wh*-item is paired with a member of the set quantified over by the in-situ *wh*-item.

b. *Point-wise uniqueness*
Every member of the set quantified over by the overtly moved *wh*-item is paired with no more than one member of the set quantified over by the in-situ *wh*-item.

Take (5.4) for instance, the domain exhaustivity presupposition requires that every boy is such that he invited a girl, and the point-wise uniqueness presupposition requires that every boy is such that he invited exactly one girl.

(5.4) Which boy invited which girl?

The point-wise uniqueness effect is easy to detect. But the domain exhaustivity effect is much more obscure. In (5.4), it is unclear which set of boys is quantified by *which boy*, and hence it leaves the possibility that this quantification domain is contextually restricted to a subset of boys who invited some girl(s). To avoid this confound, Fox (2012a) adds an explicit domain restriction to each of the *wh*-phrases, as shown in (5.5).

(5.5) a. Guess which one of these 3 kids will sit on which of these 4 chairs.
(OKsingle-pair, OKpair-list)

b. Guess which one of these 4 kids will sit on which of these 3 chairs.
(OKsingle-pair, #pair-list)

Fox argues that the embedded multi-*wh* question in (5.5b) rejects a pair-list reading because the domain exhaustivity condition presupposed under a pair-list reading is contextually infelicitous. His argument proceeds as follows: under a pair-list reading, *which one of these 3 kids will sit on which of these 4 chairs* presupposes that each of the four kids will sit on one of the three chairs; but since the chairs are fewer than the kids, this presupposition yields that there will be multiple kids sitting on the same chair, which is contextually infelicitous.

Contra the dominant view, I argue that multi-*wh* questions are not subject to domain exhaustivity. First, under the following context, the sentence (5.5b) is fully acceptable and admits only a pair-list reading.

(5.6) (Context: *Four kids are playing the game of Musical Chairs*[64] *and are competing for three chairs.*)
"Guess which one of these 4 kids will sit on which of these 3 chairs."
$\not\rightsquigarrow$ *Each of the four kids will sit on one of the three chairs.*

The game rule of Musical Chairs suggests the following conditions: (i) one of the four kids will not sit on any of the chairs, and (ii) the rest three kids will each sit on a chair. Condition (ii) ensures the embedded question to take pair-list readings (as oppose to a single-pair reading), and condition (i) contradicts the domain exhaustivity inference that every kid will sit on a chair. If the pair-list reading of a multi-*wh* question presupposes domain exhaustivity, (5.6) would suffer presupposition failure and be infelicitous, contra fact.

Next, compare the following two sentences under the given context, where the quantification domain of the subject-*wh*/quantifier is greatly larger than that of the object-*wh*. The contrast between (5.7a-b) shows that the multi-*wh* question in (5.7a) is not subject to domain exhaustivity, or at least that its domain exhaustivity effect, if any, is much less robust than that of the ∀-question in (5.7b).

(5.7) (Context: *100 candidates are competing for three jobs.*)
a. √ "Guess which candidate will get which job."
b. # "Guess which job will every candidate get."

One might suggest that the domain exhaustivity effect of a multi-*wh* question can be associated with any of the *wh*-phrases, including the insitu *wh*-phrase. For example, in (5.6) and (5.7), it could be the case that every chair and every job should be taken by some kid and some candidate, respectively. This prediction, however, is also incorrect, as shown in the following:

(5.8) (Context: *There are four boys and four girls in the dancing class. Each boy will be paired with one girl to participate in a dance competition. Only two pairs will be in the finals.*)
"Guess which one of these 4 boys will dance with which one of these 4 girls in the finals."
$\not\rightsquigarrow$ *Each boy will dance with some girl in the finals.*
$\not\rightsquigarrow$ *Each girl will dance with some boy in the finals.*

[64] "Musical Chairs is a game where a number of chairs, one fewer than the number of players, are arranged facing outward with the players standing in a circle just outside the chairs. Usually music is played while the players in the circle walk in unison around the chairs. When the music stops each player attempts to sit down in one of the chairs. The player who is left without a chair is eliminated from the game." (Wikipedia)

The following table summarizes my take on the pair-list readings:

Is the pair-list reading of ... subject to	Point-wise uniqueness?	Domain exhaustivity"
Which boy invited which girl?	✓	×
Which girl did every boy invite?	✓	✓

5.3. Previous accounts and their problems

This section reviews the two representative lines of approaches, especially the analyses proposed by Dayal (1996, 2017) and Fox (2012a). The reviews will be centered on the following issues:

(i) Are these proposals technically feasible?

(ii) Do they yield the correct empirical predictions with respect to domain exhaustivity and point-wise uniqueness?

(iii) Can they predict the quantificational variability (QV) effects in quantified indirect questions (e.g., *John mostly knows which boy invited which girl.*)?

5.3.1. Function-based approaches

The line of function-based approaches was firstly designed to deal with pair-list readings of ∀-questions (Engdahl 1980, 1986; Groenendijk and Stokhof 1984; Chierchia 1993; Dayal 1996, 2017; among others). Claiming that the pair-list readings of (5.9a-b) are identical, Engdahl (1980, 1986) and Dayal (1996, 2017) derive them based on similar LFs.

(5.9) a. Which girl did every/each boy invite?
b. Which boy invited which girl?

Contrary to Engdahl and Dayal, I derive the pair-list readings of multi-*wh* questions and ∀-questions via distinct structures, due to the following considerations: (i) these two pair-list readings are different with respect to domain exhaustivity (§5.2); and (ii) these two types of questions have a lot of structural differences, and hence it is technically difficult to analyze them based on similar LFs. In chapter 6, I will show that the derivation of the pair-list readings of ∀-questions resembles that of the choice readings of ∃-questions (e.g., *which girl did one of the boys invite?*).

The rest of this section will discuss only Dayal's analysis, because it is so far the only function-based approach that can predict the point-wise uniqueness effects of multi-wh_{SG} questions. See Dayal (2017: chap. 4) for reviews of the other function-based accounts.

5.3.1.1. The crazy functional C approach (Dayal 1996, 2017)

Dayal (1996, 2017) argues that pair-list answers to multi-*wh* questions involve a functional dependency between the quantification domains of the *wh*-items. For instance, the pair-list reading of (5.10) asks about a function **f** from atomic boys to atomic girls such that each boy x invited a girl $\mathbf{f}(x)$, as illustrated in (5.11). To specify this function, one needs to list all the boy-invite-girl pairs, which is therefore a pair-list answer.

(5.10) Which boy invited which girl?
≈ 'For which function **f** from *boy* to *girl* is such that x invited $\mathbf{f}(x)$?'

(5.11) (Context: *Andy invited Mary, Billy invited Jenny; no other boy invited any girl.*)
$$\mathbf{f} = \left\{ \begin{array}{ccc} a & \rightarrow & m \\ b & \rightarrow & j \end{array} \right\}$$

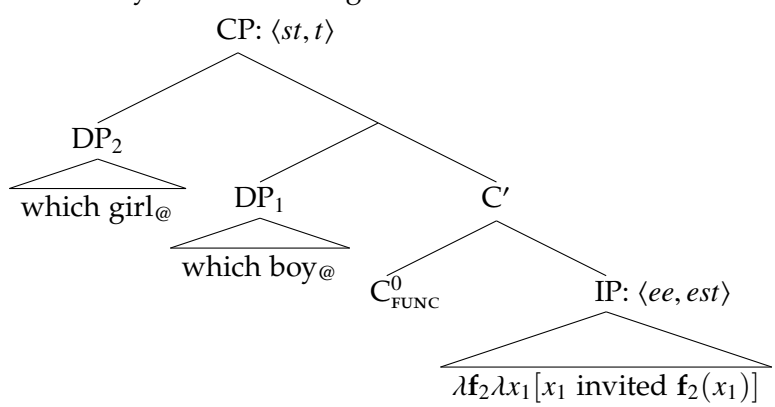
To capture this functional dependency, Dayal defines a functional C^0, written as "C^0_{FUNC}."

(5.12) $[\![C^0{}_{\text{FUNC}}]\!] = \lambda q_{\langle ee,est\rangle}\lambda D\lambda R\lambda p.\exists \mathbf{f} \in [D \rightarrow R][p = \bigcap \lambda p'.\exists x \in D[p' = q(x)(\mathbf{f})]]$
where $\mathbf{f} \in [D \rightarrow R]$ iff $\text{Dom}(\mathbf{f}) = D$ and $\forall x[\mathbf{f}(x) \in R]$

The head C^0_{FUNC} contributes the following three semantic features: (i) an existential quantification over functions (viz., $\exists \mathbf{f}$), (ii) restrictions on the domain and range of the function (viz., $\mathbf{f} \in [D \rightarrow R]$), and (iii) the creation of the graph of each such function. The graph of a function **f** is the conjunction that coordinates all the propositions obtained by quantifying over the domain of **f** (viz., $\bigcap \lambda p'.\exists x \in D[p' = q(x)(\mathbf{f})]$, or equivalently, $\bigcap\{q(x)(\mathbf{f}) : x \in D\}$). Since C^0_{FUNC} involves so many new features, Dayal calls her approach a "crazy C approach."

The pair-list denotation of a multi-*wh* question is composed via the following LF:

(5.13) Which boy invited which girl?



Both *wh*-phrases are moved to [Spec, CP]. The subject-*wh* leaves a individual trace x_2 (of type e), while the object-*wh* leaves a functional trace $\mathbf{f}_2$ (of type $\langle e, e\rangle$). IP saturates the first argument of C^0_{FUNC}. The denotation of IP is a function (of type $\langle ee, est\rangle$) that maps a function ($\mathbf{f}_2$) between two sets of individuals to a property of individuals ($\lambda x_1.{}^\wedge\textit{like}(x_1, \mathbf{f}_2(x_1))$).

(5.14) a. $[\![\text{IP}]\!] = \lambda \mathbf{f}_{\langle e,e\rangle}\lambda x_e[{}^\wedge\textit{invite}(x, \mathbf{f}(x))]$
b. $[\![C^0{}_{\text{FUNC}}]\!] = \lambda q_{\langle ee,est\rangle}\lambda D\lambda R\lambda p.\exists \mathbf{f} \in [D \rightarrow R][p = \bigcap \lambda p'.\exists x \in D[p' = q(x)(\mathbf{f})]]$
c. $[\![C']\!] = \lambda D\lambda R\lambda p.\exists \mathbf{f} \in [D \rightarrow R][p = \bigcap \lambda p'.\exists x \in D[p' = {}^\wedge\textit{invite}(x, \mathbf{f}(x)]]$

The domain and range arguments of C^0_{FUNC} are saturated by the quantification domain of the subject-*wh* and that of the object-*wh* (viz., $\textit{boy}_@$ and $\textit{girl}_@$), respectively. Dayal (2017) discusses two ways to obtain the quantification domain of a *wh*-item. One way is to employ a Be-shifter (Partee

1986). The Be-shifter can extract the quantification domain of an existential generalized quantifier, as shown in the following, repeated from (1.35):[65]

(5.15) a. $\textsc{Be} = \lambda\mathcal{P}.\lambda z[\mathcal{P}(\lambda y.y = z)]$

b. $[\![\text{which boy}_{@}]\!] = \lambda f_{\langle e,t\rangle}.\exists x \in \mathit{boy}_{@}[f(x)]$

c. $\begin{aligned}\textsc{Be}([\![\text{which boy}_{@}]\!]) &= \lambda z[(\lambda f_{\langle e,t\rangle}.\exists x \in \mathit{boy}_{@}[f(x)])(\lambda y.y = z)]\\ &= \lambda z[\exists x \in \mathit{boy}_{@}[x = z]]\\ &= \{z : z \in \mathit{boy}_{@}\}\\ &= \mathit{boy}_{@}\end{aligned}$

The other way, proposed by Bittner (1994), is to treat the root denotation of a *wh*-item as a term and derive its quantificational meaning via employing an ∃-shifter.

(5.16) a. $[\![\text{which boy}_{@}]\!] = \mathit{boy}_{@}$

b. $\exists = \lambda D\lambda f.\exists x \in D[f(x)]$

c. $\exists([\![\text{which boy}_{@}]\!]) = \lambda f_{\langle e,t\rangle}.\exists x \in \mathit{boy}_{@}[f(x)]$

Next, composing C′ with the two *wh*-phrases, Dayal gets a set of conjunctive propositions as the root denotation. With two relevant boys (viz., Andy and Billy) and two relevant girls (viz., Mary and Jenny), the root denotation is the following Hamblin set Q. Since the domain of $\mathbf{f}$ is the set quantified by the subject-*wh*, every possible answer needs to exhaustify over this set, giving rise to a domain exhaustivity effect.

(5.17) $$\begin{aligned}Q &= \lambda p.\exists \mathbf{f} \in [\mathit{boy}_{@} \to \mathit{girl}_{@}][p = \bigcap \lambda p'.\exists x \in \mathit{boy}_{@}[p' = {}^{\wedge}\mathit{invite}(x, \mathbf{f}(x))]]\\ &= \{\bigcap\{{}^{\wedge}\mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_{@}\} : \mathbf{f} \in [\mathit{boy}_{@} \to \mathit{girl}_{@}]\}\\ &= \left\{\begin{array}{l} {}^{\wedge}\mathit{invite}(a,m) \cap {}^{\wedge}\mathit{invite}(b,j)\\ {}^{\wedge}\mathit{invite}(a,m) \cap {}^{\wedge}\mathit{invite}(b,m)\\ {}^{\wedge}\mathit{invite}(a,j) \cap {}^{\wedge}\mathit{invite}(b,j)\\ {}^{\wedge}\mathit{invite}(a,j) \cap {}^{\wedge}\mathit{invite}(b,m)\end{array}\right\}\end{aligned}$$

Finally, applying the $\textsc{Ans}_{Dayal}$-operator returns the unique strongest true proposition in Q (i.e., the unique true proposition in Q that entails all the true propositions in Q) and presupposes the existence of this strongest true answer, as shown in the following:

(5.18) (Context: *Andy invited Mary, Billy invited Jenny; no other boy invited any girl.*)

a. $Q_w = \{{}^{\wedge}\mathit{invite}(a,m) \cap {}^{\wedge}\mathit{invite}(b,j)\}$

b. $\begin{aligned}\textsc{Ans}_{Dayal}(Q)(w) &= \exists p[w \in p \in Q \wedge \forall q[w \in q \in Q \to p \subseteq q]].\\ &\quad \iota p[w \in p \in Q \wedge \forall q[w \in q \in Q \to p \subseteq q]]\\ &= {}^{\wedge}\mathit{invite}(a,m) \cap {}^{\wedge}\mathit{invite}(b,j)\end{aligned}$

[65]Note that we cannot extract the quantification domain of a universal quantifier via a Be-shifter. As seen in the following, applying Be to the universal quantifier *every boy* yields an odd meaning:

(i) $\begin{aligned}\textsc{Be}([\![\text{every boy}_{@}]\!]) &= \lambda z[(\lambda f_{\langle e,t\rangle}.\forall x \in \mathit{boy}_{@}[f(x)])(\lambda y.y = z)]\\ &= \lambda z[\forall x \in \mathit{boy}_{@}[x = z]]\end{aligned}$
(# The set of z such that every boy is z.)

The presupposition of $\textsc{Ans}_{Dayal}$ captures the point-wise uniqueness effect. Consider the following scenario, where the point-wise uniqueness requirement is violated. Then the Hamblin set in (5.17a) contains two true members but does not have a strongest true member, as list in (5.19a). Hence, employing the $\textsc{Ans}_{Dayal}$-operator yields a presupposition failure.

(5.19) (Context: *Andy invited only Mary, while Billy invited both Jenny and Mary.*)

a. $Q_w = \left\{ \begin{array}{l} {}^\wedge\mathsf{invite}(a,m) \cap {}^\wedge\mathsf{invite}(b,j) \\ {}^\wedge\mathsf{invite}(a,m) \cap {}^\wedge\mathsf{invite}(b,m) \end{array} \right\}$

b. $\textsc{Ans}_{Dayal}(Q)(w)$ is undefined

5.3.1.2. Advantages and problems

Compared with the higher-order question approach, Dayal maintains a basic semantic type for dual-*wh* questions: under a pair-list reading, a dual-*wh* question denotes a set of propositions, just like what a single-*wh* question denotes.

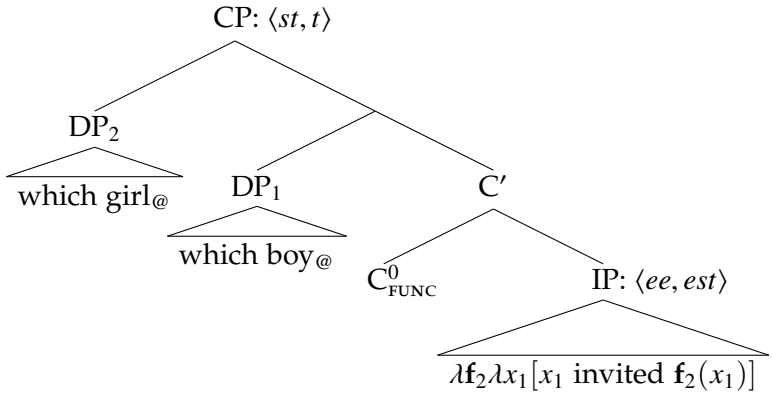
Nevertheless, Lahiri (2002) points out that the use of the $\bigcap$-closure has unwelcome consequences in predicting the quantification variability (QV) effects in interpreting indirect questions (Berman 1991). For example, in (5.20), the quantificational adverb *mostly* in the matrix clause seems to quantify over the set of true propositions of the form 'boy x invited girl y'. To predict this QV effect, we need to keep these propositions alive and should not mash them under conjunctions. Once two propositions are conjoined, there is no way to retrieve them back.

(5.20) John mostly knows which boy invited which girl.
$\rightsquigarrow$ *For most p such that p is a true proposition of the form 'boy x invited girl y', John knows p.*

Thus, in a recent colloquium talk at MIT, Dayal (2016) proposes to get rid of the $\bigcap$-closure in $\mathrm{C}^0_{\textsc{func}}$ and analyze the root denotation of a multi-*wh* question as a family of proposition sets. This revision manages to keep the atomic propositions alive, but sacrifices the advantage of keeping the semantic type of questions low.

There are also other conceptual problems with Dayal's (1996, 2016a) treatment. This section discusses only the problems that apply to the case of multi-*wh* questions. These problems also apply to the case of ∀-questions. See section 6.2.3 for other problems related to ∀-questions. For connivence, I repeat the sample LF below.

(5.21) Which boy invited which girl?



First, the IP node has an abnormal semantic type, namely, $\langle ee, est \rangle$, while canonically, IP is assumed to be of type t or $\langle s, t \rangle$. Second, the λ-operators are kept within IP and are isolated from the moved *wh*-phrases. Moreover, since there are two moved pieces for a single λ-abstract, the binding relations between the moved *wh*-phrases and the *wh*-traces are ambiguous. Third, C^0_{FUNC} is structure specific and has a lot of novel semantic features. Thus, Dayal herself calls this approach "crazy C^0 approach."

5.3.2. Higher-order question approaches

The line of higher-order question approaches (Hagstrom 1998, Fox 2012a, Nicolae 2013, Kotek 2014) regards multiple-*wh* questions with pair-list readings as *families of questions*. Answering a family of questions amounts to answering all of the questions in this family. For instance, in interpreting (5.22), one first creates a question as to for a specific boy which girl he invited, and then asks this question for each boy in the considered domain, as in (5.23a). If this domain consists of only two atomic boys, Andy and Billy, the root denotation of (5.22) would be like the question set (5.23b).

(5.22) Which boy invited which girl?

(5.23) a. $\left\{\text{which girl did x invite? } : x \in \mathit{boy}_{@}\right\}$

b. $\left\{ \begin{array}{l} \text{Which girl did Andy invite?} \\ \text{Which girl did Billy invite?} \end{array} \right\}$

Under Hamblin-Karttunen semantics, (5.23) denotes a set of proposition sets (of type $\langle\langle st, t\rangle, t\rangle$):

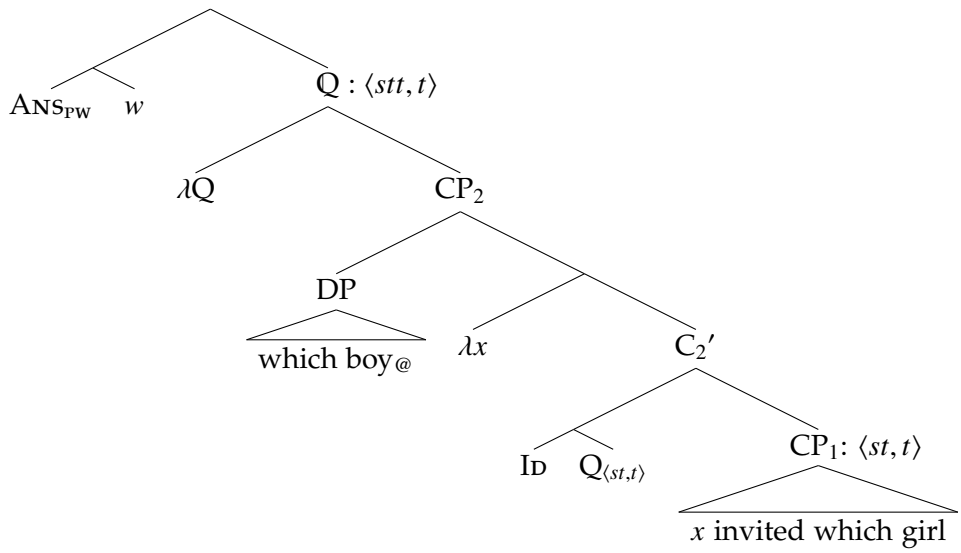
(5.24) a. $\left\{\{{}^\wedge \mathit{invite}(x, y) : y \in \mathit{girl}_{@}\} : x \in \mathit{boy}_{@}\}\right\}$

b. $\left\{ \begin{array}{l} \{{}^\wedge \mathit{invite}(a, y) : y \in \mathit{girl}_{@}\} \\ \{{}^\wedge \mathit{invite}(b, y) : y \in \mathit{girl}_{@}\} \end{array} \right\}$

5.3.2.1. Fox (2012a)

The following tree illustrates Fox's (2012) derivation for the question denotation. The internal structure of CP_1 is the same as the LF of a single-*wh* question under Karttunen Semantics (see (1.14) in §1.3.2). The identity function ID is defined type-flexible; it says that the two arguments are semantically identical, regardless of their type. The subject-*wh* moves to a higher CP and quantifies into an identity relation between two proposition sets (viz., the argument Q and the denotation of CP_1), and then the argument Q gets abstracted, yielding a family of proposition sets. Following Nicolae (2013: chap. 6), we can view the λ-abstraction of Q as a type-driven movement of the answerhood-operator.

(5.25) Which boy invited which girl?



a. $[\![\text{CP}_1]\!] = \{{}^\wedge\textit{invite}(x, y) : y \in \textit{girl}_@\}$

b. $[\![\text{ID}]\!] = \lambda\alpha\lambda\beta.\alpha = \beta$

c. $[\![\text{ID}(\text{Q})]\!] = \lambda\text{Q}'.\text{Q} = \text{Q}'$

d. $[\![\text{C}_2']\!] = \text{Q} = \{{}^\wedge\textit{invite}(x, y) : y \in \textit{girl}_@\}$

e. $[\![\text{CP}_2]\!] = \exists x \in \textit{boy}_@[\text{Q} = \{{}^\wedge\textit{invite}(x, y) : y \in \textit{girl}_@\}]$

f. $\text{Q} = \left\{\{{}^\wedge\textit{invite}(x, y) : y \in \textit{girl}_@\} : x \in \textit{boy}_@\}\right\}$

To deal with question denotations of a higher type, Fox (2012a) defines an answerhood-operator that can be applied point-wise and recursively, as schematized in the following:

(5.26) **Point-wise answerhood-operator** (Fox 2012a)

$$\textsc{Ans}_{\textsc{pw}\text{-}Fox} = \lambda Q\lambda w.\begin{cases} \textsc{Ans}_{Dayal}(Q)(w) & \text{if } Q \text{ is of type } \langle st, t\rangle \\ \bigcap\{\textsc{Ans}_{\textsc{pw}\text{-}Fox}(\alpha)(w) : \alpha \in Q\} & \text{otherwise} \end{cases}$$

Applying $\textsc{Ans}_{\textsc{pw}\text{-}Fox}$ to (5.24), we get a conjunctive proposition that coordinates the unique true answer of each sub-question, as schematized in (5.27). The point-wise uniqueness effect is captured by point-wise applying Dayal's (1996) presuppositional answerhood-operator. The domain exhaustivity effect is achieved by the application of a $\bigcap$-closure.

(5.27) Which boy invited which girl? (Pair-list reading)
(Context: *Andy invited Mary, Billy invited Jenny; no other boy invited any girl.*)

$$\textsc{Ans}_{\textsc{pw}\text{-}Fox}(\left\{\{{}^\wedge\textit{invite}(x, y) : y \in \textit{girl}_@\} : x \in \textit{boy}_@\}\right\})(w)$$
$$= \bigcap\left\{\textsc{Ans}_{\textsc{pw}\text{-}Fox}(\{{}^\wedge\textit{invite}(x, y) : y \in \textit{girl}_@\})(w) : x \in \textit{boy}_@\right\}$$
$$= \bigcap\left\{\textsc{Ans}_{Dayal}(\{{}^\wedge\textit{invite}(x, y) : y \in \textit{girl}_@\})(w) : x \in \textit{boy}_@\right\}$$
$$= \bigcap\left\{\begin{array}{l} \textsc{Ans}_{Dayal}(\{{}^\wedge\textit{invite}(a, y) : y \in \textit{girl}_@\})(w) \\ \textsc{Ans}_{Dayal}(\{{}^\wedge\textit{invite}(b, y) : y \in \textit{girl}_@\})(w) \end{array}\right\}$$

$$= \bigcap \left\{ \begin{array}{c} {}^\wedge invite(a, m) \\ {}^\wedge invite(b, j) \end{array} \right\}$$
$$= {}^\wedge invite(a, m) \cap {}^\wedge invite(b, j)$$

As we will see in section 6.2.4, Fox (2012a) predicts that the multi-*wh* question (5.27) and the ∀-question (5.28) to be semantically identical. Hence, he predicts that the pair-list readings of these two questions are identical: both pair-list readings, with the application of a point-wise answerhood-operator, are subject to domain exhaustivity and point-wise uniqueness.

(5.28) Which girl did every boy invite? (Pair-list reading)

5.3.2.2. Advantages and problems

The line of higher-order question approaches developed by Fox (2012a) and others is technically quite neat. The question denotation is derived basically via the recursive use of Karttunen's (1977) proto-question rule (viz., quantifying into an identity relation and then abstracting the first argument of the ID-function). The answers are derived via the recursive application of a point-wise answerhood-operator.

Moreover, this approach can easily derive the QV effects in quantified indirect questions. For example, in (5.29), the quantification domain of *mostly* is the set of questions denoted by the embedded multi-*wh* question. Mostly knowing a family of questions amounts to knowing most of the questions in this family.

(5.29) John mostly knows which boy invited which girl.
Most Q [Q $\in \{[\![x \text{ invited which girl}]\!] : x \in boy_{@}\}$] [John knows Q]

Despite these advantages, the following problem seems to be hard to avoided under a higher-order question approach that makes use of a point-wise answerhood operator: pair-list readings of multi-*wh* questions are predicted to be subject to domain exhaustivity, contra the observation in section 5.2. When applied to a family of questions, the $\text{ANS}_{\text{PW-}Fox}$-operator presupposes that every question in this family has a strongest true answer, yielding a mandatory domain exhaustivity effect. One might suggest to avoid this problem by weakening the point-wise answerhood-operator, such that the obtained conjunctive proposition (i.e., the pair-list answer) coordinates only the strongest true answers of the sub-questions that do have true answers. Nevertheless, since Fox (2012b,a) predicts a ∀-question and its corresponding *wh*-question have the same denotation under pair-list readings, this move would leave the domain exhaustivity effects of ∀-questions unexplained.

5.4. Proposal: a non-crazy function-based approach

This section presents a "non-crazy" function-based approach for the pair-list readings of multi-*wh* questions. This approach achieves the advantage of Dayal's (1996, 2016a) treatment as well as overcoming many of its conceptual problems. Moreover, it avoids overly generating a domain exhaustivity requirement and addresses Lahiri's (2002) concern with deriving QV effects.

5.4.1. Adding functions to the live-on sets of *wh*-items

To get functional readings, I assume that the live-on set of a *wh*-phrase '*wh*-A' includes also functions ranging over A. The domain of each such function is unrestricted.

(5.30) **Lexical entries of *wh*-items** (Old definition from §1.6.4)

a. $[\![\text{which } A]\!] = \lambda B.\exists\alpha \in [\dagger A \cap B]$

b. $\textsc{Be}([\![\text{which } A]\!]) = \dagger A$

c. $\textsc{Be}([\![\text{which girl}_{@}]\!]) = \dagger \mathit{girl}_{@} = \mathit{girl}_{@}$

(5.31) **Lexical entries of *wh*-items** (New definition)

a. $[\![\text{which } A]\!] = \lambda B.\exists x \in [[\dagger A \cup \{\mathbf{f} : \text{Range}(\mathbf{f}) \subseteq \dagger A\}] \cap B]$

b. $\textsc{Be}([\![\text{which } A]\!]) = \dagger A \cup \{\mathbf{f} : \text{Range}(\mathbf{f}) \subseteq \dagger A\}$

c. $\textsc{Be}([\![\text{which girl}_{@}]\!]) = \dagger \mathit{girl}_{@} \cup \{\mathbf{f} : \text{Range}(\mathbf{f}) \subseteq \dagger \mathit{girl}_{@}\}$
$= \mathit{girl}_{@} \cup \{\mathbf{f} : \text{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@}\}$

As seen in section 1.6.4, in a *wh*-question, the semantic type of the topical property is determined by the highest *wh*-trace: if the *wh*-item moves directly from the insitu position and leaves only an individual trace, the obtained topical property is a property of individuals, yielding an individual reading, as shown in (5.33a). Likewise, if the movement of a *wh*-item leaves a functional trace, the obtained topical property is a property over functions, as exemplified in (5.33b).[66]

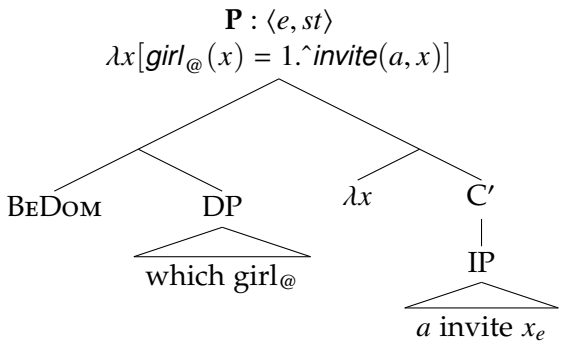
(5.32) Which girl did Andy invite?

a. Mary. (Individual answer)

b. His girlfriend. (Functional answer)

(5.33) Which girl did Andy invite?

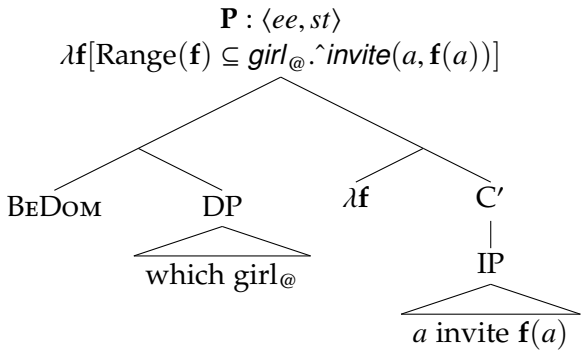
a. **Individual reading:**
'Which girl x is such that Andy invited x?'



[66] More accurately, a functional answer has an intensional meaning (of type $\langle e, se\rangle$. It denotes a function from individuals to individual concepts. A more precise schematization for the topical property of a functional reading should be as follows:

(i) 'Which girl did Andy invite?' 'His girlfriend.'
$\mathbf{P} = \lambda \mathbf{f}_{\langle e,se\rangle}[\forall x \forall w[\mathbf{f}(x)(w) \in \mathit{girl}_{@}].\lambda w[\mathit{invite}_w(a, \mathbf{f}_w(a))]]$

b. **Functional reading:**
'Which function to *girl*$_@$ is such that Andy invited *f*(*Andy*)?'



How can we derive higher-order functional answers? In the elided answers (5.34a-b), the disjunction should be interpreted as taking scope below the necessity modal. The functional answer (5.34b) should be interpreted as a function from individuals to generalized quantifiers (of type $\langle e, \langle et, t\rangle\rangle$). To be more concrete, for example, if Andy's girlfriend and mother are Mary and Kate, respectively, then the functional answer *his girl friend or his mother* would denote a function **F** such that $\mathbf{F}(a) = m \bar{\vee} k$.

(5.34) "Who is Andy required to invite?"
a. "Mary or Kate." (The choice is up to him.) ($\Box > or$)
b. "His girlfriend or his mother." (The choice is up to him.) ($\Box > or$)

By virtue of the †-operator, the new definition (5.31) rules in such higher-order functions to the live-on set of *who*:

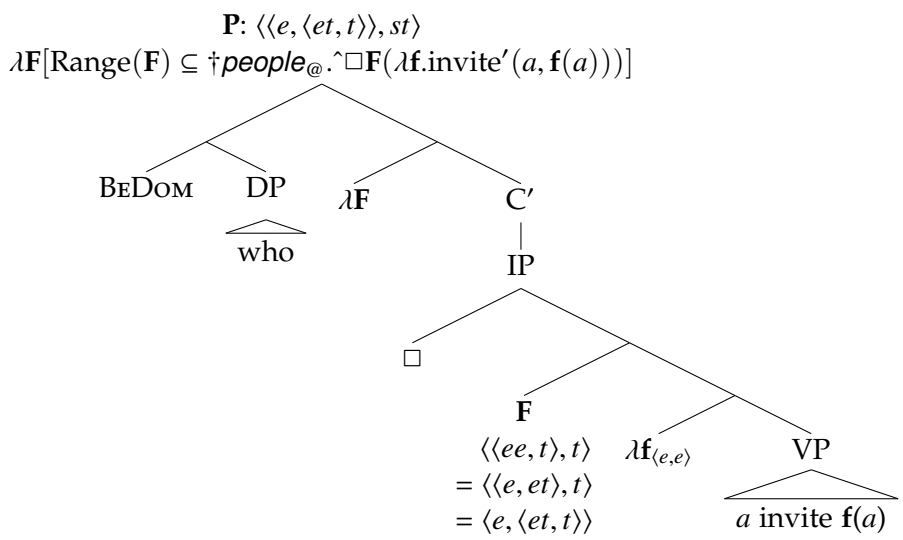
(5.35) $\textsc{Be}([\![\text{who}]\!]) = \dagger\mathit{people}_@ \cup \{\mathbf{f} : \mathrm{Range}(\mathbf{f}) \subseteq \dagger\mathit{people}_@\}$

Analogous to the LF of the higher-order answer (5.34a) in (5.36a) (see §1.6.4), we expect such higher-order functional answers to be derived through the LF in (5.36b): 'BeDom(who)' takes an IP-internal QR from **f** to **F** before it moves to [Spec, CP], leaving a basic functional trace **f** in the insitu position and a higher-order functional trace **F** below the necessity modal.

(5.36) a. [$_{\text{CP}}$ BeDom(who) $\lambda\pi$ [$_{\text{IP}}$ be-required π λx [$_{\text{VP}}$ Andy invite x]]]
b. [$_{\text{CP}}$ BeDom(who) $\lambda\mathbf{F}$ [$_{\text{IP}}$ be-required **F** $\lambda\mathbf{f}$ [$_{\text{VP}}$ Andy invite **f**(Andy)]]]

Nevertheless, the LF (5.36b) suffers type-mismatch: the highest *wh*-trace **F** is of type $\langle\langle ee, t\rangle, t\rangle$, while a higher-order functional answer like *his girl friend or his mother* should be of type $\langle e, \langle et, t\rangle\rangle$. This type mismatch can be salvaged using George's (2011: Appendix A) idea of *tuple types*, which I have adopted for deriving the single-pair answers of multi-*wh* questions (§1.4.2). The LF of the topical property is as follows:

(5.37) Who is Andy required to invite?

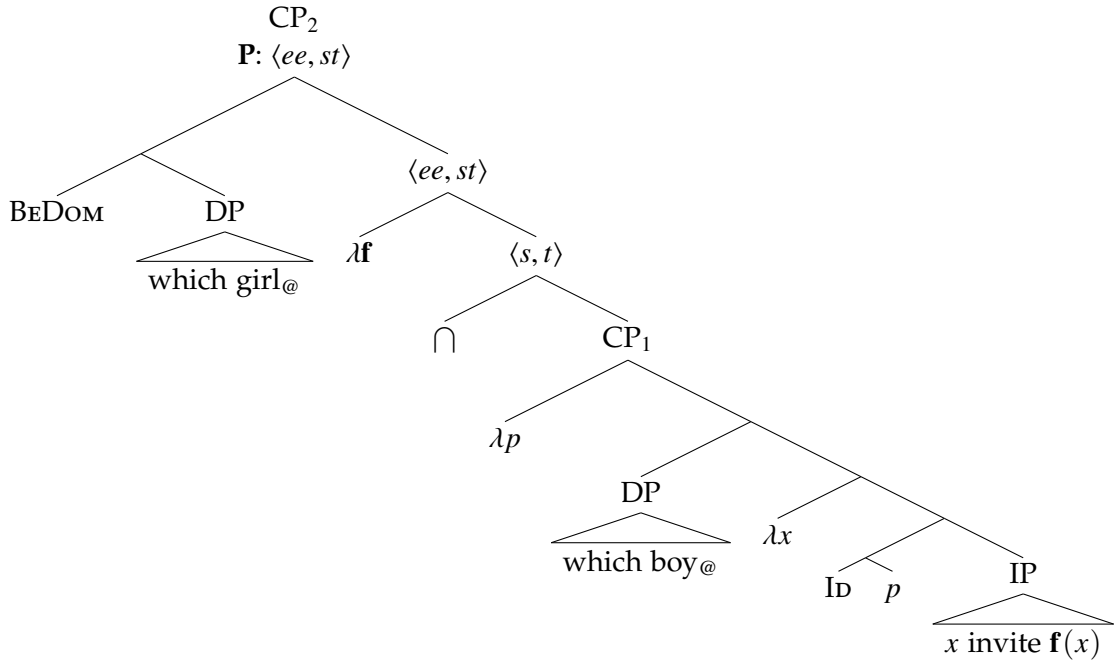


George writes an n-ary sequence as $(x_1; x_2; ...; x_n)$ which takes a tuple type $(\tau_1; \tau_2; ...; \tau_n)$, and then equivocates between the type $\langle \tau_1 \langle \tau_2 \langle ... \langle \tau_n, \sigma \rangle, ... \rangle$ and with the type $\langle (\tau_1; \tau_2; ...; \tau_n), \sigma \rangle$. For instance, $\langle e, et \rangle$ equals to $\langle (e; e), t \rangle$. Following this idea, we can consider $\langle \langle ee, t \rangle, t \rangle$ (viz., the type of the higher-order functional trace **F**) to be equivalent to $\langle \langle e, et \rangle, t \rangle$, and further equivalent to $\langle e, \langle et, t \rangle \rangle$ (viz., the type of a higher-order functional answer).

5.4.2. Deriving pair-list readings

Let's return to pair-list readings of multi-*wh* questions. The following example illustrates the derivation of a root denotation:

(5.38) Which boy invited which girl?



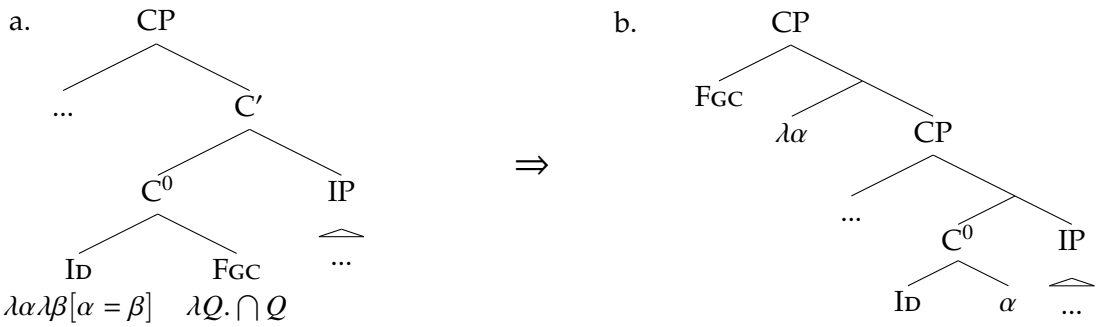
This LF involves two layers of interrogative CPs. The embedded CP_1 denotes a set of propositions,

compositionally derived based on the regular LF for Karttunen Semantics (see §1.3.2), as schematized in (5.39).

(5.39) $$\begin{aligned}[\![\mathrm{CP}_1]\!] &= \lambda p.\exists x[\mathit{boy}_{@}(x) \wedge p = {}^{\wedge}\mathit{invite}(x, \mathbf{f}(x)) \\ &= \{{}^{\wedge}\mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_{@}\}\end{aligned}$$

This set of propositions is immediately closed by a $\bigcap$-closure, returning a conjunctive proposition. This $\bigcap$-closure can be considered as a "function graph creator (Fgc)" in the sense of Dayal (2017). Accordingly, the abstraction of the first argument of Id is due to a type-driven movement of the Fgc-operator:

(5.40) **The movement of the Fgc-operator**
The Id function requires its two arguments to be of the same semantic type. Since IP denoting a proposition, interpreting Fgc insitu yields type-mismatch. Hence, Fgc moves to the left edge of CP and leaves a trace of type $\langle s, t\rangle$.



Moving 'BeDom(which girl)' to [Spec, CP_2] leaves a functional trace within IP and forms a property of functions, just like what we saw with the basic functional reading in (5.33b). This topical property, as schematized in (5.41b), is defined for functions ranging over atomic girls, and it maps each such function to a conjunctive proposition that spells out the graph of this function.

(5.41) $$\begin{aligned}\mathbf{P} &= \iota P[\mathrm{Dom}(P) = \{\mathbf{f} : \mathrm{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@}\} \wedge \forall\alpha \in \mathrm{Dom}(P)[P(\alpha) = \bigcap[\![\mathrm{CP}_1]\!]]] \\ &= \iota P[\mathrm{Dom}(P) = \{\mathbf{f} : \mathrm{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@}\} \wedge \\ &\qquad \forall\alpha \in \mathrm{Dom}(P)[P(\alpha) = \bigcap\{{}^{\wedge}\mathit{invite}(x, \alpha(x)) : x \in \mathit{boy}_{@}\}]] \\ &= \lambda\mathbf{f}[\mathrm{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@}.\bigcap\{{}^{\wedge}\mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_{@}\}]\end{aligned}$$

Note here that **P** restricts the range of **f**, but not the domain of **f**. Hence, for a function being used as a possible short answer of (5.38), its domain could be equivalent to, smaller than, or larger than the quantification domain of the subject-*wh* (viz., $\mathit{boy}_{@}$). To be more concrete, with two relevant boys Andy and Billy, **P** is defined for all the following functions, although the domains of $\mathbf{f}_1$ and $\mathbf{f}_2$ are just subsets of atomic boys.

(5.42) $$\mathbf{f}_1 = \left\{\ a \to m\ \right\} \qquad \mathbf{f}_2 = \left\{\ b \to j\ \right\} \qquad \mathbf{f}_3 = \left\{\begin{array}{c} a \to m \\ b \to j \end{array}\right\}$$

Applying **P** to the functions that **P** is defined for returns the set of possible propositional answers, as

list in (5.43a).[67] Since here the answer space is closed under conjunction, applying the Ans-operator returns a singleton set that consists of only the max-informative true pair-list answer.

(5.43) Which boy invited which girl?
(Context: *Andy invited Mary, Billy invited Jenny; no other boy invited any girl.*)

a. $Q = \{\mathbf{P}(\mathbf{f}) : \mathbf{f} \in \mathrm{Dom}(\mathbf{P})\}$

$$= \left\{ \bigcap\{{}^\wedge\mathit{invite}'(x, \mathbf{f}(x)) : x \in \mathit{boy}_{@}\} : \mathrm{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@} \right\}$$

$$= \left\{ \begin{array}{lll} {}^\wedge\mathit{invite}(a,m) & {}^\wedge\mathit{invite}(b,m) & {}^\wedge\mathit{invite}(a,m) \cap {}^\wedge\mathit{invite}(b,m) \\ {}^\wedge\mathit{invite}(a,j) & {}^\wedge\mathit{invite}(b,j) & {}^\wedge\mathit{invite}(a,m) \cap {}^\wedge\mathit{invite}(b,j) \\ & & {}^\wedge\mathit{invite}(a,j) \cap {}^\wedge\mathit{invite}(b,m) \\ & & {}^\wedge\mathit{invite}(a,j) \cap {}^\wedge\mathit{invite}(b,j) \end{array} \right\}$$

b. True answers from $\mathbf{P}$ in w: $\{{}^\wedge\mathit{invite}(a,m), {}^\wedge\mathit{invite}(b,j), {}^\wedge\mathit{invite}(a,m) \cap {}^\wedge\mathit{invite}(b,j)\}$

c. $\textsc{Ans}(\mathbf{P})(w) = \{{}^\wedge\mathit{invite}(a,m) \cap {}^\wedge\mathit{invite}(b,j)\}$

Compared with the crazy C^0 approach by Dayal (1996, 2017) and various higher-order question approaches (Fox 2012a, a.o.), the proposed function-based approach successfully predicts that multi-*wh* questions are not subject to domain exhaustivity. On the proposed account, the object-*wh* restricts the range of each function, while the domain of each function is unrestricted. For instance, in (5.43), in a world that only Andy invited any girl and that he invited only Mary, $\textsc{Ans}(\mathbf{P})(w)$ would still be defined and denote the singleton set $\{{}^\wedge\mathit{invite}(a,m)\}$.

5.4.3. Functional mention-some and pair-list mention-some

Due to the presupposition of the Ans-operator, mention-some readings are licensed only when the underlying question admits generalized quantifiers as possible answers (see §3.4.2). For the same reason, to get functional mention-some answers, we need a topical property that is defined for generalized quantifiers over functions.

Let us start with the functional answers of a basic $\Diamond$-question. As seen in chapter 2, this question admits types of answers: mention-some, conjunctive mention-all, and disjunctive mention-all. Here the elided mention-all answers are generalized quantifiers over functions (of type $\langle\langle ee, t\rangle, t\rangle$).

(5.44) "Where can John get gas?"

a. "The cheapest place near his apt." $\mathbf{f}_1$

b. "The cheapest place near his apt and the biggest place near his apt." $\mathbf{f}_1 \barwedge \mathbf{f}_2$

c. "The cheapest place near his apt or the biggest place near his apt." $\mathbf{f}_1 \barvee \mathbf{f}_2$

I define generalized disjunctions over functions as follows. Generalized conjunctions over functions are analogous.

(5.45) $\mathbf{F} = \mathbf{f}_1 \barvee \mathbf{f}_2$ iff

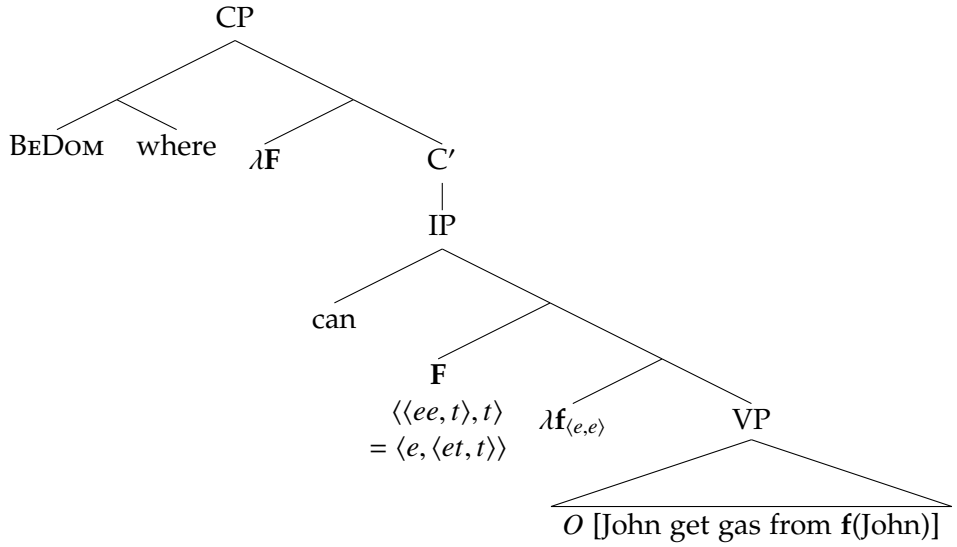
a. $\mathrm{Dom}(\mathbf{F}) = \mathrm{Dom}(\mathbf{f}_1) = \mathrm{Dom}(\mathbf{f}_2)$

[67] As a function, $\mathbf{f}$ maps every item in its domain to one and only one girl. Hence, there is no possible answer of the form $\mathit{invite}(a,m) \wedge \mathit{invite}(a,j)$.

b. $\forall x \in \mathrm{Dom}(\mathbf{F})[\mathbf{F}(x) = \mathbf{f}_1(x) \barwedge \mathbf{f}_2(x)]$

Extending the derivations of basic mention-some readings (§2.6.1), I structure the LF of (5.44) for a functional mention-some reading as follows. This LF involves an IP-internal QR of the *wh*-item from **f** to **F**, which is to rule in higher-order functional answers (e.g., $\mathbf{f}_1 \barwedge \mathbf{f}_2$, $\mathbf{f}_1 \barwedge \mathbf{f}_2$). It also evolves a local *O*-exhaustifier associated with the basic functional trace **f**.

(5.46) Where can John get gas? (Mention-some reading)



Like the case in (5.34), based on the idea of tuple types (George 2011: Appendix), the higher-order functional trace **F** can freely denote either **(i)** a generalized quantifier over functions (of type $\langle\langle ee, t\rangle, t\rangle$), so that it provides short answers like $\mathbf{f}_1 \barwedge \mathbf{f}_2$, or **(ii)** a function from individuals to generalized quantifiers (of type $\langle e, \langle et, t\rangle\rangle$), so that it ranges over $\dagger\mathit{places}_{@}$ and is included in the live-on set of the *wh*-word *where*.

The above LF yields the topical property in (5.47a). In the given world, applying the Ans-operator returns a set consisting of two mention-some answers, based on $\mathbf{f}_1$ and $\mathbf{f}_2$, respectively.

(5.47) (Context: *John can get gas at the cheapest place near his apt* ($\mathbf{f}_1$)*, and he can get gas from the biggest place near his apt* ($\mathbf{f}_2$)*; he cannot get gas from anywhere else.*)

a. $\mathbf{P} = \lambda\mathbf{F}[\mathrm{Range}(\mathbf{F}) \subseteq \dagger{}^{*}\mathit{place}_{@}.{}^{\wedge}\Diamond\mathbf{F}(\lambda\mathbf{f}.O[\mathit{get\text{-}gas}(j, \mathbf{f}(j))])]$

b. True short answers in w: $\{\mathbf{f}_1, \mathbf{f}_2, \mathbf{f}_1 \barwedge \mathbf{f}_1\}$

c. True propositional answers in w:

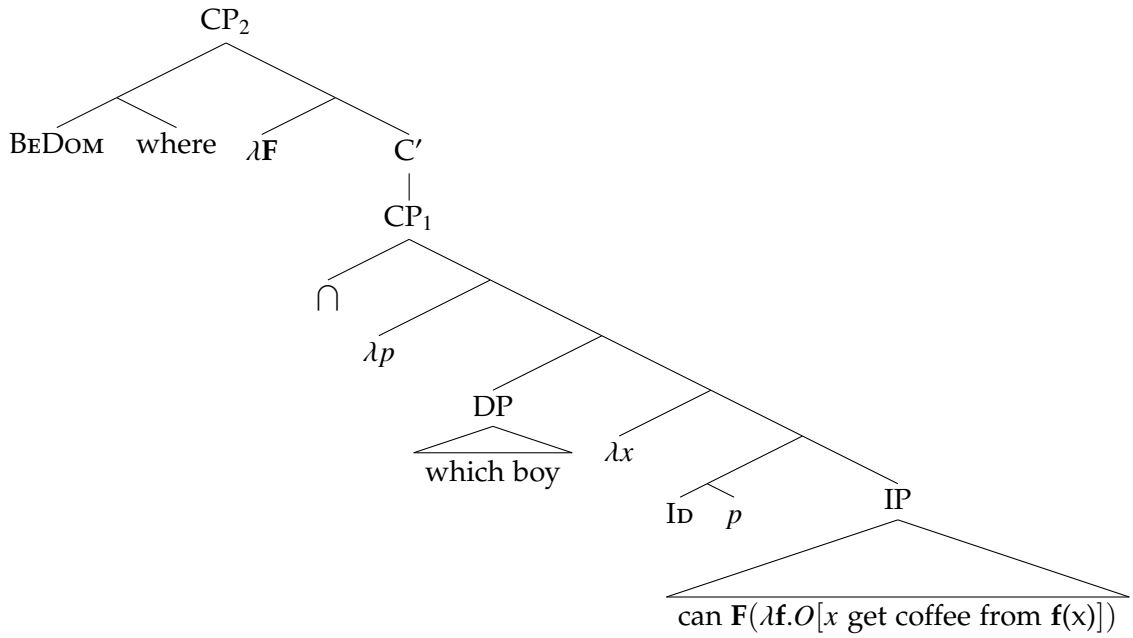
$$Q_w = \left\{ \begin{array}{l} {}^{\wedge}\Diamond O[\mathit{get\text{-}gas}(j, \mathbf{f}_1(j))] \\ {}^{\wedge}\Diamond O[\mathit{get\text{-}gas}(j, \mathbf{f}_2(j))] \\ {}^{\wedge}\Diamond[O[\mathit{get\text{-}gas}(j, \mathbf{f}_1(j))] \vee O[\mathit{get\text{-}gas}(j, \mathbf{f}_2(j))]] \end{array} \right\}$$

d. Max-informative true answers in w:

$$\begin{aligned} \textsc{Ans}(\mathbf{P})(w) &= \{\mathbf{P}(\mathbf{f}_1), \mathbf{P}(\mathbf{f}_2)\} \\ &= \{{}^{\wedge}\Diamond O[\mathit{get\text{-}gas}(j, \mathbf{f}_1(j))], {}^{\wedge}\Diamond O[\mathit{get\text{-}gas}(j, \mathbf{f}_2(j))]\} \end{aligned}$$

To get a pair-list mention-some reading, we just need to merge the assumptions for basic pair-list readings (see (5.38)) and the assumptions for mention-some functional readings (see (5.46)). The LF is as follows:

(5.48) Which boy can get coffee from where? (Pair-list mention-some)



The LF above yields a topical property of functions ranging over generalized quantifiers over places, as schematized in (5.49a). The true short answers in the given world are the functions list in (5.49b). Based on $\mathbf{f}_4$ and $\mathbf{f}_5$, we get two max-informative true answers, which are therefore the pair-list mention-some answers.

(5.49) (Context: *J.P. Licks is accessible to Andy and Billy, while McDonald's is only accessible to Billy; no other coffee place is accessible to any of the boys.*)

a. $\mathbf{P} = \lambda\mathbf{F}[\mathrm{Range}(\mathbf{F}) \subseteq \dagger{}^{*}\mathit{place}_{@}.\bigcap\{{}^{\wedge}\Diamond\mathbf{F}(\lambda\mathbf{f}.O[\mathit{get\text{-}cof}(x,\mathbf{f}(x))]) : x \in \mathit{boy}_{@}\}]$

b. True short answers in w:

$$\left\{\begin{array}{lll} \mathbf{f}_1 = \left\{\ a \to j\ \right\} & & \\ \mathbf{f}_2 = \left\{\ b \to j\ \right\} & \mathbf{f}_3 = \left\{\ b \to m\ \right\} & \mathbf{f}_2 \bar{\vee} \mathbf{f}_3 = \left\{\ b \to j \bar{\vee} m\ \right\} \\ \mathbf{f}_4 = \left\{\begin{array}{l} a \to j \\ b \to j \end{array}\right\} & \mathbf{f}_5 = \left\{\begin{array}{l} a \to j \\ b \to m \end{array}\right\} & \mathbf{f}_4 \bar{\vee} \mathbf{f}_5 = \left\{\begin{array}{l} a \to j \\ b \to j \bar{\vee} m \end{array}\right\} \end{array}\right\}$$

c. Max-informative true answers in w:

$$\begin{aligned} \textsc{Ans}(\mathbf{P})(w) &= \{\mathbf{P}(\mathbf{f}_4), \mathbf{P}(\mathbf{f}_5)\} \\ &= \left\{\begin{array}{l} {}^{\wedge}\Diamond O[\mathit{get}(a,j)] \cap {}^{\wedge}\Diamond O[\mathit{get}(b,j)] \\ {}^{\wedge}\Diamond O[\mathit{get}(a,j)] \cap {}^{\wedge}\Diamond O[\mathit{get}(b,m)] \end{array}\right\} \end{aligned}$$

5.4.4. Quantificational variability effects

Recall that Dayal (1996, 2017) has difficulties in predicting QV effect in (5.50), and hence that she has to pursue a higher-order function-based approach (Dayal 2017). This move, however, would sacrifice her advantage of keeping the semantic type of questions low.

(5.50) John mostly knows which boy invited which girl.
$\rightsquigarrow$ *For most p such that p is a true proposition of the form 'boy x invited girl y', John knows p.*

The proposed approach can easily predict the QV effect, even though the question nucleus also involves a $\bigcap$-closure. While Dayal follows Hamblin-Karttunen Semantics and treats the root dentation of a multi-*wh* question as a set of propositions, the proposed hybrid categorial approach treats the root denotation as a property of functions, which can supply short answers. Hence, under the proposed account, we are able to retrieve the quantification domain of *mostly* from based on the short answers: given a function **f** such that **f** is max-informative true short answer of the embedded question, the quantification domain of matrix quantificational adverb *mostly* is the set of functions that are atomic subsets of **f**. To get some intuition, consider the following example:

(5.51) Which boy invited which girl?
(Context: *Andy, Billy, and Clark invited only Jenny, Mary, and Sue, respectively; no other boy invited any of the girls.*)

a. The max-inf true short answer:
$$\mathbf{f} = \left\{ \begin{array}{c} a \to m \\ b \to j \\ c \to s \end{array} \right\}$$

b. Atomic subsets of **f**:
$$\textsc{At}(\mathbf{f}) = \left\{ \begin{array}{c} \{a \to m\} \\ \{b \to j\} \\ \{c \to s\} \end{array} \right\}$$

A function is atomic iff its domain is a singleton set containing only an atomic item, or equivalently, the supremum of its domain is an atomic element. Notice that $\mathbf{f}_3$ counts as an atomic function, even though a is paired with a non-atomic element.

(5.52) **Atomic functions**

a. A function **f** is atomic iff $\bigoplus \mathrm{Dom}(\mathrm{f}')$ is atomic. For example:

i. Atomic functions:
$\mathbf{f}_1 = \left\{ \ a \to m \ \right\}, \quad \mathbf{f}_2 = \left\{ \ b \to j \ \right\}, \quad \mathbf{f}_3 = \left\{ \ a \to m \oplus j \ \right\}$

ii. Non-atomic functions:
$\mathbf{f}_4 = \left\{ \ a \to m, \quad b \to j \ \right\}, \quad \mathbf{f}_5 = \left\{ \ a \oplus b \to j \ \right\}$

b. $\textsc{At}(\mathbf{f}) = \{\mathrm{f}' : \mathrm{f}' \subseteq \mathbf{f} \text{ and } \bigoplus \mathrm{Dom}(\mathrm{f}') \text{ is atomic}\}$

We can now define the QV inference of (5.50) as follows. **P** stands for the topical property of the embedded multi-*wh* question Q.

(5.53) The **QV inference** of "John mostly knows Q": (Option 1)
$\lambda w.\exists\alpha \in \textsc{Ans}^S(\mathbf{P})(w)[\textsc{Most}\ a[a \in \textsc{At}(\alpha)][\mathit{know}_w(j, \mathbf{P}(a))]]$
(For some item α such that α is a max-informative true short answer of Q, most a that are atomic subparts of α are such that John knows $\mathbf{P}(a)$.)

For a concrete example, consider the quantified indirect multi-*wh* question (5.54). The max-informative true short answer of the embedded question is a function, and its atomic subparts are atomic functions.

(5.54) John knows $[_{\text{Q}}$ which boy invited which girl$]_{\text{PL}}$.
(Context: *Andy, Billy, and Clark invited only Jenny, Mary, and Sue, respectively; no other boy invited any of the girls.*)

a. The set of max-informative true short answers of Q:

$$\textsc{Ans}^S(\mathbf{P})(w) = \left\{ \left\{ \begin{array}{c} a \to m \\ b \to j \\ c \to s \end{array} \right\} \right\}$$

b. The QV inference:

$$\textsc{Most}\ \mathrm{f}'\left[\mathrm{f}' \in \left\{ \begin{array}{c} \{a \to m\} \\ \{b \to j\} \\ \{c \to s\} \end{array} \right\}\right]\left[\mathit{know}(j, \bigcap\{{}^\wedge\mathit{invite}(x, \mathrm{f}'(x)) : x \in \mathit{boy}_{@}\})\right]$$

$$= \textsc{Most}\ \mathrm{f}'\left[\mathrm{f}' \in \left\{ \begin{array}{c} \{a \to m\} \\ \{b \to j\} \\ \{c \to s\} \end{array} \right\}\right]\left[\mathit{know}(j, {}^\wedge\mathit{invite}(x, \mathrm{f}'(x)))\right]$$

(John knows most of the following boy-invite-girl pairs: a invited m, b invited j, and c invited s.)

The schematization of QV inferences in (5.53) is intuitive. But it requires that **P** is defined for and holds for every atomic subpart of the max-informative true short answer. There are, however, many cases where this requirement is not satisfied. For example, in the indirect questions in (5.55), repeated from (1.69), the embedded question each takes a non-divisive collective predicate, and the topical property of the embedded question does not hold for the atomic subparts of the true short answer.

(5.55) a. John knows for the most part which students formed the bassoon quintet.
b. For the most part Al knows which soldiers surrounded the fort.

Moreover, as we will see in section 6.4.3, unlike that of the multi-*wh* question (5.51), the topical property of a ∀-question is only defined for functions that are defined for every atomic boy. For example, with only three relevant boys *abc*, the topical property of the ∀-question (5.56) is defined for the domain-exhaustive function **f** in (5.51a), but not for the atomic subparts of **f**.

(5.56) Which girl did every boy invite? (Pair-list reading)

$$\mathbf{P} = \lambda\mathbf{f}[\mathrm{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@}.\bigcap f_{\text{CH}}[\textsc{MaxI}\{\mathrm{K} : \forall x[x \in \mathit{boy}_{@} \to {}^\wedge\mathit{invite}(x, \mathbf{f}(x)) \in \mathrm{K}]\}]]$$
$$= \lambda\mathbf{f}[\mathrm{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@} \wedge \mathrm{Dom}(\mathbf{f}) \supseteq \mathit{boy}_{@}.\bigcap\{{}^\wedge\mathit{invite}'(x, \mathbf{f}(x)) : x \in \mathit{boy}_{@}\}]$$

Hence, the schematization (5.53) cannot predict the following QV inference:

(5.57) John mostly knows $[_{\text{Q}}$ which girl every boy invited$]_{\text{PL}}$.
⇝ *For most p such that p is a true proposition of the form 'boy x invited girl y', John knows p.*

Alternatively, extending the analysis of the QV inferences in (5.55a-b) (§1.5.2), we can schematize the QV inference in a sub-divisive form: for most of the atomic subparts of the max-informative true answer of Q, John knows that they are subparts of the max-informative true answer of Q.

(5.58) The **QV inference** of "John mostly knows Q" (Option 2)
$\lambda w.\exists f_{\text{CH}}\exists\alpha \in \textsc{Ans}^S(\mathbf{P})(w)[\textsc{Most}\ a[a \in \textsc{At}(\mathbf{f})][\mathit{know}_w(j, \lambda w'.a \leq f_{\text{CH}}[\textsc{Ans}^S(\mathbf{P})(w')])]]$
(For an item α such that α is a max-informative true short answer of Q, for most items a that are atomic subparts of α, John knows that a is a subpart of some max-informative true short answer of Q.)

For example:

(5.59) John mostly knows [$_{\text{Q}}$ which girl every boy invited]$_{\text{PL}}$.
(Context: *Andy, Billy, and Clark invited only Jenny, Mary, and Sue, respectively.*)

a. The set of max-informative true short answers of Q:

$$\textsc{Ans}^S(\mathbf{P})(w) = \left\{ \left\{ \begin{array}{c} a \to m \\ b \to j \\ c \to s \end{array} \right\} \right\}$$

b. The QV inference:

$$\exists f_{\text{CH}}\left[\textsc{Most}\ \mathrm{f}'\left[\mathrm{f}' \in \left\{ \begin{array}{c} \{a \to m\} \\ \{b \to j\} \\ \{c \to s\} \end{array} \right\}\right]\left[\mathit{know}(j, \lambda w'.\mathrm{f}' \leq f_{\text{CH}}[\textsc{Ans}^s(\mathbf{P})(w')])\right]\right]$$

With only relevant three girls mjs, this inference is true iff in every world w such that w is compatible with John's belief, the max-informative true short answer of Q in w is one of the following seven functions:

	$\left\{ \begin{array}{c} a \to j \\ b \to j \\ c \to s \end{array} \right\}$	$\left\{ \begin{array}{c} a \to s \\ b \to j \\ c \to s \end{array} \right\}$
$\left\{ \begin{array}{c} a \to m \\ b \to m \\ c \to s \end{array} \right\}$	$\left\{ \begin{array}{c} a \to m \\ b \to j \\ c \to s \end{array} \right\}$	$\left\{ \begin{array}{c} a \to m \\ b \to s \\ c \to s \end{array} \right\}$
$\left\{ \begin{array}{c} a \to m \\ b \to j \\ c \to m \end{array} \right\}$	$\left\{ \begin{array}{c} a \to m \\ b \to j \\ c \to j \end{array} \right\}$	

Hence, the QV inference is equivalent to:

$$\textsc{Most}\ \mathrm{f}'\left[\mathrm{f}' \in \left\{ \begin{array}{c} \{a \to m\} \\ \{b \to j\} \\ \{c \to s\} \end{array} \right\}\right]\left[\mathit{know}(j, {}^\wedge\mathit{invite}(x, \mathrm{f}'(x)))\right]$$

(John knows most of the following boy-invite-girl pairs: a invited m, b invited j, and c invited s.)

Appendix: Adapting the higher-order question approach

The higher-order question approach can be easily adapted to the proposed hybrid categorial approach. All we need is to change the denotation of the embedded CP from a Hamblin set into a topical property, and revise the definition of the point-wise answerhood-operator accordingly. In

other words, under a pair-list reading, a multi-*wh* question denotes a set of topical properties, as exemplified in (5.60).

(5.60) Which boy invited which girl?

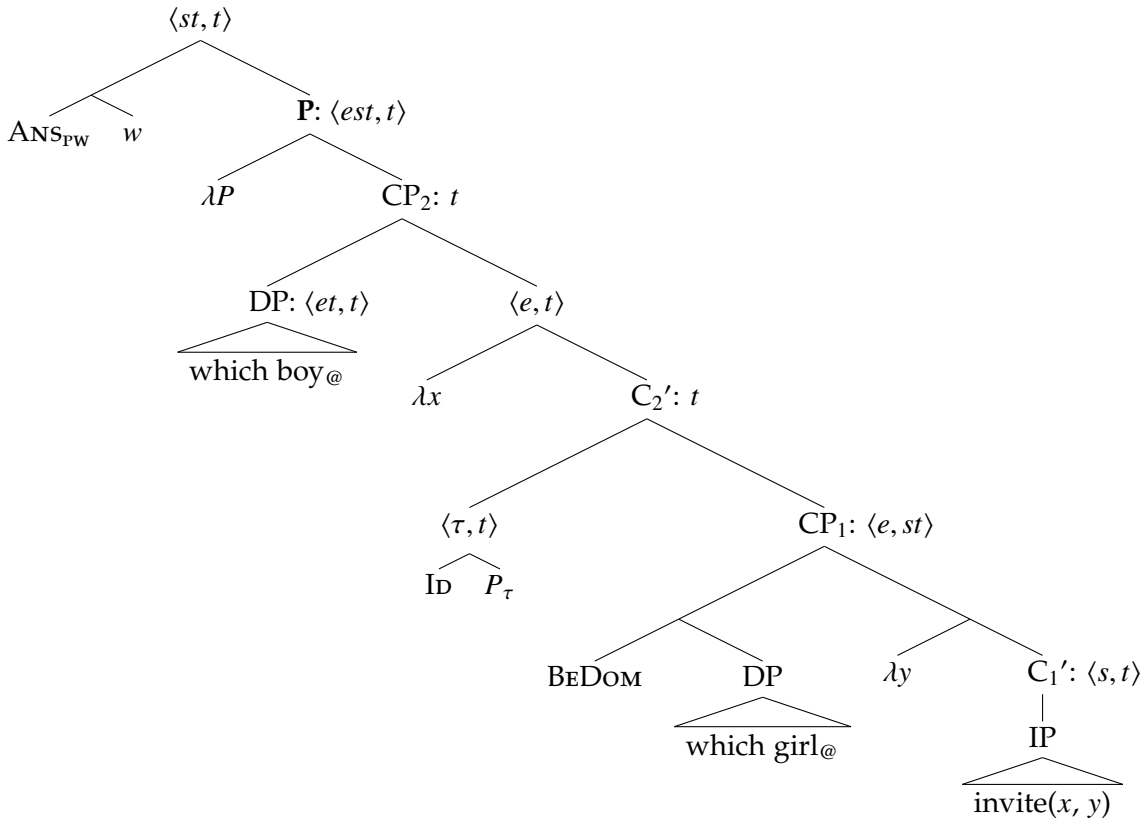
a. $\{\lambda y[\mathit{girl}_{@}(y) = 1.\hat{}\mathit{invite}(x,y)] : x \in \mathit{boy}_{@}\}$

b. With only two relevant boys a and b:

$$\left\{ \begin{array}{l} \lambda y[\mathit{girl}_{@}(y) = 1.\hat{}\mathit{invite}(a,y)] \\ \lambda y[\mathit{girl}_{@}(y) = 1.\hat{}\mathit{invite}(b,y)] \end{array} \right\}$$

This denotation is derived via the following LF. The embedded CP_1 denotes the topical property of *x invited which girl*, derived by moving 'BeDom(which girl)' to [Spec, CP_1]. The abstraction of the variable P is due to a type-driven movement of the $\textsc{Ans}_{\textsc{pw}}$-operator.

(5.61) Which boy invited which girl?



a. $[\![\mathrm{CP}_1]\!] = \lambda y[\mathit{girl}_{@}(y) = 1.\hat{}\mathit{invite}(x,y)]$

b. $[\![\textsc{Id}(P)]\!] = \lambda P'.P = P'$

c. $[\![\mathrm{C}_2']\!] = P = \lambda y[\mathit{girl}_{@}(y) = 1.\hat{}\mathit{invite}(x,y)]$

d. $[\![\mathrm{CP}_2]\!] = \exists x[\mathit{boy}_{@}(x) \wedge P = \lambda y[\mathit{girl}_{@}(y) = 1.\hat{}\mathit{invite}(x,y)]]$

e. $\mathbf{P} = \lambda P.\exists x[x \in \mathit{boy}_{@} \wedge P = \lambda y[\mathit{girl}_{@}(y) = 1.\hat{}\mathit{invite}(x,y)]]$
$= \{\lambda y[\mathit{girl}_{@}(y) = 1.\hat{}\mathit{invite}(x,y)] : x \in \mathit{boy}_{@}\}$

f. $\textsc{Ans}_{\textsc{pw}}(\mathbf{P})(w) = \bigcap_{\textsc{pw}}\{\textsc{Ans}(P)(w) : P \in \mathbf{P}\}$

The point-wise answerhood operator is defined as follows. Note that here the conjunctive closure needs to be applied point-wise, because applying the basic Ans-operator to a sub-question each returns a <u>set</u> of max-informative true answers.

(5.62) **Point-wise answerhood-operator**

$$\textsc{Ans}_{\textsc{pw}} = \lambda \mathbf{P} \lambda w. \begin{cases} \textsc{Ans}(\mathbf{P})(w) & \text{if } \mathbf{P} \text{ is of type } \langle \tau, st \rangle \\ \bigcap_{\textsc{pw}} \{\textsc{Ans}_{\textsc{pw}}(\alpha)(w) : \alpha \in \mathbf{P}\} & \text{otherwise} \end{cases}$$

(5.63) **Point-wise conjunction**

For any two sets A and B, $\bigcap_{\textsc{pw}}\{A, B\} = \{a \cap b : a \in A, b \in B\}$

Applying $\textsc{Ans}_{\textsc{pw}}$ to the root denotation in (5.60), we get a set of conjunctive propositions. Each conjunctive proposition coordinates one max-informative true answer of each sub-question. Since here each sub-question has only one max-informative true answer, the output of employing $\textsc{Ans}_{\textsc{pw}}$ is a singleton set.

(5.64) Which boy invited which girl?

(Context: *Andy invited Mary, Billy invited Jenny; no other boy invited any girl.*)

$$\begin{aligned}
&\textsc{Ans}_{\textsc{pw}}(\{\lambda y[\mathit{girl}_{@}(y) = 1.{}^{\wedge}\mathit{invite}(x, y)] : x \in \mathit{boy}_{@}\})(w) \\
&= \bigcap_{\textsc{pw}} \left\{\textsc{Ans}(\lambda y[\mathit{girl}_{@}(y) = 1.{}^{\wedge}\mathit{invite}(x, y)](w) : x \in \mathit{boy}_{@}\right\} \\
&= \bigcap_{\textsc{pw}} \left\{ \begin{array}{l} \textsc{Ans}(\lambda y[\mathit{girl}_{@}(y) = 1.{}^{\wedge}\mathit{invite}(a, y)])(w) \\ \textsc{Ans}(\lambda y[\mathit{girl}_{@}(y) = 1.{}^{\wedge}\mathit{invite}(b, y)])(w) \end{array} \right\} \\
&= \bigcap_{\textsc{pw}} \left\{ \begin{array}{l} \{{}^{\wedge}\mathit{invite}(a, m)\} \\ \{{}^{\wedge}\mathit{invite}(b, j)\} \end{array} \right\} \\
&= \{{}^{\wedge}\mathit{invite}(a, m) \cap {}^{\wedge}\mathit{invite}(b, j)\}
\end{aligned}$$

The adapted analysis can also derive pair-list mention-some readings, as exemplified below. If one of the sub-question has multiple max-informative true answers, the output set of employing the $\textsc{Ans}_{\textsc{pw}}$-operator will be a non-singleton set, each member of which counts as a max-informative true answer of the multi-*wh* question.

(5.65) Which boy can get coffee from where?

(Context: *J.P. Licks is accessible to Andy and Billy, while McDonald's is only accessible to Billy; no other coffee place is accessible to any of the boys.*)

a. $[\![x \text{ can get coffee from where}]\!] = \lambda \pi_{\langle et,t \rangle}[\dagger {}^{*}\mathit{place}_{@}(\pi) = 1.{}^{\wedge}\Diamond\pi(\lambda y.O[\mathit{get}(x, y)])]$

b. $\textsc{Ans}([\![a \text{ can get coffee from where}]\!])(w) = \{{}^{\wedge}\Diamond O[\mathit{get}(a, j)]\}$

c. $\textsc{Ans}([\![b \text{ can get coffee from where}]\!])(w) = \{{}^{\wedge}\Diamond O[\mathit{get}(b, j)], {}^{\wedge}\Diamond O[\mathit{get}(b, m)]\}$

d. $\textsc{Ans}_{\textsc{pw}}([\![\text{which boy can get coffee from where}]\!])(w)$

$$\begin{aligned}
&= \bigcap_{\textsc{pw}} \left\{ \begin{array}{l} \textsc{Ans}([\![a \text{ can get coffee from where}]\!])(w) \\ \textsc{Ans}([\![b \text{ can get coffee from where}]\!])(w) \end{array} \right\} \\
&= \bigcap_{\textsc{pw}} \left\{ \begin{array}{l} \{{}^{\wedge}\Diamond O[\mathit{get}(a, j)]\} \\ \{{}^{\wedge}\Diamond O[\mathit{get}(b, j)], {}^{\wedge}\Diamond O[\mathit{get}(b, m)]\} \end{array} \right\} \\
&= \left\{ \begin{array}{l} {}^{\wedge}\Diamond O[\mathit{get}(a, j)] \cap {}^{\wedge}\Diamond O[\mathit{get}(b, j)] \\ {}^{\wedge}\Diamond O[\mathit{get}(a, j)] \cap {}^{\wedge}\Diamond O[\mathit{get}(b, m)] \end{array} \right\}
\end{aligned}$$

Nevertheless, as seen in section 5.3.2, regardless of what a basic question denotes, a higher-order question approach always overly predicts domain exhaustivity effect and cannot capture the semantic difference between the pair-list readings of multi-*wh* questions and ∀-questions. Hence, I do not pursue this approach.

Chapter 6

Quantifying into questions

6.1. Introduction

Questions with a universal quantifier (called "∀-questions" henceforth) admit three types of readings, including individual readings[68], functional readings, and pair-list readings (Engdahl 1980).

(6.1) Which girl did every/each boy invite?

a. **Individual reading** ($\iota > \forall$)
'For which unique girl y is such that every boy invited y?'
'Mary.'

b. **Functional reading** ($\iota > \forall$)
'For which unique function $\mathbf{f}$ to a girl is such that every boy x invited $\mathbf{f}(x)$?'
'His girlfriend.'

c. **Pair-list reading** ($\forall > \iota$)
'For every boy x, which unique girl did x invite?'
'Andy invited Mary, Billy invited Jenny.'

Pair-list readings of ∀-questions with a singular *wh*-item (henceforth called "singular ∀-questions") exhibit clear domain exhaustivity and point-wise uniqueness effects. For example, under a pair-list reading, the ∀-question in (6.1) presupposes that every boy invited exactly one girl, and it requests the addressee to list all the boy-invite-girl pairs.

Analogously, questions with an existential quantifier (called "∃-questions" henceforth) admit

[68]Note that the term "individual reading" has been used to mean different concepts in the literature. For interpreting questions with quantifiers, it is used in comparison to "functional reading." But in Spector (2007, 2008) and chapter 1-3 of this dissertation, "individual reading" refers to a reading under which each answer names an individual, in comparison to "higher-order reading" under which each answer names a generalized quantifier. Consider the following □-∀-question for illustration. The described reading is an individual reading in the sense of Engdahl (1980) because it isn't functional, but a higher-order reading in the sense of Spector (2007, 2008) because each answer names a generalized quantifier.

(i) What does every student have to read?
'For which generalized disjunction/conjunction π is such that every student has to read π?'

choice readings, as exemplified below.[69]

(6.2) Which girl did one of the boys invite?
Choice reading: 'For one of the boys x, which girl did x invite?' ($\exists > \iota$)
(Context: *Andy only invited Mary, Billy only invited Jenny, Clark invited Mary and Jenny.*)
a. Andy invited Mary.
b. Billy invited Jenny.
c. # Clark invited Mary.
d. # Clark invited Mary and Jenny.

Due to the uniqueness effect of the singular *wh*-object *which girl*, the ∃-question in (6.2) presupposes that at least one of the boys invited exactly one girl. To answer this question, the addressee needs to utter one true proposition of the form 'boy x invited girl y' such that x invited exactly one girl. For instance, since Clark invited two girls, the answers in (6.2c-d) are inappropriate.[70]

Pair-list readings of ∀-questions and choice readings of ∃-questions are usually described as involving "quantification into questions": intuitively, the quantifiers are interpreted above a question. Deriving these readings compositionally is however quite challenging, because quantifiers are defined in terms of propositions or truth values, while questions are not propositions or truth values. For example, under Hamblin-Karttunen Semantics, the LF in (6.3) is ill-formed: the scope of *every boy* should be of type $\langle e, t\rangle$ (or $\langle e, st\rangle$, depending on the theory of intensionality), but here the scope of *every boy* is of type $\langle e, stt\rangle$, because the embedded question Q denotes a set of propositions.

(6.3) Which girl did every boy invite?
* [[every boy] λx [$_Q$ which girl did x invite]]

There are more facts related to quantifying into questions that are hard to capture. As I will show in section 6.2, despite numerous discussions on quantifying-into questions, no account has achieved all the following goals:

(i) maintaining the standard use of quantifiers (cf. Dayal 1996, among others) and the simple system of semantic composition (cf. Pafel 1999);

[69] It is unclear to me whether ∃-questions admit individual and functional readings. If these readings are available, we expect a possible reading where uniqueness scopes below the ∃-quantifier. Nevertheless, the following individual and functional answers sound quite odd.

(i) Which girl did one of the boys invite?
a. ? Mary. (Intended meaning: 'one of the boys invited Mary.')
b. ? His girlfriend. (Intended meaning: 'one of the boys invited his girlfriend.')

[70] We need to distinguish the choice reading of the ∃-question in (6.2) from the single-pair reading of the multi-*wh* question in (i). Under a single-pair reading, (i) presupposes that there is only one boy-invite-girl pair (i.e., that only one of the boys invited a girl and that this boy invited exactly one girl). In the scenario described in (6.2), the single-pair reading of (i) is undefined.

(i) which boy invited which girl?

(ii) predicting the domain exhaustivity effects of ∀-questions and the point-wise uniqueness effects of questions with singular *wh*-items (cf. Chierchia 1993);

(iii) explaining the unavailability of pair-list readings in questions with non-∀ quantifiers (cf. Chierchia 1993);

(iv) uniformly accounting for the quantifying-into question readings of ∀-questions and ∃-questions (cf. Groenendijk and Stokhof 1984, Dayal 1996, Pafel 1999, Fox 2012b, among others).

Before moving on to the actual analysis, we should first decide on the following problem: among the following three types of readings, which and which readings should be treated uniformly?

A. Pair-list readings of multi-*wh* questions

B. Pair-list readings of ∀-questions

C. Choice readings of ∃-questions

Intuitively, the two pair-list readings A and B are quite similar. Hence, previous accounts either try to derive these two readings via similar LFs (Engdahl 1980, 1986; Dayal 1996, 2017), or at least assign the related questions with the same root denotation (Fox 2012a,b). Nevertheless, as argued in section 5.2, these two pair-list readings have a crucial semantic difference: B is subject to domain exhaustivity, but A is not, contra what Dayal (1996) and Fox (2012b) claim. This difference suggests that A and B should be treated differently. The following example is repeated from (5.7). Observe that the pair-list reading of the ∀-question in (6.4b) is subject to domain exhaustivity (i.e., it presupposes that each of the 100 candidates will get one of the three jobs, which is contextually infeasible), while the pair-list reading of the multi-wh question in (6.4a) is not.

(6.4) (Context: *100 candidates are competing for three jobs.*)

a. √ Guess which candidate will get which job. multi-*wh* question

b. # Guess which job every/each candidate will get. ∀-question

Alternatively, I argue that the two quantifying-into question readings B and C should be derived uniformly. These two readings both involve quantifications and both are subject to subject-object/adjunct asymmetries (Chierchia 1991, 1993). As shown in the following examples, repeated from section 2.3.2, both readings are available when the non-*wh* quantifier serves as the subject and the *wh*-item serves as the object or an adjunct, and are unavailable otherwise.

(6.5) **Pair-list readings of ∀-questions**

a. *Subject-Object*

i. Which candidate did everyone vote for? √ pair-list

ii. Which voter voted for every candidate? × pair-list

b. *Subject-Adjunct*

i. At which station did every guest get gas? √ pair-list

ii. Which guest got gas from every gas station? × pair-list

(6.6) **Choice readings of ∃-questions**

a. *Subject-Object*
   i. Which candidate did [one of the students] vote for? √ choice
   ii. Which person voted for [one of the students]? ?choice
b. *Subject-Adjunct*
   i. At which station did [one of the guests] get gas? √ choice
   ii. Which guest got gas at [one of the nearby stations]? ?choice

Given the similar surface structures and distributional patterns, we can conjecture that the pair-list readings of ∀-questions and the choice readings of ∃-questions should be derived via similar grammatical procedures.

The rest of this chapter is organized as follows. Section 6.2 reviews the previous representative studies on quantifying into questions. Section 6.3 and 6.4 propose two new compositional approaches to derive the quantification-into questions readings, including a higher-order question approach and a function-based approach. Both accounts manage to treat quantifying-into question as a regular quantification operation.

6.2. Previous accounts

6.2.1. Groenendijk and Stokhof (1984)

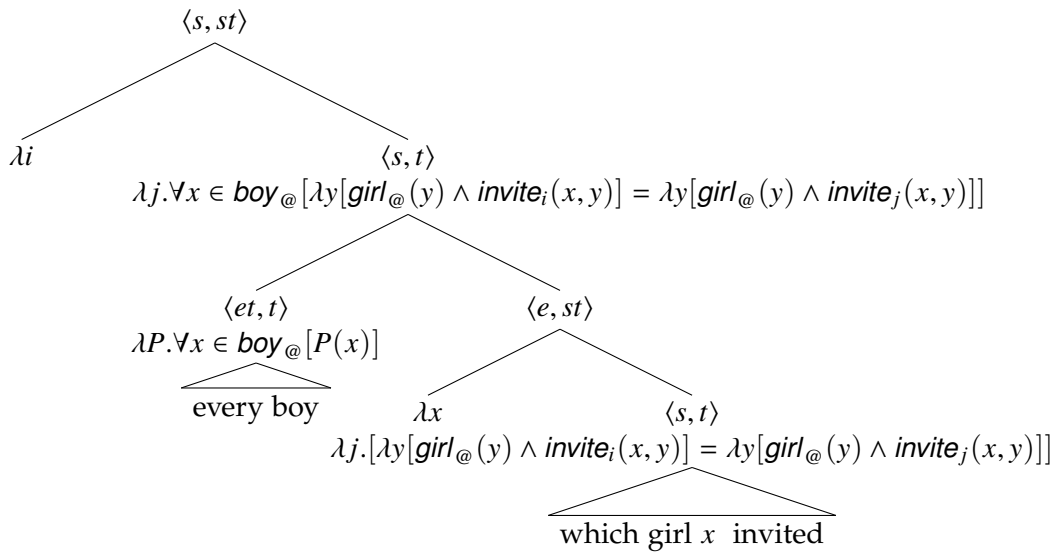
Groenendijk and Stokhof (1984) provide two accounts. One is based on partitions, and the other is based on witness sets.

6.2.1.1. The partition-based account

Groenendijk and Stokhof (1984) firstly analyze a ∀-question like (6.7) as a partition that can identify which boy invited which girl. From the derivation in (6.8), it can be nicely observed that the scope of the quantifier *every boy* is of type $\langle e, st\rangle$, and hence that quantifying-into a question does not cause type mismatch.

(6.7) Which girl did every boy invite?
$\{\langle i, j\rangle : \forall x[\mathit{boy}_{@}(x) \rightarrow \{y : \mathit{girl}_{@}(y) \wedge \mathit{invite}_{i}(x, y)\} = \{y : \mathit{girl}_{@}(y) \wedge \mathit{invite}_{j}(x, y)\}]\}$
(i and j are in the same cell iff every boy x is such that x invited the same girl in i and in j.)

(6.8)



Nevertheless, this account does not work for questions with a non-∀ quantifier. Consider the corresponding ∃-question (6.9) for illustration, extending the above account to (6.9) yields the following set of world cells:

(6.9) Which girl did one of the boys invite?
$\{\langle i, j\rangle : \exists x[\textsf{boy}_{@}(x) \wedge \{y : \textsf{girl}_{@}(y) \wedge \textsf{invite}_i(x,y)\} = \{y : \textsf{girl}_{@}(y) \wedge \textsf{invite}_j(x,y)\}]\}$
(i and j are in the same cell as long as one of the boys x is such that x invited the same girl in i and in j.)

The schematization in (6.9) says that any two worlds are in the same cell as long as one of the boys invited the same girl in these two worlds. To be more concrete, as exemplified in (6.10a), the three worlds $w_1w_2w_3$ are in the same cell C_1: Andy invited the same girl in w_1 and w_2, and Billy invited the same girl in w_1 and w_3. Likewise, as shown in (6.10b), the three worlds $w_2w_3w_4$ are in the same cell C_2: Billy invited the same girl in w_2 and w_4. Nevertheless, C_1 and C_2 are different cells because none of the boys invited the same girl in w_1 and w_4.

(6.10) a. $C_1 = \left\{ \begin{array}{ll} w_1: & [a \to m, b \to j] \\ w_2: & [a \to m, b \to m] \\ w_3: & [a \to j, b \to j] \end{array} \right\}$ b. $C_2 = \left\{ \begin{array}{ll} w_2: & [a \to m, b \to m] \\ w_3: & [a \to j, b \to j] \\ w_4: & [a \to j, b \to m] \end{array} \right\}$

This schematization does not give a partition, because the cells are overlapped (Krifka 2001). For example, C_1 and C_2 are different cells, but they both include w_2 and w_3. Moreover, based on this way of classifying worlds, there is no boy such that we can identify which girl he invited. For example, if we assume that w_1 is the actual world, then C_1 is the cell which the actual world belongs to. Nevertheless, based on C_1, we cannot decide on whether Andy invited Mary (as in w_1 and w_2) or he invited Jenny (as in w_3), nor decide on whether Billy invited Jenny (as in w_1 and w_3) or he invited Mary (as in w_2).

6.2.1.2. A witness sets-based account

To account for the phenomena of quantifying-into questions uniformly, Groenendijk and Stokhof (1984) provide an alternative account. They propose that quantifiers in questions supply minimal witness sets, and that questions are quantified internally over minimal witness sets. This account is influential on the subsequent accounts proposed by Chierchia (1993), Dayal (1996), Nicolae (2013).

(6.11) **Minimal witness sets** (Barwise and Cooper 1981)

a. A generalized quantifier $\mathcal{P}$ lives on a set B iff for any set C: $C \in \mathcal{P} \Leftrightarrow C \cap B \in \mathcal{P}$.

b. If $\mathcal{P}$ lives on the set B, A is a minimal witness set of $\mathcal{P}$ iff

i. $A \subseteq B$;

ii. $A \in \mathcal{P}$;

iii. $\neg\exists A' \subset A[A \in \mathcal{P}]$

Assuming that $\textit{boy} = \{a, b, c\}$, we get the following:

Quantifier	Minimal witness sets
every boy	$\{a, b, c\}$
some boy	$\{a\}$, $\{b\}$, $\{c\}$
two of the boys	$\{a, b\}$, $\{b, c\}$, $\{a, c\}$
no boy	$\varnothing$
at most two boys	$\varnothing$

The ∀-quantifier *every boy* has a unique minimal witness set, namely, its quantification domain. The ∃-quantifier *two of the boys* has multiple minimal witness sets, each of which is made up of two boys. Downward monotone quantifiers (e.g., *no boy*, *at most two boys*) have only one minimal witness set, namely the emptyset.

To see how this account works in practice, consider the ∃-question in (6.12). The predicted root denotation is a set of partitions. Each partition is yielded by one sub-question of the form 'which member of A invited who' where A is a minimal witness set of the quantifier *two of the boys*. To answer this ∃-question, one just need to answer one of these sub-questions. Since the quantifier *two of the boys* has multiple minimal witness sets, we obtain a choice reading.

(6.12) Who did two of the boys invite?

$$\lambda Q.\exists A[\textsc{mws}(\textit{two-of-the-boys}, A) \wedge Q = \lambda w \lambda w'[\lambda x \lambda y[x \in A \wedge \textit{invite}(x, y) = \lambda x \lambda y[x \in A \wedge \textit{invite}(x, y)]]]$$

$$= \left\{\lambda w \lambda w'[\lambda x \lambda y[x \in A \wedge \textit{invite}(x, y) = \lambda x \lambda y[x \in A \wedge \textit{invite}(x, y)]]] : \textsc{mws}(\textit{two-of-the-boys}, A)\right\}$$

More generally, this account paraphrases the meaning of *who did $\mathcal{P}$ invite?* as follows: for some set A such that A is a minimal witness set of $\mathcal{P}$, what is the pair-list answer to 'who did which member of A invite'? Accordingly, the choice answer of an ∃-question amounts to the pair-list answer of one of the sub-questions, while the pair-list answer of a ∀-question amounts to the pair-list answer of the unique sub-question.

This account yields two desired predictions. First, it predicts the contrast between ∀-quantification and ∃-quantification: a ∀-quantifier has only one minimal witness set, while an ∃-quantifier has multiple minimal witness sets. Second, this account captures the fact in (6.13) that questions with a downward monotone quantifier does not admit pair-list readings: downward monotone quantifiers has a unique minimal witness set, namely the emptyset.

(6.13) a. Who does at most two of the students love?
Andy loves Mary, Billy loves Jenny.
b. Who does no student love?
[silence]

Nevertheless, regardless of the general problems related to defining questions as partitions (§1.3.3), the witness sets-based account has the following deficiencies. First of all, the use of minimal witness sets is quite artificial. It is undesirable not to keep the standard use of quantifiers. Second, this account overly predicts pair-list readings. As argued in a number of works (Srivastav 1991, Krifka 1991, Dayal 1996, Moltmann and Szabolcsi 1994, Szabolcsi 1997, Beghelli 1997, among others), pair-list readings are only available to ∀-questions. The seeming pair-list answer with respect to some two boys in (6.12) is actually an individual answer with an atomic or non-atomic distributive reading, as shown in the following:

(6.14) Who did two of the boys invite?
Andy and Billy invited Mary and Jenny. In particular, Andy invited Mary and Billy invited Jenny.

To avoid the confounds from distributive individual answers, we need to check the availability of pair-list readings in questions with a singular *wh*-item. As shown in the following examples, pair-list readings are only licensed by distributive ∀-quantificational phrases (e.g., *every student*, *each student*).

(6.15) I know that every student voted for a different candidate, please tell me ...
a. Which candidate did every student vote for? $(\forall > \iota)$
b. Which candidate did each of the students vote for? $(\textsc{each} > \iota)$
c. # Which candidate did two of the students vote for? $(\exists 2 > \cancel{\textsc{each}} > \iota)$
d. # Which candidate did most of the students vote for? $(\textsc{most} > \cancel{\textsc{each}} > \iota)$

6.2.2. Chierchia (1993)

Chierchia (1993) argues that quantifying-into question readings are special species of functional readings. This idea is motivated by the observation that pair-list readings and functional readings of ∀-questions are both subject to subject-object asymmetry. As exemplified below, both readings are available the ∀-quantifier is used as a subject, as in (6.16), and both readings are unavailable if the ∀-quantifier is used as an object, as in (6.17).

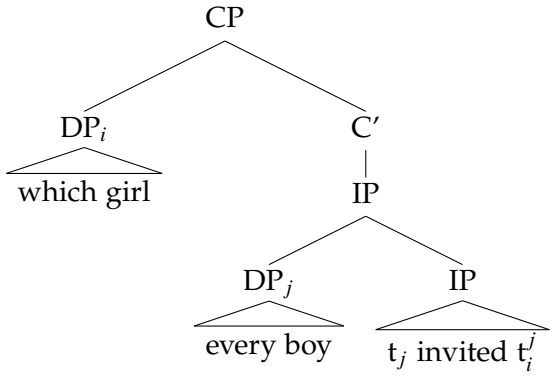
(6.16) Which girl did every boy invite?

a. Mary. √ Individual
b. Every boy invited his girlfriend. √ Functional
c. Andy invited Mary, Billy invited Jenny. √ Pair-list

(6.17) Which boy invited every girl?
a. Andy (invited every girl). √ Individual
b. # Her boyfriend (invited every girl). × Functional
c. # Andy invited Mary, Billy invited Jenny. × Pair-list

Chierchia subsumes this syntactic asymmetry under the *Weak Crossover Constraint*. He proposes that a *wh*-item is associated with two things: a function and an argument. The function is bound by an existential quantifier within the *wh*-determiner, and the argument is locally bound by some suitable nominal expression. Thus, the movement of a *wh*-item thus leaves a complex trace. For instance, in (6.18), the trace of *which girl* has a functional (f-)index i bound by *which girl*, and an argument (a-)index j bound by the c-commanding quantificational expression *every boy*.

(6.18) Which girl did every boy invite?



In case that *every boy* serves as the object, it must be moved to a position that c-commands the *wh*-trace, so as to bind the a-index, as shown below. This movement, however, results in a weak cross over violation: *every boy* is co-indexed with the a-trace, which is a pronominal element.

(6.19) * [which girl$_i$ [every boy$_j$ [t$_i^j$ likes t$_i$]]]

Formally, Chierchia adopts Groenendijk & Stokhof's (1984) witness sets-based account and analyzes questions of the form (6.20) as denoting a family of sub-questions. Each sub-question quantifies over a set A such that A is a minimal witness set of the generalized quantifier $\mathcal{P}$. This A set also restricts the function domain.[71]

(6.20) $\textit{which girl}_{@} + \mathcal{P}_j + \textit{invite}(\mathrm{t}_j, \mathrm{t}_i^j)$
$\Rightarrow \lambda \mathrm{Q}.\exists A[\textsc{mws}(\mathcal{P}, A) \wedge \mathrm{Q} = \lambda p.\exists \mathbf{f} \in [A \rightarrow \textit{girl}_{@}]\exists x \in A[p = \textit{invite}(x, \mathbf{f}(x))]]$
$= \left\{\left\{\textit{invite}(x, \mathbf{f}(x)) : x \in A \wedge \mathbf{f} \in [A \rightarrow \textit{girl}_{@}]\right\} : \textsc{mws}(\mathcal{P}, A)\right\}$

[71] The treatment of the quantifier $\mathcal{P}$ involves some complexities. On the one hand, as seen in (6.18), $\mathcal{P}$ is interpreted within the question nucleus (viz., IP). On the other hand, to be used to restrict the function domain, $\mathcal{P}$ has to take scope outside interrogative C^0. Chierchia salvages this problem via a restructuring operation called "absorption."

With only two relevant boys Andy and Billy, and two relevant girls Mary and Jenny, Chierchia predicts the following denotations. The ∀-question in (6.21) denotes a singleton set containing only one proposition set, while the ∃-question in (6.22) denotes a set made up of two proposition sets. To answer a question of this form, the addressee needs to select one of the proposition sets included in the question denotation, and name all the true propositions in this proposition set.

(6.21) Which girl did every boy invite?

$$\{Q : \exists A[\textsc{wms}(\textit{every boy}, A) \wedge Q = \{p : \exists \mathbf{f}[A \rightarrow \textit{girl}_{@}]\exists x \in A[p = {}^{\wedge}\textit{invite}(x, \mathbf{f}(x))]\}]\}$$
$$= \left\{\left\{{}^{\wedge}\textit{invite}(x, \mathbf{f}(x)) : x \in A \wedge \mathbf{f} \in [A \rightarrow \textit{girl}_{@}]\right\} : \textsc{mws}(\textit{every boy}, A)\right\}$$
$$= \left\{\left\{{}^{\wedge}\textit{invite}(x, \mathbf{f}(x)) : x \in A \wedge \mathbf{f} \in [A \rightarrow \textit{girl}_{@}]\right\} : A \in \{\{a, b\}\}\right\}$$
$$= \left\{\ \{{}^{\wedge}\textit{invite}(a, m), \textit{invite}(b, m), \textit{invite}(a, j), \textit{invite}(b, j)\}\ \right\}$$

(6.22) Which girl did one of the boys invite?

$$\{Q : \exists A[\textsc{wms}(\textit{one boy}, A) \wedge Q = \{p : \exists \mathbf{f}[A \rightarrow \textit{girl}_{@}]\exists x \in A[p = {}^{\wedge}\textit{invite}(x, \mathbf{f}(x))]\}]\}$$
$$= \left\{\left\{{}^{\wedge}\textit{invite}(x, \mathbf{f}(x)) : x \in A \wedge \mathbf{f} \in [A \rightarrow \textit{girl}_{@}]\right\} : \textsc{mws}(\textit{one boy}, A)\right\}$$
$$= \left\{\left\{{}^{\wedge}\textit{invite}(x, \mathbf{f}(x)) : x \in A \wedge \mathbf{f} \in [A \rightarrow \textit{girl}_{@}]\right\} : A \in \{\{a\}, \{b\}\}\right\}$$
$$= \left\{\begin{array}{l} \{{}^{\wedge}\textit{invite}(a, m), {}^{\wedge}\textit{invite}(a, j)\} \\ \{{}^{\wedge}\textit{invite}(b, m), {}^{\wedge}\textit{invite}(b, j)\} \end{array}\right\}$$

Due to the use of witness sets, Chierchia's account inherits the advantages and deficiencies of Groenendijk & Stokhof's (1984) witness sets-based account (§6.2.1.2). A more serious problem with Chierchia's account, as indicated by Dayal (1996), is that it cannot account for the domain exhaustivity effects of ∀-questions and uniqueness effects of singular *wh*-items. For example, the ∀-question in (6.21) presupposes that every boy invited exactly one of the girls. Under Chierchia's account, to answer a ∀-question, one simply needs to specify all the true answers to the unique sub-question of this ∀-question. There is no constraint that can block uttering (6.21) in a scenario that only Andy invited any girls, which violates domain exhaustivity, or a scenario that Andy invited both Mary and Jenny, which violates point-wise uniqueness.

6.2.3. Dayal (1996, 2017)

Dayal (1996, 2017) proposes a function-based account to derive pair-list readings of multi-*wh* questions and ∀-questions. I have discussed the consequences of this account on multi-*wh* questions in section 5.3.1. This section will only consider its consequences on questions with quantifiers.

The meaning of the following LF is composed in exactly the same as what we saw from (5.13) to (5.18) for *which boy invited which girl?*:

(i) IP contributes the first argument of C^0_{func}, which is a function from functions of type $\langle e, e\rangle$ to properties of types $\langle e, st\rangle$;

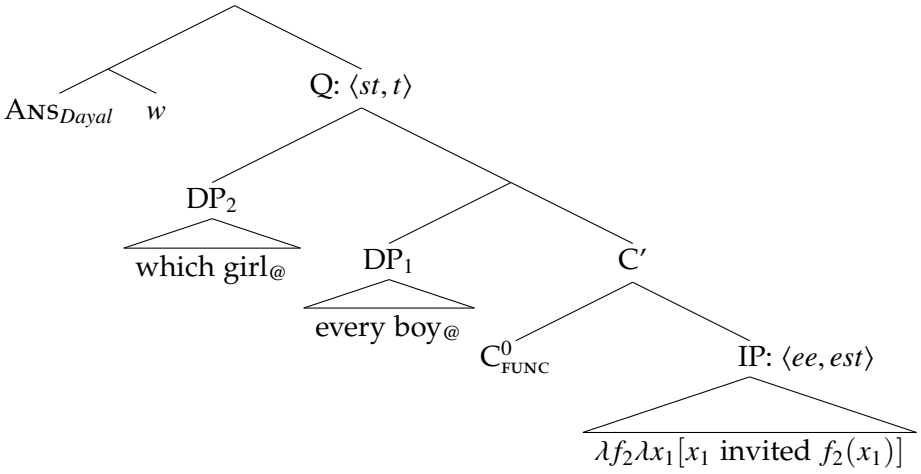
(ii) the subject quantifier *every boy* restricts the domain (D) of the function, and the object quantifier *which girl* restricts the range (R) of the function;

(iii) the obtained denotation is a set of propositions, each of which names a function from atomic boys to atomic girls;

(iv) applying the $\textsc{Ans}_{Dayal}$-operator returns the strongest true member in this proposition set.

A concrete example is given in the following:

(6.23) Which girl did every boy invite?
(Context: *Andy invited Mary, Billy invited Jenny; no other boy invited any girl.*)



a. $[\![\text{IP}]\!] = \lambda \mathbf{f}_{\langle e,e\rangle} \lambda x_e [\hat{}\mathit{invite}(x, \mathbf{f}(x))]$

b. $[\![\text{C}^0{}_{\textsc{func}}]\!] = \lambda q_{\langle ee,est\rangle} \lambda D \lambda R \lambda p.\exists \mathbf{f} \in [D \to R][p = \bigcap \lambda p'.\exists x \in D[p' = q(x)(\mathbf{f})]]$

c. $[\![\text{C}']\!] = \lambda D \lambda R \lambda p.\exists \mathbf{f} \in [D \to R][p = \bigcap \lambda p'.\exists x \in D[p' = \hat{}\mathit{invite}(x, \mathbf{f}(x)]]$

d. $\text{Q} = \lambda p.\exists \mathbf{f} \in [\mathit{boy}_@ \to \mathit{girl}_@][p = \bigcap \lambda p'.\exists x \in \mathit{boy}_@[p' = \hat{}\mathit{invite}(x, \mathbf{f}(x))]]$
$= \left\{ \bigcap \{\hat{}\mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_@\} : \mathbf{f} \in [\mathit{boy}_@ \to \mathit{girl}_@] \right\}$

e. $\textsc{Ans}_{Dayal}(\text{Q})(w) = \hat{}\mathit{invite}(a, m) \cap \hat{}\mathit{invite}(b, j)$

But, unlike the case of the multi-*wh* question in (5.13), here the function domain $\mathit{boy}_@$ is extracted from a universal quantifier *every boy* (as oppose to the existential indefinite *which boy*). Hence, this function domain cannot be obtained in the same way as we saw in the case of the multi-*wh* question in (5.13). Dayal assumes that here the set $\mathit{boy}_@$ is extracted as the minimal witness set of *every boy*. Moreover, to avoid overly generating pair-list readings in non-∀-questions like (6.24), she stipulates that such an extraction operation is only available to a quantifier that has a unique minimal witness set, and hence that only ∀-questions admit pair-list answers.

(6.24) Which girl did two of the boys invite?
Andy invited Mary, and Billy invited Jenny.

Compared with earlier accounts, Dayal's account has two major advantages. First. it captures the functionality effects in pair-list readings of ∀-questions, namely, domain exhaustivity and point-wise uniqueness. Second, it maintains a low semantic type for ∀-questions: a ∀-question taking a pair-list reading denotes a set of propositions, not a set of questions.

Nevertheless, this account faces many problems. All the problems raised for the case of multi-*wh* questions (see details in §5.3.1.2) also apply to the case of ∀-questions: (i) the denotation of IP has

an abnormal semantic type; (ii) the lambda operators are isolated from the moved phrases; (iii) the functional C^0 is structure specific and has a lot of "crazy" features; and (iv) it cannot capture the QV effects of quantified indirect ∀-questions (e.g., *John most knows which candidate each of the students vote for*). Moreover, for questions with quantifiers, this account faces more problems. **First**, it is syntactically impermissible to move a non-interrogative phrase *every boy* to the spec of an interrogative CP (Heim 2012). **Second**, this account incorrectly predicts universal pair-list readings for ∃-questions. On Dayal's account, the LF (6.25) should be available to all the three questions in (6.26). Dayal has shown that this LF yields universal pair-list readings in the case of (6.26a-b), but she has not discussed the case of (6.26c). But, since *which boy* and *some boy* are lexically identical, this account would predict the ∃-question in (6.26c) to take a universal pair-list reading under the LF in (6.25), contra fact.

(6.25) $[_{\text{CP}}\ [_{\text{DP}}\ \text{which girl}]_i\ [[_{\text{DP}}\ \text{every/which/some boy}]_j\ [\text{C}^0_{\text{func}}\ [_{\text{IP}}\ t_j\ \text{invited}\ t_i^j]]]]$

(6.26) a. 'Which girl did every boy invite?'
√ 'Andy invited Mary, Billy invited Jenny.'

b. 'Which boy invited which girl?'
√ 'Andy invited Mary, Billy invited Jenny.'

c. 'Which girl did some boy invite?'
'Andy invited Mary, Billy invited Jenny.'

Third, this account cannot capture the choice readings of ∃-questions. Recall that, in the earlier witness sets-based accounts (Groenendijk and Stokhof 1984, Chierchia 1993), the choice readings of ∃-questions are captured based on the idea that an existential quantifier has multiple minimal witness sets. Nevertheless, to avoid overly predicting pair-list readings in cases like (6.24), Dayal has to stipulate that a non-universal quantifier cannot supply witness sets for the restriction of the function domain. This stipulation makes her account unable to generate choice readings of ∃-questions based on witness sets. Instead, as we just saw, Dayal predicts that, with a C^0_{FUNC} in the LF, an ∃-question admits only a universal pair-list reading.

6.2.4. Fox (2012b)

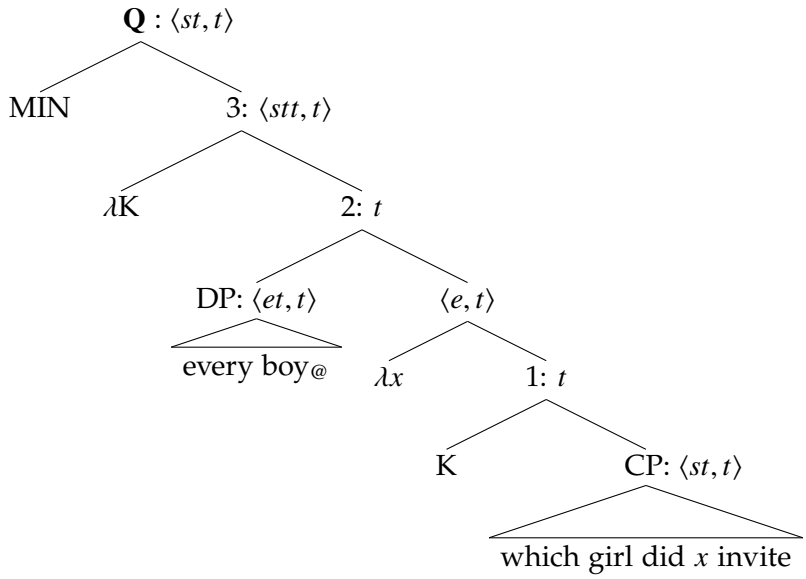
Fox (2012b) proposes a higher-order question approach to derive the pair-list readings of ∀-questions. On this approach, the pair-list reading of a ∀-question is derived as follows: it firstly generates a set of sets such that each of these sets contains all the sub-questions, and then it gets back down to the set of sub-questions (of type $\langle stt, t\rangle$) with the application of a minimization operator (Pafel 1999, Preuss 2001). As defined below, the MIN-operator applies to a set of sets α and returns the unique set that is a subset of every set in α.

(6.27) **Minimization operator** (Pafel 1999)
$\text{MIN} = \lambda\alpha.\iota\text{K}[\text{K} \in \alpha \wedge \forall\text{K}' \in \alpha[\text{K}' \subseteq \text{K}]]$

A concrete example for the derivation of the root denotation is given in (6.28). This LF has three novel pieces: the movement of a null operator K, the movement of the ∀-quantifier over CP, and the application of a MIN-operator. The internal structure of CP is omitted. It is the basic GB-style

structure for Karttunen Semantics, the same as what we saw in (1.14) in section 1.3.2. A step-to-step explanation is provided after the schematization.

(6.28) Which girl did every boy invite?



a. $[\![\text{CP}_1]\!] = \{\textit{invite}(x, y) : y \in \textit{girl}_@\}$

b. $[\![1]\!] = \text{K}(\{\textit{invite}(x, y) : y \in \textit{girl}_@\})$
$= \{\textit{invite}(x, y) : y \in \textit{girl}_@\} \in \text{K}$

c. $[\![\text{every boy}_@]\!] = \lambda f.\forall x \in \textit{boy}_@[f(x)]$

d. $[\![2]\!] = \forall x \in \textit{boy}_@[\{\textit{invite}(x, y) : y \in \textit{girl}_@\} \in \text{K}]$

e. $[\![3]\!] = \lambda\text{K}.\forall x \in \textit{boy}_@[\{\textit{invite}(x, y) : y \in \textit{girl}_@\} \in \text{K}]$

$$= \left\{ \begin{array}{l} \left\{ \begin{array}{l} \{\textit{invite}(a, y) : y \in \textit{girl}_@\} \\ \{\textit{invite}(b, y) : y \in \textit{girl}_@\} \\ \\ \end{array} \right\}, \quad \left\{ \begin{array}{l} \{\textit{invite}(a, y) : y \in \textit{girl}_@\} \\ \{\textit{invite}(b, y) : y \in \textit{girl}_@\} \\ \bigstar \end{array} \right\}, \quad \ldots \end{array} \right\}$$

$$= \left\{ \text{K} : \text{K} \supseteq \left\{ \begin{array}{l} \{\textit{invite}(a, y) : y \in \textit{girl}_@\} \\ \{\textit{invite}(b, y) : y \in \textit{girl}_@\} \end{array} \right\} \right\}$$

f. $\mathbf{Q} = \text{MIN}([\![3]\!]) = \left\{ \begin{array}{l} \{\textit{invite}(a, y) : y \in \textit{girl}_@\} \\ \{\textit{invite}(b, y) : y \in \textit{girl}_@\} \end{array} \right\}$

The question denotation of (6.28) is derived as follows. The bracketed parts are the paraphrases.

- ('which girl did *x* invite?')
  The CP denotes the Hamblin set of *which girl did x invite*, as in (6.28a).
- ('which girl did *x* invite?' is in K)
  The insertion of the null operator K yields a membership relation that the Hamblin set of *which girl did x invite* is a member of K, as in (6.28b).
- (EVERY *x* is such that 'which girl did *x* invite?' is in K.)
  Every boy moves over CP and quantifies into the membership relation, yielding a universal membership relation, as in (6.28c-d).

- ({K: every boy x is such that 'which girl did x invite?' is in K})
  At node 3, as in (6.28e), abstracting the null operator K yields a family of "K sets," namely, the sets that contain all the subquestions. Here the ★-sign stands for an arbitrary object that is not a subquestion.
- (MIN{K: every boy x is such that 'which girl did x invite?' is in K})
  Employing the MIN-operator returns the minimal K set, which is simply the set of all the sub-questions, as in (6.28f).

The obtained root denotation **Q** is identical to what Fox (2012b) proposes for the pair-list reading of the multi-*wh* question *which boy invited which girl?* (see §5.3.2). Employing the point-wise answerhood-operator returns the conjunction of the strongest true answers of the sub-questions, namely, the pair-list answer. Just like what we saw in the case of multi-*wh* questions, the conjunctive closure within the point-wise answerhood-operator yields domain exhaustivity, and the point-wise application of $\textsc{Ans}_{Dayal}$ predicts point-wise uniqueness.

(6.29) **Point-wise answerhood operator** (Fox 2012b)

$$\textsc{Ans}_{\textsc{pw}\text{-}Fox} = \lambda \mathrm{Q} \lambda w. \begin{cases} \textsc{Ans}_{Dayal}(\mathrm{Q})(w) & \mathrm{Q} \text{ is of type } \langle st, t\rangle \\ \bigcap\{\textsc{Ans}_{\textsc{pw}\text{-}Fox}(\alpha)(w) : \alpha \in \mathrm{Q}\} & \text{otherwise} \end{cases}$$

(6.30) (Context: *Consider only two boys Andy and Billy. Andy only invited Mary, and Billy only invited Jenny.*)

$$\begin{aligned} &\textsc{Ans}_{\textsc{pw}\text{-}Fox}(\mathbf{Q})(w) \\ &= \bigcap \left\{ \begin{array}{l} \textsc{Ans}_{Dayal}(\{\mathit{invite}(a, y) : y \in \mathit{girl}_{@}\})(w) \\ \textsc{Ans}_{Dayal}(\{\mathit{invite}(b, y) : y \in \mathit{girl}_{@}\})(w) \end{array} \right\} \\ &= \bigcap \left\{ \begin{array}{l} \mathit{invite}(a, m) \\ \mathit{invite}(b, j) \end{array} \right\} \\ &= \mathit{invite}(a, m) \wedge \mathit{invite}(b, j) \end{aligned}$$

Fox's account has three advantages over the previous accounts. **First**, it manages to analyze the semantic contribution of the generalized quantifier *every boy* as a regular universal quantification (as oppose to supplying a witness set, which is artificial): due to the insertion of the null operator K, the scope of *every boy* is of type $\langle e, t\rangle$, and hence quantification does not suffer type-mismatch. **Second**, it captures the limited distribution of pair-list readings: with any quantifier other than a universal, the MIN-operator is undefined. Compare the following sets of K sets for instance. Observe that (6.31a) has a minimal K, while that (6.31b-c) do not; hence the MIN-operator is defined in (6.31a) but not in (6.31b-c).

(6.31) a. {K: EVERY x is such that 'which girl did x invite' is in K}
b. {K: MOST x are such that 'which girl did x invite' is in K}
c. {K: TWO x are such that 'which girl did x invite' is in K}

Third, it can easily account for the quantificational variability (QV) effects of quantified indirect ∀-questions. For example, in (6.32), defining the embedded ∀-question as a family of sub-questions, the

higher-order question approach can defined the quantification domain of the matrix quantificational adverb *mostly* based on the set of sub-questions. Accordingly, mostly knowing a ∀-question means knowing most of the sub-questions of this ∀-question.

(6.32) John mostly knows which candidate each of the students voted for.
Most Q [Q ∈ {which candidate x voted for: x is a student}] [John knows Q]

Nevertheless, Fox's account is not problem-free. It cannot extend to questions with a non-universal quantifier and hence cannot capture the choice readings of ∃-questions. For example, the denotation in (6.33) does not have a minimal K set, and hence Pafel's MIN-operator is undefined.

(6.33) {K: ONE of the boys x is such that 'which girl did x invite' is in K}

6.3. Proposal I: A higher-order question approach

This and the next sections present a pair of twin proposals. Both proposals work uniformly for the pair-list readings of ∀-questions and the choice readings of ∃-questions. These two proposals are distinct from each other mainly with respect to whether (under a pair-list/choice reading) a ∀/∃-question denotes a family of sub-questions (*à la* Fox 2012b) or a basic question taking a special functional reading (*à la* Chierchia 1993, Dayal 1996a).

The semantic compositions in these two sections will follow my hybrid categorial approach developed in chapter 1. But the core ideas, except the one for getting QV effects under the function-based approach, also extend to other frameworks of question semantics, such as Hamblin-Karttunen Semantics, Inquisitive Semantics, and so on.

6.3.1. Overview

This section presents a higher-order question approach. The most crucial pieces of this approach are the following three:

(i) A complex non-interrogative $C^0_{[-\text{WH}]}$, which provides a membership relation between its two arguments, just like the null operator K in Fox's (2012) treatment.

(6.34) **Non-interrogative C^0**

a. $[\![\text{IN}]\!] = \lambda K \lambda \alpha.\alpha \in K$

b. $\left[\!\!\left[\begin{array}{c} C^0_{[-\text{WH}]} \\ \text{IN} \quad K \end{array} \right]\!\!\right] = \lambda \alpha.\alpha \in K$

(ii) A cross-categorial max-informativity operator MaxI and a choice function f_{CH}, which together replace the role of Pafel's MIN-operator.[72] As schematized in (6.35), MaxI applies to a set A and returns the set of max-informative members of A. If A is a set of sets, the maximal

[72] It does not matter whether we consider f_{CH} and MaxI as a single operator or two separate operators.

members of A are the sets in A that are not proper supersets of any sets in A.[73] Further, applying the choice function f_{CH} to $\text{MaxI}(A)$ returns one of these max-informative members.

(6.35) **Max-informativity operator**
$\text{MaxI}(A) = \{\alpha : \alpha \in A \wedge \forall\beta \in A[\beta \not\subset \alpha]\}$
(the set of members in A that are not proper supersets of any members in A)

(iii) A point-wise answerhood-operator. Definition is repeated from (5.62).

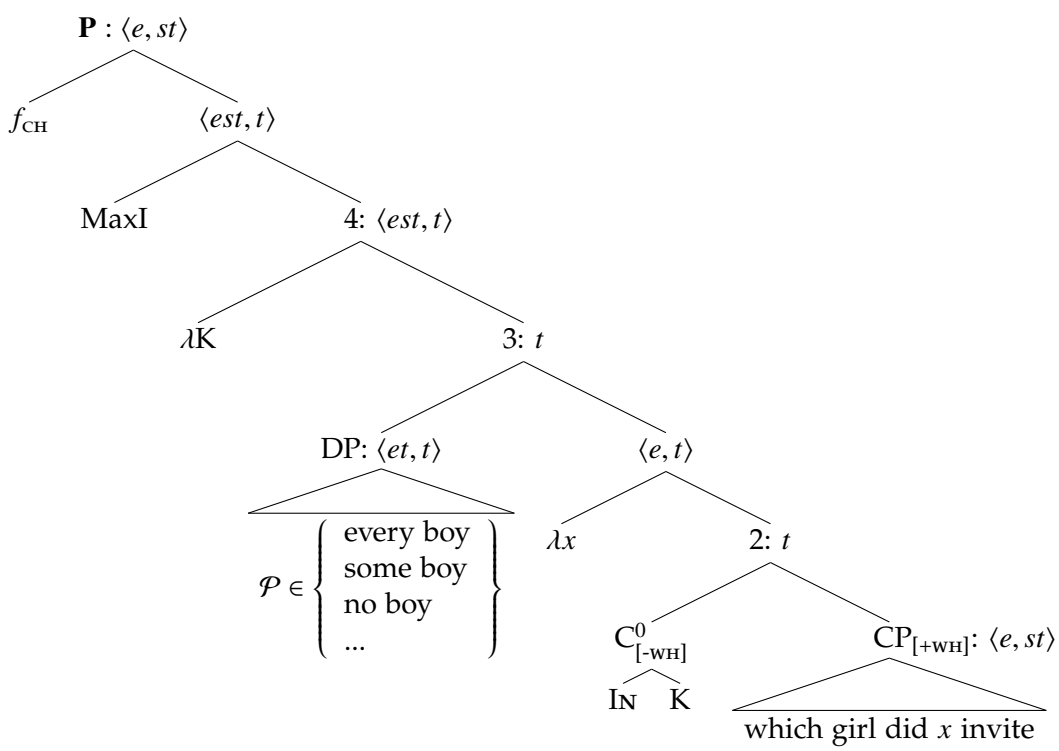
(6.36) **Point-wise answerhood-operator**

$$\textsc{Ans}_{\text{PW}} = \lambda\mathbf{P}\lambda w. \left\{ \begin{array}{ll} \textsc{Ans}(\mathbf{P})(w) & \mathbf{P} \text{ is of type } \langle\tau, st\rangle \\ \bigcap_{\text{PW}}\{\textsc{Ans}_{\text{PW}}(\alpha)(w) : \alpha \in \mathbf{P}\} & \text{otherwise} \end{array} \right\}$$

where $\bigcap_{\text{PW}}\{A, B\} = \{a \cap b : a \in A, b \in B\}$

The following tree illustrates the LF of a question with a quantifying-into question reading. The letter $\mathcal{P}$ stands for a quantifier. Compared with the LF in (6.28) proposed by Fox (2012b), the main novel piece in following LF is that the MIN-operator is replaced with a max-informativity (MaxI-)operator and a choice function f_{CH}. This revision makes the proposed analysis feasible to ∃-questions (§6.3.3).

(6.37) Which girl did $\mathcal{P}$ invite?



[73]The definition of MaxI in (6.35) is consistent with what Fox (2013) assumes for max-informative true answers. Let A be the set of true propositional answers, since a proposition denotes a set of worlds, the max-informative true answers are the ones that are not asymmetrically entailed by any of the true answers.

(i) $\text{MaxI}(A_{\langle st,t\rangle}) = \{p : p \in A \wedge \forall q \in A[q \not\subset p]\}$

6.3.2. ∀-questions

In the case of a ∀-question, its ∀-pair-list reading is derived as follows. A step-by-step explanation is provided after the formalization.

(6.38) Which girl did every boy invite?
(Context: *Consider only two boys Andy and Billy. Andy only invited Mary, and Billy only invited Jenny.*)
$[_4\ f_{\text{CH}}$ [MaxI λK $[_3$ [every boy] λx $[_2$ $[_{C^0_{[\text{-WH}]}}$ IN K] $[_{CP_{[+\text{WH}]}}$which girl did x invite]]]]]

a. $[\![\text{CP}_{[+\text{WH}]}]\!] = \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(x,y)]$

b. $[\![2]\!] = [\lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(x,y)]] \in \text{K}$

c. $[\![3]\!] = \forall x[\mathit{boy}_@(x) \rightarrow [\lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(x,y)]] \in \text{K}]$

d. $[\![4]\!] = \{\lambda\text{K} : \forall x[\mathit{boy}_@(x) \rightarrow [\lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(x,y)]] \in \text{K}]\}$

$$= \left\{ \left\{ \begin{array}{l} \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(a,y)] \\ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(b,y)] \\ \end{array} \right\}, \left\{ \begin{array}{l} \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(a,y)] \\ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(b,y)] \\ \bigstar \end{array} \right\}, \ \ldots \right\}$$

$$= \left\{ \text{K} : \text{K} \supseteq \left\{ \begin{array}{l} \{\hat{}\mathit{invite}(a,y) : y \in \mathit{girl}_@\} \\ \{\hat{}\mathit{invite}(b,y) : y \in \mathit{girl}_@\} \end{array} \right\} \right\}$$

e. $\mathbf{P} = f_{\text{CH}}[\text{MaxI}([\![4]\!])]$

$$= f_{\text{CH}}(\left\{ \left\{ \begin{array}{l} \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(a,y)] \\ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(b,y)] \end{array} \right\} \right\})$$

$$= \left\{ \begin{array}{l} \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(a,y)] \\ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(b,y)] \end{array} \right\}$$

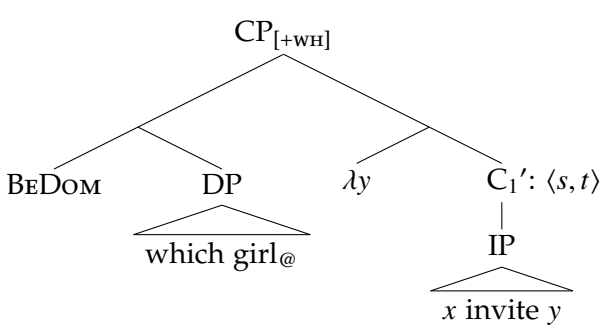
f. $\text{ANS}_{\text{PW}}(\mathbf{P})(w) = \bigcap_{\text{PW}}\{\text{ANS}(P)(w) : P \in \mathbf{P}\}$

$$= \bigcap_{\text{PW}} \left\{ \begin{array}{l} \{\hat{}\mathit{invite}(a,m)\} \\ \{\hat{}\mathit{invite}(b,j)\} \end{array} \right\}$$

$$= \{\hat{}\mathit{invite}(a,m) \cap \hat{}\mathit{invite}(b,j)\}$$

Step 1: ('which girl did x invite?')

The embedded interrogative $\text{CP}_{[+\text{WH}]}$ denotes the topical property of the simple question *which girl did x invite?*, as in (6.38a). The internal structure of $\text{CP}_{[+\text{WH}]}$ is as follows (see relevant definitions and assumptions in section 1.4.1). For the purpose of this chapter, it is also fine to define the denotation of $\text{CP}_{[+\text{WH}]}$ as a Hamblin set, a partition, or some other commonly assumed question denotation.



Step 2: ('which girl did x invite?' is in K)

The IN-function in the non-interrogative $C^0_{[-\text{WH}]}$ yields a membership relation that the root denotation of *which girl did x invite?* is a member of K, as in (6.38b).

Step 3: (every boy x is such that 'which girl did x invite?' is in K)

The quantifier *every boy* moves to [Spec, $C^0_{[-\text{WH}]}$] and quantifies into the membership relation, as in (6.38c). Observe that the scope of this quantifier is standardly of type $\langle e, t\rangle$.

Step 4: ({K: every boy x is such that 'which girl did x invite?' is in K})

At node 3, abstracting the variable K yields a family of "K sets," namely, the supersets of {which girl did x invite?: $x \in \mathit{boy}_{@}$}, as in (6.38d). The ★-sign stands for an arbitrary object that is not a subquestion.

Step 5: (f_{CH} MaxI {K: every boy x is such that 'which girl did x invite?' is in K})

Employing the MaxI-operator and the choice function f_{CH} returns one of the max-informative K sets, which is therefore s a possible root denotation **P**. In the case of a ∀-question, there is only one max-informative K set, namely, the set consists of exactly all the sub-questions: {which girl did x invite?: x is a boy}. Hence, the ∀-question has only one possible **P**, as in (6.38e).

Step 6: Employing the point-wise ANS-operator returns a set of conjunctive propositions. Each conjunctive proposition conjoins a max-informative true answer of each sub-question in **P**.

In the considered question, the obtained answer is a universal pair-list mention-all answer. Let me explain the features one by one. First, the obtained answer is a *pair-list* answer because the denotation **P** consists of *multiple* sub-questions. Second, the obtained answer is a *universal* answer because the unique **P** consists of *all* the sub-questions. Third, since each sub-question has *only one* max-informative true answer, $\text{ANS}_{\text{PW}}(\mathbf{P})(w)$ denotes a singleton set consisting of only one such conjunctive proposition, which is therefore a *mention-all* answer. In comparison, the following ◇-∀-question admits mention-some answers. In this question, the sub-questions can have *multiple* max-informative true answers. Therefore, the set $\text{ANS}_{\text{PW}}(\mathbf{P})(w)$ can be made up of multiple conjunctive propositions, each of which represents a universal pair-list *mention-some* answer.

(6.39) Where can every guest get gas?
(Context: *John can get gas from A or B, Mary can get gas from B or C, ...*)

e. $\mathbf{P} = \left\{ \begin{array}{l} [\![\text{where can John get gas?}]\!]_{\langle e,st\rangle} \\ [\![\text{where can Mary get gas?}]\!]_{\langle e,st\rangle} \end{array} \right\}$

f. $\text{ANS}_{\text{PW}}(\mathbf{P})(w) = \bigcap_{\text{PW}}\{\text{ANS}(P)(w) : P \in \mathbf{P}\}$

$= \bigcap_{\text{PW}} \left\{ \begin{array}{l} \{\Diamond f(j,a), \Diamond f(j,b)\} \\ \{\Diamond f(m,b), \Diamond f(m,c)\} \end{array} \right\}$

$= \left\{ \begin{array}{ll} \Diamond f(j,a) \wedge \Diamond f(m,b), & \Diamond f(j,b) \wedge \Diamond f(m,b), \\ \Diamond f(j,a) \wedge \Diamond f(m,c), & \Diamond f(j,b) \wedge \Diamond f(m,c) \end{array} \right\}$ ∀-PL-MS

The following table summarizes the characteristics of the pair-list reading of a ∀-question and the explanations or conditions for each characteristic:

The obtained reading is ...	
pair-list	because **P** consists of *multiple* sub-questions
universal	because **P** consists of *all* the sub-questions
mention-all	if each sub-question in **P** has *only one* max-inf true answer.
mention-some	if some sub-question in **P** has *multiple* max-inf true answer.

Table 6.1: Features of pair-list answers of ∀-questions

6.3.3. ∃-questions

6.3.3.1. Why a "choice" reading?

Let us move to the case of ∃-question. The choice reading of an ∃-question is derived as follows:

(6.40) Which girl did one of the boys invite?
(Context: *Consider only two boys Andy and Billy. Andy only invited Mary, and Billy only invited Jenny.*)
$[_4\ f_{\text{CH}}$ [MaxI λK $[_3$ [one of the boys] λx [[In K] [which girl did x invite]]]]]

c. $[\![3]\!] = \exists x[\mathit{boy}_@(x) \wedge \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(x,y)] \in \text{K}]$

d. $[\![4]\!] = \{\text{K} : \exists x[\mathit{boy}_@(x) \wedge \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(x,y)] \in \text{K}]\}$

$$= \left\{ \begin{array}{cc} \left\{ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(a,y)] \right\} & \left\{ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(b,y)] \right\} \\ \left\{ \begin{array}{c} \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(a,y)] \\ \bigstar \end{array} \right\} & \left\{ \begin{array}{c} \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(b,y)] \\ \bigstar \end{array} \right\} \\ \ldots & \ldots \end{array} \right\}$$

$$= \left\{ \text{K} : \text{K} \supseteq \left\{ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(a,y)] \right\} \vee \text{K} \supseteq \left\{ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(b,y)] \right\} \right\}$$

e. $\mathbf{P} = f_{\text{CH}}[\text{MaxI}([\![4]\!])]$

$$= f_{\text{CH}}\left(\left\{ \begin{array}{c} \left\{ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(a,y)] \right\} \\ \left\{ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(b,y)] \right\} \end{array} \right\} \right)$$

$$= \left\{ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(a,y)] \right\} \text{ or } \left\{ \lambda y[\mathit{girl}_@(y).\hat{}\mathit{invite}(b,y)] \right\}$$

f. $\textsc{Ans}_{\text{PW}}(\mathbf{P})(w) = \bigcap_{\text{PW}}\{\textsc{Ans}(P)(w) : P \in \mathbf{P}\}$

$= \bigcap_{\text{PW}} \left\{ \{\hat{}\mathit{invite}(a,m)\} \right\}$ or $\bigcap_{\text{PW}} \left\{ \{\hat{}\mathit{invite}(b,j)\} \right\}$

$= \{\hat{}\mathit{invite}(a,m)\}$ or $\{\hat{}\mathit{invite}(b,j)\}$

The composition of the ∃-question differs from that of the corresponding ∀-question starting at **Step 5**, as schematized in (6.40e). While the ∀-question has *only one* max-informative K set (i.e., the set consists of exactly all sub-questions), the ∃-question has *multiple* max-informative K-sets, each of which consists of exactly one sub-question. Each such K set is a possible root denotation **P**. Thus, ∃-question admits a choice reading because it has multiple possible **P**s.

For each possible **P**, employing the $\textsc{Ans}_{\text{PW}}$-operator returns a set of max-informative true answers of the sub-question contained in that **P**. Since each sub-question has *at most one* max-informative

true answer, $\textsc{Ans}_{\textsc{pw}}(\mathbf{P})(w)$ denotes a singleton set, yielding a *mention-all* reading. In comparison, the sub-questions of the $\Diamond$-$\exists$-question in (6.41) can have *multiple* max-informative true answers. Hence we get a *mention-some* reading.

(6.41) Where can one of the guests get gas?
(Context: *Consider only two individuals John and Mary. John can get gas from A or B, and Mary can get gas from B or C.*)

a. $\mathbf{P} = \left\{ \ [\![\text{where can John get gas}]\!] \ \right\}$
$\text{or} = \left\{ \ [\![\text{where can Mary get gas}]\!] \ \right\}$

f. $\textsc{Ans}_{\textsc{pw}}(\mathbf{P})(w)$
$= \bigcap_{\textsc{pw}}\{\textsc{Ans}(P)(w) : P \in \mathbf{P}\}$
$= \bigcap_{\textsc{pw}} \left\{ \ \{\Diamond f(j,a), \Diamond f(j,b)\} \ \right\}$
$\text{or} = \bigcap_{\textsc{pw}} \left\{ \ \{\Diamond f(m,b), \Diamond f(m,c)\} \ \right\}$
$= \{\Diamond f(j,a), \Diamond f(j,b)\}$
$\text{or} = \{\Diamond f(m,b), \Diamond f(m,c)\}$

The following table summarizes the characteristics of the choice reading of an $\exists$-question and the explanations or conditions for each characteristic:

The obtained reading is ...	
choice	because there are multiple possible **P**s
not universal	because no **P** consists of all the sub-questions
not pair-list	because each **P** consists of only one sub-question
mention-all	if the sub-question in each **P** has *only one* max-inf true answer.
mention-some	if the sub-question in some **P** has *multiple* max-inf true answers.

Table 6.2: Features of choice readings of $\exists$-questions

6.3.3.2. Why not a "pair-list" reading?

The proposed account easily explains the unavailability of pair-list readings in the following $\exists$-question:

(6.42) "Which girl did two of the boys invite?"
"# Andy invited Mary, and Billy invited Jenny."
[$f_{\textsc{ch}}$ [MaxI λK [[two of the boys] λx [[In K] [which girl did x invite]]]]]

The quantifier *two of the boys* is an existential generalized quantifier living on a set of sums of two boys, as defined in (6.43a). Hence, each possible **P** of (6.42) consists of exactly one sub-question of the form "which girl did x invite" where x is the sum of two boys. For instance, with only three boys *abc* taken into considerations, the possible **P**s would be those list in (6.43b), each of which is a singleton set containing only one sub-question.

(6.43) a. $[\![\varnothing_{\exists}$ two of the boys$_{@}]\!]$
$= \lambda f_{\langle e,t\rangle}.\exists x[x \leq \iota y[{}^{*}\mathsf{boy}_{@}(y)] \wedge |x| = 2 \wedge f(x)]$
$= \lambda f_{\langle e,t\rangle}.\exists x[{}^{*}\mathsf{boy}_{@}(x) \wedge |x| = 2 \wedge f(x)]$

b. $[\![$Which girl did two of the boys invite?$]\!]$
$= \{[\![$which girl did $a \oplus b$ invite?$]\!]\}$
or $= \{[\![$which girl did $b \oplus c$ invite?$]\!]\}$
or $= \{[\![$which girl did $a \oplus c$ invite?$]\!]\}$

To obtain a pair-list reading, however, there must be some possible **P** that consists of multiple sub-questions. Therefore, the ∃-question in (6.42) cannot take a pair-list reading.

Inserting a VP-distributor *each* also does not evoke a pair-list reading, as seen in (6.44). The reason is that *each* is a VP-operator and is interpreted within the embedded interrogative CP.

(6.44) "Which girl did two of the boys each invite?"
"# Andy invited Mary, and Billy invited Jenny."
[f_{CH} [MaxI λK [[two of the boys] λx [[In K] [which girl did x **each** invite]]]]]

6.3.3.3. ∃-questions versus multi-*wh* questions

Compared with the account by Dayal (1996, 2017) (see the discussion around (6.25) in §6.2.3), the proposed function-based accounts can easily account for the differences between ∃-questions and multi-*wh* questions. A *wh*-item must be moved to [Spec, CP$_{[+\text{WH}]}$], where C$^{0}_{[+\text{WH}]}$ contains an identify function Id, as in (6.45a). In contrast, as a syntactic constraint, a non-interrogative existential quantifier can only be moved to [Spec, CP$_{[\text{-WH}]}$], where C$^{0}_{[\text{-WH}]}$ contains a membership function In, as in (6.45b). These structural differences make these two types questions take different readings.

(6.45) a. Which girl did one of the boys invite?
... [[one boy]$_j$ [[$_{\text{C}^0_{[-\text{WH}]}}$ In K] [$_{\text{CP}}$ which girl did t_j invite]]]

b. Which girl did which boy invite?
... [[which boy]$_j$ [[$_{\text{C}^0_{[+\text{WH}]}}$ Id P] [$_{\text{CP}}$ which girl did t_j invite]]]

6.3.4. Other cases

6.3.4.1. Questions with N-quantifiers

A question with an N-quantifier (e.g., *nobody*, *no boy*) has only one max-informative K set, namely the empty set ∅. For example, in (6.46), the K sets are the sets that do not contain a subquestion of the form 'which girl did boy x invite?'. Since the emptyset is also a qualified K set, is it therefore the unique max-informative K set.

(6.46) "Which girl did no boy invite?" "# [Silence ...]"

a. [f_{CH} [MaxI [$_3$ λK [$_{\text{CP}}$ [no boy] λx [[$_{\text{C}^0[-\text{WH}]}$ In K] [$_{\text{CP}}$ which girl did x invite]]]]]]

b. $[\![3]\!] = \{\text{K} : \neg\exists x[x \in \mathsf{boy} \wedge [\![\text{which girl did } x \text{ invite}]\!] \in \text{K}]\}$

c. $\mathbf{P} = f_{\text{CH}}[\text{MaxI}([\![3]\!])] = f_{\text{CH}}\{\varnothing\} = \varnothing$

I assume the point-wise use of the answerhood-operator is subject to a presupposition that the answerhood-operator is defined for at least one of the sub-questions. Accordingly, in the case of (6.46), $\textsc{Ans}_{\text{PW}}(\varnothing)(w)$ suffers a presupposition failure and is therefore deviant.

(6.47) **Point-wise answerhood-operator** (Final version)

$$\textsc{Ans}_{\text{PW}} = \lambda \mathbf{P} \lambda w. \left\{ \begin{array}{ll} \textsc{Ans}(\mathbf{P})(w) & \mathbf{P} \text{ is of type } \langle \tau, st \rangle \\ \\ \bigcap_{\text{PW}}\{\textsc{Ans}_{\text{PW}}(\alpha)(w) : \alpha \in \mathbf{P}\} & \text{otherwise} \\ \text{defined only if } \exists \alpha \in \mathbf{P}[\textsc{Ans}_{\text{PW}}(\alpha)(w) \text{is defined}] & \end{array} \right\}$$

6.3.4.2. Questions with numeral-modified quantifiers

One might suggest to use the idea for questions with N-quantifiers to explain the unavailability of pair-list readings in (6.48a-b), each of which contains a downward monotone quantifier (viz., *at most three boys* and *less than three boys*). Such a line of thought, however, cannot uniformly explain the unavailability of pair-list readings in (6.49a-b). The quantifiers *at least two boys* and *more than two boys* are upward monotone. More generally speaking, pair-list readings cannot be licensed by any numeral-modified quantifiers. This fact should be explained uniformly.

(6.48) a. Which girl did at most two boys invite?
Andy invited Mary, Billy invited Jenny.
b. Which girl did less than three boys invite?
Andy invited Mary, Billy invited Jenny.

(6.49) a. Which girl did at least two boys invite?
Andy invited Mary, Billy invited Jenny.
b. Which girl did more than two boys invite?
Andy invited Mary, Billy invited Jenny, Clark invited Helen.

A simple way of thought would be to treat numeral-modified quantifiers as existential with a numeral-modified restriction. For instance, for *at least two boys*, the closure is a null existential closure $\varnothing_{\exists}$ (Link 1987), and the restriction is a set of plural boys that have a cardinality equal to or greater than 2.[74]

(6.50) a. $[\![\varnothing_{\exists} \text{ at least two boys}_{@}]\!] = \lambda f.\exists x[{}^{*}\textsf{boy}(x) \wedge \mid x \mid \geq 2 \wedge f(x)]$
b. $[\![\varnothing_{\exists} \text{ more than two boys}_{@}]\!] = \lambda f.\exists x[{}^{*}\textsf{boy}(x) \wedge \mid x \mid > 2 \wedge f(x)]$

Accordingly, each possible **P** of the question (6.49a) consists of exactly one sub-question of the form "which girl did x invite" where x an individual denoting the sum of two or more boys. Such a singleton **P** does not yield a pair-list reading, just like what we saw in the basic ∃-question (6.42).

[74]Semantics of downward monotone quantifiers involve more complexities. See Buccola and Spector (2016) for discussions and solutions.

6.3.5. Summary

The semantic properties of quantifying-into question readings and the conditions for each of these properties are summarized in the following:

(6.51) For a question Q of the form '*wh*-A does $\mathcal{P}$ f?' where $\mathcal{P}$ is a non-interrogative quantifier, the quantifying-into question reading of Q is ...

a. **pair-list**, iff Q has a possible **P** that consists of multiple sub-questions.

b. **universal** (viz., subject to domain exhaustivity), iff Q has a unique **P** and this **P** consists of all the sub-questions.

c. **choice**, iff Q has multiple possible **P**, or equivalently, multiple max-informative K sets such that $\mathcal{P}(\lambda x[[\![wh\text{-A does } x\ f?]\!] \in \mathrm{K}])$ is true.

d. **mention-some**, iff for some individual x in the domain of $\mathcal{P}$, the sub-question '*wh*-A does x f?' takes a mention-some reading; otherwise **mention-all**.

e. subject to **uniqueness**, iff for every individual x in the domain of $\mathcal{P}$, the sub-question '*wh*-A does x f?' is subject to uniqueness.

f. **undefined**, if Q has no possible **P**, or if $\textsc{Ans}_{\mathrm{PW}}(\mathbf{P})(w)$ is undefined for every possible **P**.

6.4. Proposal II: A function-based approach

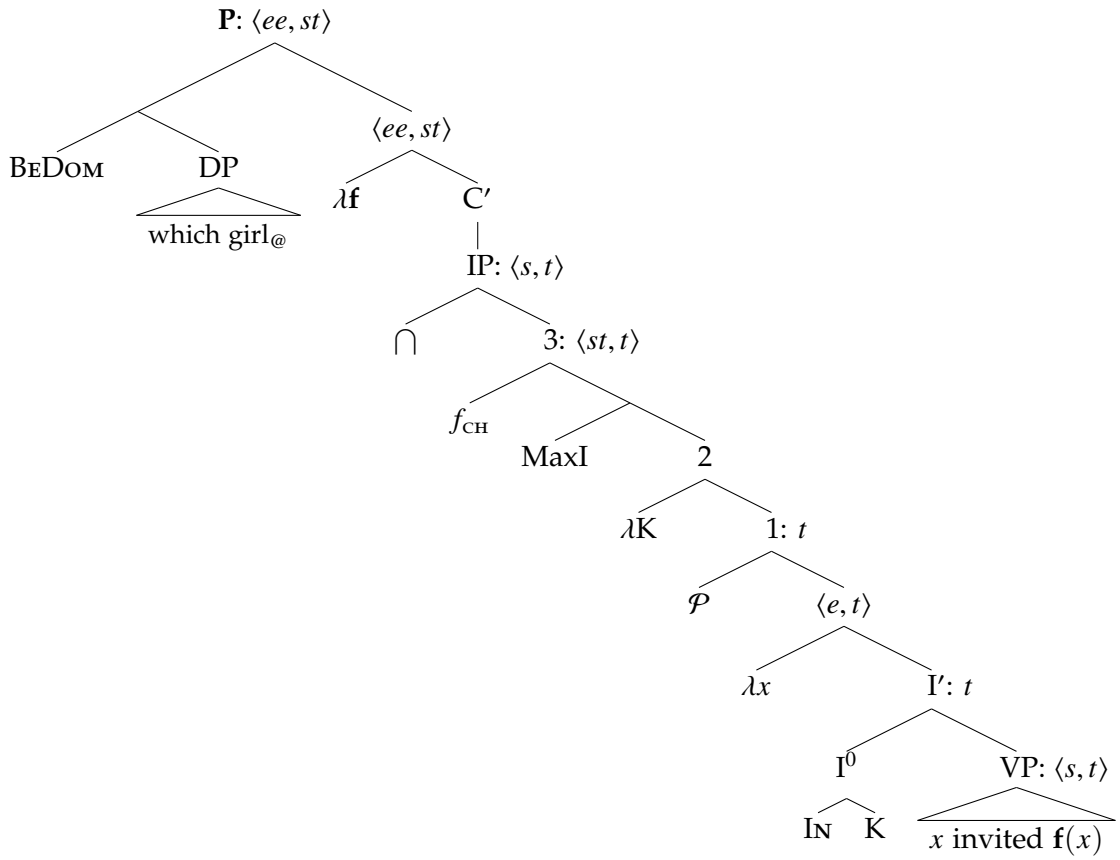
6.4.1. Overview

This section presents a function-based approach. The core idea is similar to what I proposed for the higher-order question approach: the quantifier quantifies into a membership relation, each max-informative K set that satisfies this quantificational membership relation counts as a possible topical property.

I assume the tree in (6.52) as the LF schema for questions with a quantifier, where $\mathcal{P}$ stands for a non-interrogative quantifier. None of the ingredients of this LF is new for this dissertation. Some of the ingredients were firstly proposed in my function-based approach for multi-*wh* questions (see §5.4), and the others were adapted from my high-order question approach for questions with quantifiers (see §6.3).

Despite using similar tricks, this approach differs from the higher-order question approach in both syntax and semantics. **In syntax**, the QR of the quantifier leaves a functional trace **f** and its landing position is still within IP (or say, within the question nucleus). The membership function In which was ascribed to a non-interrogative C^0 is now ascribed to an I^0. **In semantics**, a question with a quantifier is treated as a basic question taking a special functional reading (*à la* Chierchia 1993, Dayal 1996). In particular, under the proposed hybrid categorial approach, the root denotation is a property of functions.

(6.52) which girl did $\mathcal{P}$ invite?



The rest of this section will only discuss how this LF yields pair-list readings of ∀-questions and choice readings of ∃-questions. Other issues, such as the unavailability of pair-list readings in ∃-questions, can be explained in the same way as what I proposed for the higher-order question approach.

6.4.2. ∀-questions

Based on the LF in (6.52), the ∀-question in (6.53) yields its universal pair-list answer as follows. A step-by-step explanation is provided after the schematization.

(6.53) Which girl did every boy invite?
(Context: *Consider only two boys Andy and Billy. Andy only invited Mary, and Billy only invited Jenny.*)
[$_{\mathbf{P}}$ BeDom(which girl) $\lambda\mathbf{f}$ [$\cap$ [$_3$ f_{CH} MaxI [$_2$ λK [$_1$ (every boy) λx [$_{\text{I}'}$[In K] [x invited **f**(x)]]]]]]]

a. $[\![\text{I}']\!] = {}^\wedge\mathit{invite}(x, \mathbf{f}(x)) \in \text{K}$

b. $[\![1]\!] = \forall x[x \in \mathit{boy}_{@} \rightarrow {}^\wedge\mathit{invite}(x, \mathbf{f}(x)) \in \text{K}]$

c. $[\![2]\!] = \left\{\text{K} : \forall x[x \in \mathit{boy}_{@} \rightarrow {}^\wedge\mathit{invite}(x, \mathbf{f}(x)) \in \text{K}]\right\}$

$$= \left\{ \left\{ \begin{array}{c} {}^\wedge\mathit{invite}(a, \mathbf{f}(a)) \\ {}^\wedge\mathit{invite}(b, \mathbf{f}(b)) \\ \\ \end{array} \right\}, \left\{ \begin{array}{c} {}^\wedge\mathit{invite}(a, \mathbf{f}(a)) \\ {}^\wedge\mathit{invite}(b, \mathbf{f}(b)) \\ \bigstar \end{array} \right\}, \quad \ldots \right\}$$

$$= \left\{ \mathrm{K} : \mathrm{K} \supseteq \left\{ \begin{array}{c} {}^\wedge\mathit{invite}(a, \mathbf{f}(a)) \\ {}^\wedge\mathit{invite}(b, \mathbf{f}(b)) \end{array} \right\} \right\}$$

d. $[\![3]\!] = f_{\mathrm{CH}}[\mathrm{MaxI}(\{\mathrm{K} : \forall x[x \in \mathit{boy}_{@} \rightarrow {}^\wedge\mathit{invite}(x, \mathbf{f}(x)) \in \mathrm{K}]\})]$

$$= \left\{ \begin{array}{c} {}^\wedge\mathit{invite}(a, \mathbf{f}(a)) \\ {}^\wedge\mathit{invite}(b, \mathbf{f}(b)) \end{array} \right\}$$

e. $[\![\mathrm{IP}]\!] = {}^\wedge\mathit{invite}(a, \mathbf{f}(a)) \cap {}^\wedge\mathit{invite}(b, \mathbf{f}(b))$

f. $[\![\text{which girl}_{@}]\!] = \lambda f.\exists\alpha[[\mathit{girl}_{@}(\alpha) \vee \mathrm{Range}(\alpha) \subseteq \mathit{girl}_{@}] \wedge f(\alpha)]$

g. $[\![\textsc{BeDom}]\!] = \lambda\mathcal{P}\lambda\theta.\iota P[[\mathrm{Dom}(P) = \textsc{Be}(\mathcal{P})] \wedge \forall\alpha \in \mathrm{Dom}(P)[P(\alpha) = \theta(\alpha)]]$

h. $\mathbf{P} = \iota P[[\mathrm{Dom}(P) = \{\mathbf{f} : \mathrm{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@}\}] \wedge$
$\forall\alpha \in \mathrm{Dom}(P)[P(\alpha) = {}^\wedge\mathit{invite}(a, \mathbf{f}(a)) \cap {}^\wedge\mathit{invite}(b, \mathbf{f}(b))]]$
$= \lambda\mathbf{f}[\mathrm{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@}.{}^\wedge\mathit{invite}(a, \mathbf{f}(a)) \cap {}^\wedge\mathit{invite}(b, \mathbf{f}(b))]$

i. $\textsc{Ans}(\mathbf{P})(w) = \mathrm{MaxI}(\{\mathbf{P}(\mathrm{f}) : w \in \mathbf{P}(\mathrm{f})\})$
True short answers: $f_1 : [a \rightarrow m, b \rightarrow j]$
True propositional answers: ${}^\wedge\mathit{invite}(a, m) \cap {}^\wedge\mathit{invite}(b, j)$
Hence: $\textsc{Ans}(\mathbf{P})(w) = \{\mathbf{P}(\mathrm{f}_1)\} = \{{}^\wedge\mathit{invite}(a, m) \cap {}^\wedge\mathit{invite}(b, j)\}$

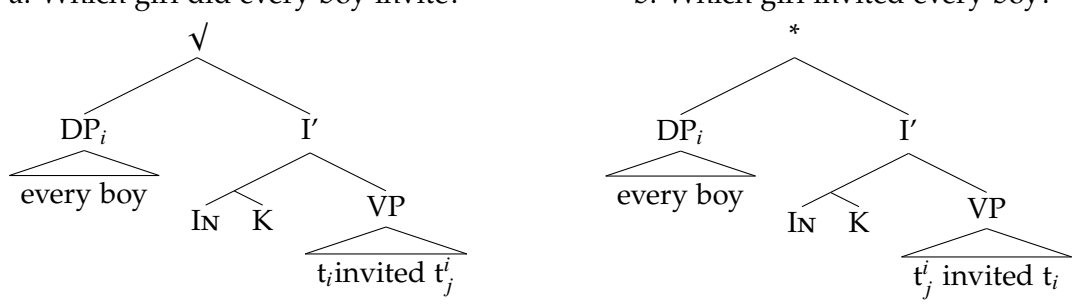
Step 1: ('x invited **f**(x)' is in K)

The membership function In in the complex I^0 yields a membership relation that the proposition 'x invited $\mathbf{f}(x)$' is a member of K, as in (6.53a).

Step 2: (every boy x is such that 'x invited **f**(x)' is in K)

Every boy takes QR to [Spec, IP] and quantifies into the membership relation generated in Step 1, as in (6.53b). It is crucial to notice that for (6.53b) being defined, the function **f** must be defined for every boy. In syntax, following Chierchia (1993), I assume that the nominal quantifier *every boy* binds two argument indexes, namely, the index of its own trace and the argument index of the *wh*-trace. Accordingly, due to the Weak Crossover Constraint, such a movement is available if *every boy* higher than the *wh*-trace t_i.

(6.54) a. Which girl did every boy invite? b. Which girl invited every boy?



Step 3: ({K: every boy x is such that 'x invited **f**(x)' is in K})

At node 2, abstracting the first argument of the In-function yields a family of "K sets," namely, the sets consisting of at least all the propositions of the form 'x invited $\mathbf{f}(x)$' where x is an atomic boy, as in (6.53c). The ★-sign stands for an arbitrary object that is not a proposition of this form. More generally, the obtained denotation equals to the following:

(6.55) $\{\mathrm{K} : \{{}^\wedge \mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_@\} \subseteq \mathrm{K}\}$, defined only if $\mathbf{f}$ is defined for every member in $\mathit{boy}_@$.

Step 4: (f_{CH} MaxI {K: every boy x is such that 'x invited **f**(x)' is in K})

Employing the MaxI-operator and the choice function f_{CH} returns one of the max-informative K sets. In the case of a ∀-question, there is only one max-informative K set, as in (6.53d). More generally, this denotation also equals to the following, namely, the set consists of exactly all the propositions of the form 'x invited $\mathbf{f}(x)$' where x is an atomic boy.

(6.56) $\mathit{boy}_@ \subseteq \mathrm{Dom}(\mathbf{f}).\{{}^\wedge \mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_@\}$

With the unique choice of max-informative K set, the ∀-question ultimately has only one possible **P**.

Step 5: ($\bigcap f_{\mathrm{CH}}$ MaxI {K: every boy x is such that 'x invited **f**(x)' is in K})

Closing the obtained max-informative K set under conjunction, as in (6.53e). Since here **f** is defined for every atomic boy, the obtained conjunctive proposition is a universal pair-list statement.

Step 6: The *wh*-movement of 'BeDom(which girl)' leaves a functional trace and creates a topical property of functions, as in (6.53f-h). This topical property maps a function ranging over atomic girls to a universal pair-list answer. Due to the following definition of the *wh*-determiner, the live-on set of *which girl* consists of not only atomic girls (§1.6.4) but also functions ranging over the set of atomic girls (§5.4).

(6.57) **Lexical entries of *wh*-items** (repeated from (5.31))

a. $[\![\text{which } A]\!] = \lambda B.\exists x \in [[\dagger A \cup \{\mathbf{f} : \mathrm{Range}(\mathbf{f}) \subseteq \dagger A\}] \cap B]$

b. $\mathrm{Be}([\![\text{which } A]\!]) = \dagger A \cup \{\mathbf{f} : \mathrm{Range}(\mathbf{f}) \subseteq \dagger A\}$

c. $\mathrm{Be}([\![\text{which girl}_@]\!]) = \dagger \mathit{girl}_@ \cup \{\mathbf{f} : \mathrm{Range}(\mathbf{f}) \subseteq \dagger \mathit{girl}_@\}$
$= \mathit{girl}_@ \cup \{\mathbf{f} : \mathrm{Range}(\mathbf{f}) \subseteq \mathit{girl}_@\}$

Since the *wh*-movement of *which girl* leaves a functional trace, the obtained question denotation is a property of functions, as generalized in the following:

(6.58) $\mathbf{P} = \lambda \mathbf{f}[\mathrm{Range}(\mathbf{f}) \subseteq \mathit{girl}_@ \wedge \mathrm{Dom}(\mathbf{f}) \supseteq \mathit{boy}_@ . \bigcap\{{}^\wedge \mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_@\}]$

This idea inherits Chierchia's (1993) insight that quantifying-into question readings are special kinds of functional readings and are subject to similar syntactic constraints.

Step 7: Employing the basic Ans-operator returns a set of universal pair-list answers. In the considered question, $\mathrm{Ans}(\mathbf{P})(w)$ is a singleton set consisting of only one such universal pair-list answer, which is also the unique true answer and therefore a *mention-all* answer.

6.4.3. A note on domain exhaustivity

In section 5.2 and 6.1, I have argued that the pair-list readings of ∀-questions are subject to domain exhaustivity, while those of multi-*wh* questions are not. In the following, I show how the proposed

function-based accounts for the pair-list readings of each question type capture their contrast with respect to domain exhaustivity.

While both denoting a set of propositions of the form 'boy x invited **f**(x),' the following two formulas have a crucial distinction: (6.59b) has a extra requirement that the function **f** is defined for every atomic boy. To be more specific, if the domain of **f** is a proper subset of atomic boys, (6.59a) is defined in such a case and would denote a set smaller than $\mathit{boy}_{@}$, while (6.59b) will be undefined.

(6.59) a. $\{{}^\wedge\mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_{@}\}$

b. $f_{\text{CH}}[\text{MaxI}(\{\text{K} : \forall x[x \in \mathit{boy}_{@} \rightarrow {}^\wedge\mathit{invite}(x, \mathbf{f}(x)) \in \text{K}]\})]$

Equivalent to: $\mathit{boy}_{@} \subseteq \text{Dom}(\mathbf{f}).\{{}^\wedge\mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_{@}\}$

Therefore, the topical properties for the pair-list readings of the following two questions are different. The one for the multi-*wh* question (6.60a) is defined for any function ranging over atomic girls, while the one for the ∀-question (6.60b) also requires the functions to be defined for every atomic boy, which therefore gives rise to a domain exhaustivity effect.

(6.60) a. Which girl did which boy invite?

$\mathbf{P} = \lambda\mathbf{f}[\text{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@}. \bigcap\{{}^\wedge\mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_{@}\}]$

b. Which girl did every boy invite?

$\mathbf{P} = \lambda\mathbf{f}[\text{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@}. \bigcap f_{\text{CH}}[\text{MaxI}(\{\text{K} : \forall x[x \in \mathit{boy}_{@} \rightarrow {}^\wedge\mathit{invite}(x, \mathbf{f}(x)) \in \text{K}]\})]]$

$= \lambda\mathbf{f}[\text{Range}(\mathbf{f}) \subseteq \mathit{girl}_{@} \wedge \text{Dom}(\mathbf{f}) \supseteq \mathit{boy}_{@}. \bigcap\{{}^\wedge\mathit{invite}(x, \mathbf{f}(x)) : x \in \mathit{boy}_{@}\}]$

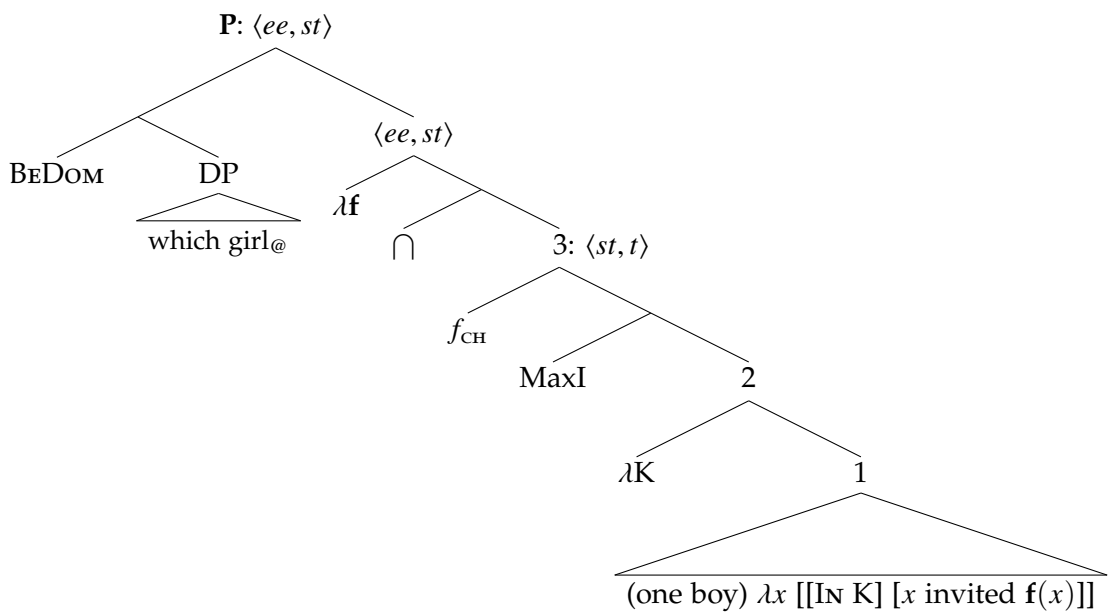
6.4.4. ∃-questions

Let us move to ∃-questions. In analogous to what we saw with the ∀-question in (6.53), the following LF for an ∃-question involves two movements. First, the quantifier *one of the boys* moves to [Spec, IP] and existentially quantifies into a membership relation. Second, the *wh*-object, together with a type-shifter BeDom, moves to [Spec, CP] and leaves a functional trace **f**. The argument of this functional trace is locally bound by the non-interrogative quantifier *one of the boys*.

A difference arises at Step 4, namely composing the semantics of Node 3. There are multiple possible max-informative K sets such that for one of the boys, 'x invited $\mathbf{f}(x)$' is a member of K. Each of such K sets names one of the boys. The unique proposition in each such K set yields a possible nucleus of the topical property. Thus, an ∃-question takes a choice reading because it has multiple possible topical properties.

(6.61) Which girl did one of the boys invite?

(Context: *Consider only two boys Andy and Billy. Andy only invited Mary, and Billy only invited Jenny.*)



a. $[\![1]\!] = \exists x[x \in \textit{boy}_{@} \wedge {}^{\wedge}\textit{invite}(x, \mathbf{f}(x)) \in \mathrm{K}]$

b. $[\![2]\!] = \{\mathrm{K} : \exists x[x \in \textit{boy}_{@} \wedge {}^{\wedge}\textit{invite}(x, \mathbf{f}(x)) \in \mathrm{K}]\}$

$$= \left\{ \begin{array}{cc} \left\{ {}^{\wedge}\textit{invite}(a, \mathbf{f}(a)) \right\}, & \left\{ {}^{\wedge}\textit{invite}(b, \mathbf{f}(b)) \right\} \\ \left\{ \begin{array}{c} {}^{\wedge}\textit{invite}(a, \mathbf{f}(a)) \\ \bigstar \end{array} \right\}, & \left\{ \begin{array}{c} {}^{\wedge}\textit{invite}(a, \mathbf{f}(a)) \\ \bigstar \end{array} \right\} \\ \ldots & \ldots \end{array} \right\}$$

$$= \left\{ \mathrm{K} : \mathrm{K} \supseteq \left\{ {}^{\wedge}\textit{invite}(a, \mathbf{f}(a)) \right\} \vee \mathrm{K} \supseteq \left\{ {}^{\wedge}\textit{invite}(b, \mathbf{f}(b)) \right\} \right\}$$

c. $[\![3]\!] = \left\{ {}^{\wedge}\textit{invite}(a, \mathbf{f}(a)) \right\}$

or $= \left\{ {}^{\wedge}\textit{invite}(b, \mathbf{f}(b)) \right\}$

d. $\mathbf{P} = \lambda\mathbf{f}[\mathrm{Range}(\mathbf{f}) \subseteq \textit{girl}_{@}.{}^{\wedge}\textit{invite}(a, \mathbf{f}(a))]$

or $= \lambda\mathbf{f}[\mathrm{Range}(\mathbf{f}) \subseteq \textit{girl}_{@}.{}^{\wedge}\textit{invite}(b, \mathbf{f}(b))]$

e. $\textsc{Ans}(\mathbf{P})(w) = \{{}^{\wedge}\textit{invite}(a, m)\}$

or $= \{{}^{\wedge}\textit{invite}(b, j)\}$

Chapter 7

The Mandarin particle *dou*

7.1. Introduction

The Mandarin particle *dou* is famous for its function diversity. As a rough classification, *dou* can be used as a quantifier-distributor, a universal free choice item (∀-FCI) licenser, and an *even*-like scalar marker. This chapter presents a uniform semantics of *dou* to capture its seemingly diverse functions.[75] I propose that *dou* is an exhaustifier with the following characteristics:

(i) *dou* operates on pre-exhaustified sub-alternatives;

(ii) *dou* presupposes the existence of at least one sub-alternative.

The basic idea of my proposal is as follows. For a *dou*-sentence of the form "*dou*(S_A)" where S is the prejacent clause and A is the associate of *dou*, its meaning is roughly 'S_A and not only $S_{A'}$' where A' can be a proper subpart of A, or a weak scale-mate of A, and so on. For example, "A and B *dou* came" means 'A and B came, not only A came, and not only B came'; "it's *dou* five o'clock" means 'it's 5 o'clock, not just 4 o'clock, not just 3 o'clock, ...'

For the over-arching goal of this dissertation on questions admitting non-exhaustive readings, this chapter provides theoretical preparations for the analyses on the mention-some/mention-all ambiguity in ◇-questions (chapter 2), especially the exhaustivity-marker use of *dou* and the derivation of disjunctive mention-all readings (§2.6.3).

Moreover, independent from the particular interests on question semantics, the function diversity of *dou* also raises up questions that are fundamental for the natural language semantics (Chierchia 2016): what is the initial logical state of the universal grammar (UG), and how it is developed? Functional particles such as negation and connectives are components of the underlying logical system of UG. This system should be very simple, otherwise we wouldn't have been able to acquire it such easily. Nevertheless, many natural language particles (such as Mandarin *dou* and *ye*, Japanese *ya* and *mo*) have various basic functions. The sources of these functions should be primarily the same, otherwise the initial logical state of UG would be unrecognizable. The shifts among the functions should result from small variations, otherwise function diversity would not be cross-linguistic.

[75] This chapter significantly expands on my preliminary proposal, Xiang (2016b) in *EISS 11*. Other earlier versions of this work were presented at EACL 9, LAGB 2015, and MIT Exhaustivity workshop 2016.

The Mandarin particle *dou*, with a long history of at least 2000 years,[76] is an excellent case to study the development of the logical system in UG. In what follows, I will argue for the following development path for the functions of *dou*:

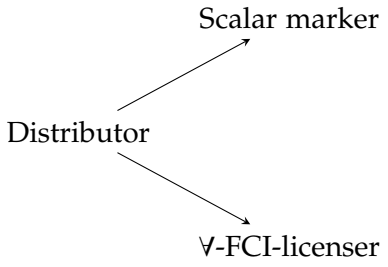


Figure 7.1: Path for the development of the functions of *dou*

First, *dou* is primarily a pre-exhaustification exhaustifier, which immediately derives its quantifier-distributor use. Next, *dou* obtains its scalar marker use and ∀-FCI-licenser use via two independent semantic weakening operations. In particular, the scalar marker use comes from a semantic weakening from logical strength to likelihood, while the ∀-FCI-licenser use comes from a semantic weakening from non-excludability to non-innocent excludability. These two weakening operations are partial and are only licensed under particular syntactic or prosodic conditions.

The rest of this chapter is organized as follows. Section 7.2 describes the three basic uses of *dou*, including the quantifier-distributor use, the ∀-FCI licenser use, and the scalar marker use. Section 7.3 discusses the advantages and problems of two representative approaches to the semantics of *dou*, namely, the distributor approach (Lin 1998) and the maximality operator approach (Giannakidou and Cheng 2006, Ming Xiang 2008). Section 7.4 starts with the canonical exclusive particle *only*, so as to introduce Alternative Semantics for focus and the theory of exhaustifications. Then it outlines a preliminary semantic treatment of *dou*. Section 7.5 derives the three basic uses of *dou* and explains the relevant semantic effects. Section 7.6 discusses the transitions between the alternations of the semantics of *dou*. I argue that the logical strength-based semantics of *dou* is primary, which gives rise to a distributor use, while that the other two uses are obtained by two independent semantic weakening operations.

7.2. Describing the uses of *dou*

Quantifier-distributor

In a basic declarative sentence, *dou* is associated with a preceding nominal expression and universally quantifies over the subparts of the denotation of its associate, as exemplified in (7.1). This use is similar to the post-nominal use of English *all*. Here and throughout this chapter, the associate of *dou* is enclosed in "[•]".

(7.1) a. [Tamen] **dou** dao -le.
they DOU arrive -ASP

[76]The quantifier-distributor use of *dou* emerged as early as the Eastern Han Dynasty (25-220) (Gu 2015).

'They all arrived.'

b. [Tamen] **dou** ba naxie wenti da dui -le.
they DOU BA those question answer correct -ASP
'They all correctly answered these questions.'

c. Tamen ba [naxie wenti] **dou** da dui -le.
they BA those question DOU answer correct -ASP
'They correctly answered all of these questions.'

Moreover, under the quantifier-distributor use, *dou* brings up three semantic consequences in addition to universal quantification, namely, a "maximality requirement," a "distributivity requirement," and a "plurality requirement." The "maximality requirement" means that presence of *dou* forces the predicate denoted by the remnant VP to predicate on the maximal element in the extension of *dou*'s associate (Ming Xiang 2008). For instance, in a discourse that a large group of children, with one or two exceptions, went to the park, the sentence in (7.2) is true only when *dou* is absent.

(7.2) [Haizimen] (#**dou**) qu -le gongyuan.
children DOU go -PERF park
'The children (#all) went to the park.'

The "distributivity requirement" says that if a sentence admits both collective and (atomic or non-atomic) distributive readings, then adding *dou* to this sentence eliminates the collective reading (Lin 1998). For instance, (7.3a) is infelicitous if John and Mary married each other, and (7.3b) is infelicitous if all the considered individuals only participated in one house-buying event.

(7.3) a. [Yuehan he Mali] **dou** jiehun -le.
John and Mary DOU get-married -ASP
'John and Mary each got married.'

b. [Tamen] **dou** mai -le fangzi.
they DOU buy -PERF house
'They all bought houses.' (#collective)

The "plurality requirement" says that the item associated with *dou*, overt or covert, must be non-singular. If the prejacent sentence of *dou* has no overt non-atomic term, *dou* needs to be associated with a covert non-atomic item. For example, in (7.4), since the overt part of the prejacent clause has no non-singular term, *dou* is associated with a covert item such as *mei-ci* 'every time.'

(7.4) Yuehan [(mei-ci)] **dou** qu de Beijing.
John every-time DOU go DE Beijing
'For all of the times, the place that John went to was Beijing.'

Scalar marker

The scalar marker use of *dou* occurs prominently in the [*lian* Foc *dou* ...] construction. This construction evokes an *even*-like inference. It implies that the prejacent proposition is less likely

than (some of) its contextually relevant alternatives, as exemplified in (7.5).[77] In this construction, the presence of *lian* is optional, but the associate of *dou* must be stressed. In the following, stressed items are capitalized, and focused items are marked with a subscript '$_F$'.

(7.5) (Lian) [DUIZHANG]$_F$ **dou** chi dao -le.
LIAN team-leader DOU late arrive -ASP
'Even [the team leader]$_F$ arrived late.'
$\rightsquigarrow$ *The team leader is less likely to arrive late (than a regular team member).*

In particular, 'one-CL-NP' can be licensed as a minimizer at the focal position in the [*lian* Foc *dou* NEG ...] construction, as shown in (7.6a). Interestingly, as C.-T. James Huang (pers. comm.) points out, the post-*dou* negation is not always needed, as seen in (7.6b).

(7.6) a. Yuehan (lian) [YI$_F$-ge ren] *(**dou**) *(mei) qing.
John LIAN one-CL person DOU NEG invite
'John didn't invite even one person.'

b. Yuehan (lian) [YI$_F$-fen qian] *(**dou**) (mei) yao.
John LIAN one-cent money DOU NEG request
With negation: 'John doesn't want any money.'
Without negation: 'Even if it is just one cent, John wants it.'

In addition to occurring in the [*lian* Foc *dou* ...] construction, *dou* functions as a scalar marker also when it is associated with a scalar item. It implies that the prejacent proposition ranks relatively high with respect to the contextually relevant measurement. For example, in (7.7a), *dou* is associated with the numeral phrase *WU dian* 'five o'clock', and the alternatives are ranked in chronological order. When *dou* takes this use, its associate can stay in-situ or be raised to the right side of *dou*, but this associate must be focus-marked with stress.

(7.7) a. **Dou** [WU$_F$-dian] -le.
DOU five-o'clock -ASP
'It is five o'clock.'
$\rightsquigarrow$ *It's too late.*

b. Ta **dou** lai -guo zher [LIANG$_F$-ci] -le.
he DOU come -EXP here two-time -ASP.
'He has been here twice.'
$\rightsquigarrow$ *He has been here quite a lot.*

FCI-licenser

As a well-known fact, when associated with a pre-verbal *wh*-item, *dou* evokes a universal free choice (FC) reading, as exemplified in (7.8). Moreover, I observe that *dou*, in company with an existential modal, can also license the ∀-FCI use of a pre-verbal disjunction, as shown in (7.9a). In particular, if the existential modal *keyi* 'can' is dropped or replaced with a universal modal *bixu* 'must', the presence of *dou* makes the sentence ungrammatical, as seen in (7.9b-c).

[77] '$\rightsquigarrow p$' means that the Mandarin example implies p.

(7.8) a. [Shui] (**dou**) he -guo jiu.
who DOU drink -EXP alcohol
'Anyone/everyone has had alcohol.'

b. [Na-ge nanhai] *(**dou**) he -guo hejiu.
which-CL boy DOU drink -EXP alcohol
'Any/Every boy has had alcohol.'

(7.9) a. [Yuehan huozhe Mali] (**dou**) keyi jiao hanyu.
John or Mary DOU can teach Chinese
Without *dou*: 'Either John or Mary can teach Chinese.'
With *dou*: 'Both John and Mary can teach Chinese.'

b. [Yuehan huozhe Mali] (*__dou__) jiao hanyu.
John or Mary DOU teach Chinese

c. [Yuehan huozhe Mali] (*__dou__) bixu jiao hanyu.
John or Mary DOU must teach Chinese

Disambiguation

If a sentence has multiple items that are eligible to be associated with *dou*, the function of *dou* and the association relation can be disambiguated by stress. Compare the following three sentences:

(7.10) a. [Tamen] **DOU**/**dou** lai -guo liang-ci -le.
they DOU/DOU come -EXP two-time -ASP
'They ALL have been here twice.'

b. Tamen **dou** lai -guo [LIANG$_F$-ci] -le.
they DOU come -EXP two-time -ASP
'They've been here for even twice.'
$\rightsquigarrow$ *Being here twice is a lot for them.*

c. (Lian) [TAMEN]$_F$ **dou** lai -guo liang-ci -le.
LIAN they DOU come -EXP two-time -ASP
'Even THEY have been here twice.'

In (7.10a), where the prejacent of *dou* has no stressed item, *dou* functions as a quantifier and is associated with the preceding plural term *tamen* 'they'; while in (7.10b) and (7.10c), *dou* functions as a scalar marker and is associated with the stressed item.

7.3. Previous studies

There are numerous studies on the syntax and semantics of *dou*. Earlier approaches treat *dou* as an adverb with universal quantification power (Lee 1986, Cheng 1995, among others). Portner (2002) analyzes the scalar marker use of *dou* in a way similar to the inherent scalar semantics of the English focus sensitive particle *even*. Liao (2011) and Liu (2016b,c) also define *dou* as *even*, and derive the distributor use of *dou* based on a universal scalar presupposition. Hole (2004) treats *dou* as a universal quantifier over the domain of alternatives. This section will review two representative

studies on the semantics of *dou*, one is the distributor approach by Lin (1998), and the other is the maximality operator approach along the lines of Giannakidou and Cheng (2006) and Ming Xiang (2008).

7.3.1. The distributor approach

Lin (1998) provides the first extensive treatment of the semantics of *dou*. He proposes that *dou* is an overt counterpart of the generalized distributor PART in the sense of Schwarzschild (1996), as defined in (7.11).

(7.11) **Semantics of** *dou* (Lin 1998)
$[\![dou]\!](P, X) = 1$ iff $\textsc{Part}_C(P, X) = 1$
iff $\forall y[C(y) \wedge y \leq X \rightarrow P(y)]$, where C is a cover of X.

Unlike the regular distributor *each* which distributes over an atomic domain, the generalized distributor PART distributes over the cover of the associated item, whose members can be atomic or non-atomic. A cover of an individual X is a set of subparts of X, as defined in (7.12). The value of a cover is determined by both linguistic and non-linguistic factors.

(7.12) C is a **cover** of X (written as '$Cov(C, X) = 1$') iff
a. C is a set of subparts of X;
b. every subpart of X belongs to some member in C.

When a cover is a set of atomic elements, the PART-operator distributes down to atoms, yielding a atomic distributive reading. When a cover is a singleton set, distributivity becomes trivial, and applying PART returns a collective reading. In other cases, applying PART gives rise to a non-atomic distributive reading.

(7.13) Possible covers of $a \oplus b \oplus c$ and the corresponding readings:

$\{a, b, c\}$	Atomic distributive
$\{a \oplus b, c\}$	Non-atomic distributive
$\{a \oplus b, b \oplus c\}$	
...	
$\{a \oplus b \oplus c\}$	Collective

The distributor approach by Lin only considers the quantifier-distributor use of *dou*. It is unclear how to extend it to the other uses, such as the FCI-licenser use and the scalar marker use. Moreover, even for the quantifier use, this approach faces the following challenges.

First, *dou* evokes a distributivity requirement, but the generalized PART-distributor does not. For instance, as seen in (7.3b) and repeated below, the presence of *dou* eliminates the collective reading of the prejacent sentence. As Ming Xiang (2008) argues, if *dou* were a generalized distributor, it should be compatible with a single cover reading (viz., the collective reading). For example, in (7.14), there can be a discourse under which the cover of *tamen* 'they' denotes a singleton set like $\{a \oplus b \oplus c\}$, and then Lin predicts *dou* to distribute over this singleton set, yielding a collective reading, contra fact.

(7.14) [Tamen] **dou** mai -le fangzi.
they DOU buy -PERF house
'They **dou** bought houses.' (#collective)

Second, unlike English distributors like *each* and *all*,[78] Mandarin *dou* can be associated with a distributive expression such as NP-*gezi* 'NP each'.[79]

(7.15) a. They each (*each/*all) has some advantages.
b. [Tamen gezi] **dou** you yixie youdian.
They each DOU have some advantage
'They each **dou** has some advantages.'

7.3.2. The maximality operator analysis

Another representative approach, initiated by Giannakidou and Cheng (2006) and extended by Ming Xiang (2008), is to treat *dou* as a maximality operator. Briefly speaking, this approach proposes *dou* to have the following semantic properties: (i) it operates on a non-singleton cover of the associated item and returns the maximal plural element in this cover, and (ii) it presupposes the existence of this maximal plural element. I schematize this idea as follows:

(7.16) **Semantics of** *dou* (based on Giannakidou and Cheng 2006 and M. Ming Xiang 2008)
Let $Cov(C, X) = 1$, then
$$[\![dou]\!](X) = |C| > 1 \wedge \exists y \in C[\neg \textsc{Atom}(y) \wedge \forall z \in C[z \leq y]].$$
$$\iota y \in C[\neg \textsc{Atom}(y) \wedge \forall z \in C[z \leq y]]$$
($[\![dou]\!](X)$ is defined only if the cover of X is non-singleton and has a unique non-atomic maximal element; when defined, the reference of $[\![dou]\!](X)$ is this maximal element.)

The maximality operator approach of *dou* is close to the standard treatment of the definite determiner *the* (Sharvy 1980, Link 1983): *the* picks out the unique maximal element in the extension of its NP complement and presupposes the existence of this maximal element.

(7.17) $$[\![the]\!](P_{\langle\alpha,t\rangle}) = \exists x_\alpha[x \in P \wedge \forall y \in P[y \leq x]].$$
$$\iota x_\alpha[x \in P \wedge \forall y \in P[y \leq x]]$$

[78] Champollion (2015) argues that *all* is a distributor that distributes down to subgroups, while that *each* distributes all the way down to atoms.

[79] Similar arguments have been reached in previous studies (Cheng 2009, among others), but they are mostly based on the fact that *dou* can be associated with the distributive quantificational phrase *mei*-CL-NP 'every NP', as exemplified in (i). This fact, however, cannot knock down the distributor approach for the quantifier use of *dou*: observe in (i) that stress falls on the distributive phrase *mei*-CL-NP, not the particle *dou*; therefore, here *dou* functions as a scalar marker, not a quantifier.

(i) a. [MEI-ge ren] **dou** you youdian.
every-CL person DOU have advantage
'Everyone **dou** has some advantages.'
b??[Mei-ge ren] **DOU** you youdian.
every-CL person DOU have advantage

($[\![the]\!](P_{\langle\alpha,t\rangle})$ is defined only if there is a unique maximal object x such that $P(x)$ is true (based on an ordering on elements of type α); when defined, the reference of $[\![the]\!](P_{\langle\alpha,t\rangle})$ is this maximal element.)

The maximality operator approach has two advantages over the distributor approach. First, it captures the maximality requirement. Second, it can be extended to the scalar use of *dou* (see Ming Xiang 2008). Nevertheless, this approach still faces several conceptual or empirical problems. First, it predicts no distributivity effect at all. Under this approach, "[X] **dou** did f" only asserts that the maximal element in the cover of X did f, not that each element in the cover of X did f. For instance, in (7.14), repeated below, if the cover of *tamen* 'they' is $\{a \oplus b, a \oplus b \oplus c\}$, then assertion predicted by the maximality operator approach would simply be '$a \oplus b \oplus c$ bought houses,' which says nothing as to whether $a \oplus b$ bought houses.

(7.18) [Tamen] **dou** mai -le fangzi.
they DOU buy -PERF house
'They **dou** bought houses.' (#collective)

Second, the plurality requirement comes as a stipulation on the presupposition of *dou*: *dou* presupposes that the selected maximal element is non-atomic. It is unclear why this is so, because the definite article *the* does not trigger such a plural presupposition. Moreover, as we will see in section 7.5.1.2, this plural presupposition is neither sufficient nor necessary for accounting for the relevant facts.

7.4. Defining *dou* as a special exhaustifier

This section will start with the semantics of the canonical exhaustifier *only*, and then define the Mandarin particle *dou* as a special exhaustifier. Briefly, *only* operates on excludable alternatives and presupposes the existence of an excludable alternative, while *dou* operates on pre-exhaustified sub-alternatives and presupposes the existence of a sub-alternative.

7.4.1. The canonical exhaustifier *only*

The exclusive particle *only* is a canonical exhaustifier. It is standardly assumed that *only* presupposes the truth of its prejacent proposition (Horn 1969) and asserts an exhaustivity inference. This exhaustivity inference negates all the focus alternatives of the prejacent clause that are excludable. An alternative is excludable as long as it is not entailed by the prejacent.

(7.19) **Semantics of** *only* (to be revised in (7.21))
a. $[\![only]\!](p) = \lambda w[p(w) = 1.\forall q \in \textsc{Excl}(p)[q(w) = 0]]$
b. $\textsc{Excl}(p) = \{q : q \in \textsc{Alt}(p) \wedge p \not\subseteq q\}$

In addition to the prejacent presupposition, I argue that *only* also triggers an additive presupposition, namely, that the prejacent clause has at least one excludable alternative. Consider (7.20) for illustration of this additive presupposition:

(7.20) Which of John and Mary will you invite?

a. Only JOHN$_F$, (not Mary / not both).

b. # Only BOTH$_F$.

c. BOTH$_F$.

In this example, *only* has a restricted exhaustification domain {*I will invite John, I will invite Mary*, *I will invite John and Mary*}. Contrary to the response in (7.20a), (7.20b) is infelicitous because the additive presupposition of *only* is not satisfied: the prejacent proposition *I will invite both John and Mary* is the strongest one among the alternatives and has no excludable alternative. As Martin Hackl (pers. comm.) points out, the additive presupposition of *only* can be reduced to a more general economy condition that an overt operator cannot be applied vacuously.[80] For sake of comparison, observe that the response in (7.20c) is felicitous, even though *BOTH* is focused and is associated with a covert exhaustifier. The reason is that covert exhaustification is free from the economy condition and does not trigger an additive presupposition.

To sum up, I define the semantics of *only* as follows: *only* presupposes the truth of its prejacent and the existence of an excludable focus alternative; when the presuppositions are satisfied, it negates the excludable focus alternatives of its prejacent clause.[81]

(7.21) **Semantics of** *only* (Final version)

$[\![only]\!](p) = \lambda w[p(w) = 1 \wedge \exists q \in \textsc{Excl}(p).\forall q \in \textsc{Excl}(p)[q(w) = 0]]$

($[\![only]\!](p)$ is defined only if p is true and p has at least one excludable alternative; when defined, $[\![only]\!](p)$ is true iff the excludable alternatives of p are false.)

[80] In this sense, the additive presupposition of *only* can be understood as a part of Al Khatib's (2013) *non-vacuity presupposition*, which says that some excludable alternative is such that its negation is not entailed by the assertion, as schematized in (ia). Another way to characterize this non-vacuity presupposition is as in (ib), which says that there is some alternative such that the prejacent entails neither this alternative nor the negation of this alternative,

(i) **Non-vacuity presupposition of *only*** (Al Khatib 2013)

a. *only* (p) presupposes $\exists q \in \textsc{Excl}(p)[p \not\subseteq \neg q]$

b. *only* (p) presupposes $\exists q \in \text{ALT}(p)[p \not\subseteq q \wedge \boxed{p \not\subseteq \neg q}]$

The boxed part in (ib) is needed for predicting the infelicity of the answer in (ii): the prejacent $\phi_{\textsc{every}}$ does not entail the alternative $\phi_{\textsc{no}}$ itself but entails its negation ($\neg\phi_{\textsc{no}} = \phi_{\textsc{some}}$).

(ii) A: Did John see every student, or did he see no student(s)?
B: # He only saw [every student]$_F$.

[81] For simplicity, this chapter treats all exhaustifiers as propositional operators. Following Rooth (1985, 1992, 1996), I define the semantics of *only* cross-categorically as follows. Here f and P correspond to the left argument (i.e., the restrictor) and the right argument (i.e., the scope), respectively. This definition can easily extend to other exhaustifiers.

(i) **Cross-categorical semantics of** *only*

$[\![only]\!](f_\alpha)(P_{\langle\alpha,st\rangle}) = \lambda w[P(f)(w) = 1 \wedge$ — Prejacent presupposition

$\exists f' \in \textsc{Alt}(f)[P(f) \not\subseteq P(f')]$. — Additive presupposition

$\forall f' \in \textsc{Alt}(f)[P(f) \not\subseteq P(f') \rightarrow P(f)(w) = 0]]$ — Assertion

7.4.2. Defining *dou* in analogous to *only*

In analogous, I define *dou* as special exhaustifier that operates on (pre-exhaustified) sub-alternatives and presupposes the existence of a sub-alternative, as schematized in (7.22):

(7.22) **Semantics of** *dou* (To be revised)
$[\![dou]\!](p) = \exists q \in \textsc{Sub}(p).\lambda w[p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)[O(q)(w) = 0]]$
($[\![dou]\!](p)$ is defined only if p has at least one sub-alternative; when defined, $[\![dou]\!](p)$ is true iff p is true and the exhaustification of each sub-alternative of p is false.)

The additive presupposition is motivated by the economy principle of overt functional particles, just like what we saw with the canonical exhaustifier *only*. The asserted component of *dou* is an "anti-exhaustification" inference. It differs from the assertion of *only* in two respects. First, *only* operates on excludable alternatives, but *dou* operates on sub-alternatives. For now we can understand sub-alternatives as weaker alternatives, or equivalently, the alternatives that are not excludable (viz., not entailed by the prejacent) and are distinct from the prejacent, as schematized in (7.23). The sign '–' stands for set subtraction. A revision will be made in section 7.5.2.

(7.23) $\textsc{Sub}(p) = \{q : q \in \textsc{Alt}(p) \wedge p \subset q\}$ (To be revised)
$= (\textsc{Alt}(p) - \textsc{Excl}(p)) - \{p\}$
(The set of alternatives of p that are not excludable and distinct from the prejacent p.)

Second, *dou* has a pre-exhaustification effect, meaning that it does not negate the sub-alternatives, but rather the "exhaustification" of each sub-alternative. In a basic case, the pre-exhaustification effect is realized by applying an O-operator to each sub-alternative.[82] The O-operator is a covert counterpart of the exclusive particle *only*, coined by the grammatical view of scalar implicatures (Fox 2007, Chierchia et al. 2012, Fox and Spector to appear, among others). As schematized in (7.24), this O-operator affirms the prejacent and negates all the excludable alternatives of the prejacent.

(7.24) $O(p) = \lambda w[p(w) = 1 \wedge \forall q[q(w) = 1 \rightarrow p \subseteq q]]$ (Chierchia et al. 2012)
$= \lambda w[p(w) = 1 \wedge \forall q \in \textsc{Excl}(p)[q(w) = 0]]$
(The prejacent is true, while all the excludable alternatives are false.)

Consider (7.25) and (7.26) for simple illustrations of the proposed definition of *dou*.

(7.25) [John and Mary] **dou** arrived.
a. $\textsc{Alt}(j \oplus m) = D_e$
b. $[\![\text{S}]\!] = \textit{arrive}(j \oplus m)$
c. $\textsc{Alt}(\text{S}) = \{\textit{arrive}(x) : x \in D_e\}$
d. $\textsc{Sub}(\text{S}) = \{\textit{arrive}(j), \textit{arrive}(m)\}$
e. $[\![dou(S)]\!] = \textit{arrive}(j \oplus m) \wedge \neg O[\textit{arrive}(j)] \wedge \neg O[\textit{arrive}(m)]$

(7.26) [John] (***dou**) arrived.

[82] When *dou* is used as a scalar marker, the pre-exhaustification effect is realized by applying a scalar exhaustifier (≈ *just*) to the sub-alternatives. See section 7.5.3.

a. $[\![S]\!] = \textit{arrive}(j)$
b. $\textsc{Sub}(S) = \varnothing$
c. $[\![\textit{dou}(S)]\!]$ is undefined

In (7.25), the prejacent proposition and its alternative set are schematized as in (7.25b) and (7.25c), respectively. Among those alternatives, only the two in (7.25d) are asymmetrically entailed by the prejacent, which are therefore the sub-alternatives. The application of *dou* affirms the prejacent and negates the exhaustification of each sub-alternative, yielding the inference in (7.25e): John and Mary arrived, not only John arrived, and not only Mary arrived. The anti-exhaustification inference given by the *not only*-clauses is entailed by the prejacent and adds nothing new to the truth conditions.[83]

In comparison, in (7.26), *dou* cannot be present and associated with an atomic proper name *John* (unless *John* is stressed): the prejacent clause S has no sub-alternative, and hence the additive presupposition of *dou* cannot be satisfied.

7.5. Deriving the uses of *dou*

7.5.1. The universal quantifier use

Recall that *dou* evokes three requirements when used as a quantifier-distributor: (i) the "maximality requirement," namely, that *dou* forces maximality with respect to the domain denoted by the associated item; (ii) the "distributivity requirement," namely, that the prejacent sentence cannot take a collective reading; (iii) the "plurality requirement," namely, that the item associated with *dou* must take a non-atomic interpretation. This section will focus on the latter two requirements. (See

[83]One might wonder why *dou* is used even though it does not change the truth conditions. Such uses are observed cross-linguistically. For instance, in (i), the distributor *both* adds nothing to the truth conditions.

(i) John and Mary *both* arrived.

One possibility, raised by the audience at LAGB 2015, is that *dou* and *both* are used for the sake of contrasting with non-maximal operators like *only part of* or *only one of*. If this is the case, the question under discussion for (7.25) and (i) would be 'is it the case that John and Mary both arrived or that only one of them arrived?' This idea is supported by the oddness of using *both*/*dou* in the following conversation:

(ii) Q: "Who arrived?"
A: "John and Mary #(*both*/*dou*) arrived."

Using *dou* makes the answer incongruent with the explicit question: if *dou* is present, the answer has an alternative "only John or only Mary arrived", which is not in the Hamblin set of the explicit question (viz., $\{x \textit{ arrived}: x \in D_e\}$).

This idea also explains the maximality requirement of *dou* under the quantifier-distributor use. Here let me just sketch out this idea informally: the assertion of the *dou*-sentence (iii) is identical to that of (iiia), which is tolerant of non-maximality; but (iii) also implicates the anti-non-maximality inference (iiib), giving rise to a maximality requirement.

(iii) (Context: *The children, with only one or two exceptions, went to the park.*)

[Haizimen] (#**dou**) qu -le gongyuan.
children DOU go -PERF park
'The children (#all) went to the park.'

a. The children went to the park.
b. Not [only part of the children went to the park.]

footnote 83 for a rough idea regarding to the maximality requirement.) I will argue that these two requirements are both illusions. Moreover, I will argue that all the facts that are thought to result from these two requirements actually result from the additive presupposition of *dou*.

7.5.1.1. Explaining the "distributivity requirement"

To generate sub-alternatives and satisfy the additive presupposition of *dou*, the prejacent of *dou* needs to be strictly stronger than some of its alternatives. In case that the associate of *dou* is an entity (of type e), this requirement is satisfied only when the predicate denoted by the remnant VP is (atomically or non-atomically) distributive or divisive. Consider the *dou*-sentence in (7.27) for illustration. For simplicity, I will follow the well-known cover-based treatment of generalized distributivity by Schwarzschild (1996), although this treatment has some undesired consequences in generating alternatives.[84] The prejacent clause of *dou* is interpreted as in (7.27a), where a generalized distributor PART distributes over the contextually determined cover of $a \oplus b \oplus c$. The alternatives of this prejacent clause are derived by replacing $a \oplus b \oplus c$ with an individual of type e, as in (7.27b). The sub-alternatives are the ones that are formed based on the sum of some proper subset of the cover variable C, as in (7.27c).[85] If C is non-singleton, the prejacent clause of *dou* takes an atomic or non-atomic distributive reading and does have some weaker/sub- alternatives, which therefore satisfies the additive presupposition of *dou*. In contrast, if the prejacent clause takes a collective/single-cover reading for the following reason, it does not have a weaker/sub- alternative, making the use of *dou* undefined.

(7.27) **Dou** [$_S$ *abc* bought houses]

a. $[\![S]\!] = \textsc{Part}_C(f, a \oplus b \oplus c)$

b. $\textsc{Alt}(S) = \{\textsc{Part}_C(f, X) : X \in D_e\}$

c. $\textsc{Sub}(S) = \{\textsc{Part}_C(f, X) : X \in D_e \wedge \exists C' \subset C[X = \bigoplus C']\}$

d. *Atomic distributive* √

If $C = \{a, b, c\}$, then: $\textsc{Sub}(S) = \left\{ \begin{array}{l} \textsc{Part}_C(f, a), \textsc{Part}_C(f, b), \textsc{Part}_C(f, c) \\ \textsc{Part}_C(f, a \oplus b), \textsc{Part}_C(f, a \oplus c), \textsc{Part}_C(f, b \oplus c) \end{array} \right\}$

[84] In the alternatives, the value of C constantly equals to the contextually determined cover of the associated item in the prejacent (viz. the cover of $a \oplus b \oplus c$), and PART only distributes over C. (See Liao 2011: chap. 4.) For example, if $C = \{a, b, c\}$, the alternative $\textsc{Part}_C(f, d)$ is vacuously a tautology, and the alternative $\textsc{Part}_C(f, a \oplus b \oplus c \oplus d)$ is logically equivalent to $\textsc{Part}_C(f, a \oplus b \oplus c)$. These consequences are harmless for now. Nevertheless, problems arise if we want an operator to operate on excludable alternatives. For example, to derive the exhaustification inference of (i), '*b* bought houses' shall not be a tautology.

(i) Only abc_F bought houses. $\rightsquigarrow$ *d didn't bought houses.*

See a solution in Liu (2016c) based on Link-Landman's approach of encoding distributivity/collectivity distinction.

[85] More precisely, under the cover-based account of distributivity, sub-alternatives shall be formulated as follows:

(i) $\textsc{Sub}(S) = \{\textsc{Part}_C(f, X) : X \in D_e \wedge \{y : y \leq X \wedge C(y)\} \subset C\}$

An alternative is a sub-alternative as long as it is based on an individual X such that the set of subparts of X that are members of C is a proper subset of C (or equivalently, C has at least one member that is a subpart of X as well as one member that is not a subpart of X). In other words, as we saw in footnote 84, it doesn't matter whether X contains parts that are not members of C.

$$= \left\{ \begin{array}{l} f(a), f(b), f(c) \\ f(a) \wedge f(b), f(a) \wedge f(c), f(b) \wedge f(c) \end{array} \right\}$$

Non-atomic distributive √

If $C = \{a, b \oplus c\}$, then: $\textsc{Sub}(\mathrm{S}) = \{\textsc{Part}_C(f, a), \textsc{Part}_C(f, b \oplus c)\} = \{f(a), f(b \oplus c)\}$

Collective ×

If $C = \{a \oplus b \oplus c\}$, then: $\textsc{Sub}(\mathrm{S}) = \varnothing$

In sum, the particle *dou* itself is not a distributor. But in certain cases, its additive presupposition forces the application of a distributor, or any operation that makes the prejacent clause distributive. We can now easily explain why *dou* can be associated with the distributive expression NP-*gezi* 'NP-each'. The presence of the distributor *gezi* 'each' is not redundant; instead, it is required for satisfying the additive presupposition of *dou*. If *gezi* is not overtly used, there would still be a covert distributor present in the LF.

(7.28) [Tamen gezi] **dou** you yixie youdian.
They each DOU have some advantage
'They each **dou** has some advantages .'

This account also explains why *dou* can occur in some collective sentences: *dou* can be applied to a collective statement as long as the collective predicate used in this statement is divisive.

(7.29) P is **divisive** iff $\forall x[P(x) \rightarrow \exists y < x[P(y)]]$
(Whenever P holds of something x, it also holds of some proper subpart(s) of x.)

For instance, *dou* is compatible with divisive collective predicates such as *shi pengyou* 'be friends', *jihe* 'gather', and *jianmian* 'meet', as seen in (7.30a-c). Consider (7.30a) for a concrete example. Let *tamen* 'they' denote three individuals *abc*. The set of sub-alternatives is {*ab* are friends, *bc* are friends, *ac* are friends}. Applying *dou* yields inference that '*abc* are friends, not only *ab* are friends, not only *bc* are friends, and not only ac are friends.' In comparison, *dou* cannot be applied to a collective statement if the predicate is not divisive, as shown in (7.30d).

(7.30) a. [Tamen] (**dou**) shi pengyou.
they DOU be friends
'They are (all) friends.'

b. [Tamen] (**dou**) zai dating jihe -le.
they DOU at hallway gather -ASP
'They (all) gathered in the hallway.'

c. [Tamen] (**dou**) jian-guo-mian -le.
they DOU see-EXP-face -ASP
'They (all) have met.'

d. [Tamen] (*__dou__) zucheng -le zhe-ge weiyuanhui.
they DOU form -ASP this-CL committee
'They (*all) formed this committee.'

7.5.1.2. Explaining the "plurality requirement"

The "plurality requirement" says that the associate of *dou* has to take a non-atomic interpretation. I argue that this requirement is also illusive, and that the related facts all result from the additive presupposition of *dou*.

On the one hand, the plurality requirement is unnecessary: *dou* can be associated with an atomic item as long as the remnant VP denotes a divisive predicate. For instance, in (7.31a), *dou*'s associate *na-ge pingguo* 'that apple' has only an atomic interpretation. With a divisive predicate $\lambda x.$*John ate* x, the prejacent clause of *dou* does have some sub-alternatives, as schematized in (7.32a), which therefore supports the additive presupposition of *dou*. In contrast, in (7.31b), the predicate $\lambda x.$*John ate half of* x is not divisive and hence is incompatible with the presence of *dou*, as shown in (7.32b).

(7.31) a. Yuehan ba [na-ge pingguo] (**dou**) chi -le.
John BA that-CL apple DOU eat -PERF
'John ate that apple.'

b. Yuehan ba [na-ge pingguo] (***dou**) chi -le yi-ban.
John BA that-CL apple DOU eat -PERF one-half
Intended: 'John ate half of that apple.'

(7.32) a. 'John ate that apple.' ⇒ 'if x is part of that apple, John ate x.'
SUB (*John ate that apple*) = {*John ate* x: x < that apple}

b. 'John ate half of that apple.' ⇏ 'If x is part of that apple, John ate half of x.'
SUB (*John ate half of that apple*) = $\varnothing$

On the other hand, the plurality requirement is insufficient. When applied to a statement with a divisive collective predicate, *dou* requires its associate to denote a group consisting of at least three distinct individuals, as exemplified in (7.33).

(7.33) [Tamen -sa/*-lia] **dou** shi pengyou.
they -three/-two DOU be friends
'They three/*two are all friends.'

The proposed additive presupposition of *dou* also accounts for this fact. As schematized in (7.34), the proper subparts of a dual-individual (e.g., $a \oplus b$) are atomic individuals, which however are undefined for the collective predicate $\lambda x.$*be-friends*(x). Hence, in (7.33), if the associate of *dou* denotes only a dual-individual, the prejacent clause of *dou* has no sub-alternative, which therefore leaves the additive presupposition of *dou* unsatisfied.

(7.34) [*ab*] (***dou**) are friends.

a. $[\![\text{be friends}]\!] = \lambda x[\neg \textsc{Atom}(x).\textit{be-friends}(x)]$

b. $\textsc{Sub}(ab$ *are friends*$) = \varnothing$

7.5.2. The ∀-FCI-licenser use

The particle *dou* can license the ∀-FCI uses of pre-verbal polarity items, *wh*-items, and disjunctions. In this section, I argue that the assertion of *dou* turns a disjunctive/existential statement into a

conjunctive/universal statement, giving rise to an FC inference. I will also explain why the licensing of a ∀-FCI requires the presence of *dou*, as well as why the licensing of a ∀-FCI disjunction is subject to modal obviation.

7.5.2.1. Licensing conditions of Mandarin FCIs

In English, the emphatic item *any* is licensed as a ∀-FCI when appearing in prior to an existential modal, but not licensed when appearing in an episodic sentence or before a universal modal. This fact that existential modals help to license FCIs is called *modal obviation*.

(7.35) a. Anyone can/*must come in.
b. * Anyone came in.

In Mandarin, to license the ∀-FCI use of a pre-verbal disjunction, *dou* must be present and must be followed by an existential modal, as shown in (7.36).

(7.36) a. [Yuehan huozhe Mali] **dou** keyi/*bixu jiao jichu hanyu.
John or Mary DOU can/must teach intro Chinese
Intended: 'Both John and Mary can/must teach Intro Chinese.'
b. [Yuehan huozhe Mali] (***dou**) jiao -guo jichu hanyu.
John or Mary DOU teach -EXP intro Chinese
Intended: 'Both Johan and Mary have taught Intro Chinese.'

The licensing of the ∀-FCI uses of *wh*-items and polarity items (e.g., *renhe* 'any') also requires the presence of *dou*. But the requirements regarding to modal obviations are quite unclear. For instance, as Giannakidou and Cheng (2006) claim, the bare *wh*-word *shei* 'who' can be licensed as a ∀-FCI in an episodic *dou*-sentence, as exemplified in (7.37a). Nevertheless, this distributional pattern turns to be very unproductive. For example, the sentence in (7.37b) sounds to me very odd.

(7.37) a. [Shei] *(**dou**) jiao -guo jichu hanyu.
who DOU teach -EXP intro Chinese.
'Everyone has taught Intro Chinese.'
b. ?? [Shei] **dou** jinlai -le.
who DOU enter -ASP.
Intended: 'Everyone came in.'

The licensing conditions of *na*-CL-NP 'which-NP' and *renhe*-NP 'any-NP' are even harder to tell. Giannakidou and Cheng (2006) claim that the ∀-FCI uses of these items are only licensed in a pre-*dou*+◇ position. Their judgements are illustrated in (7.38). Nevertheless, it is difficult to justice the data because judgements on (7.38) vary greatly among native speakers.

(7.38) a. [Na-ge/Renhe -ren] **dou** keyi/?bixu jinlai.
which-CL/anywhat -person DOU can/must enter
Intended: 'Everyone can/must come in.'

b. ? [Na-ge/Renhe -ren] **dou** shou dao -le yaoqing.
which-CL/anywhat -person DOU get arrive -asp invitation
Intended: 'Everyone got an invitation.'

Given the variations in the judgments and unproductivity of ∀-FCIs in sentences without a possibility modal, I will neglect the variations with respect to modal obviations and say that Mandarin ∀-FCIs need to occur in pre-*dou*+◇ positions. For other recent studies on Mandarin ∀-FCIs, see Liao (2011), Cheng and Giannakidou (2013), and Chierchia and Liao (2015).

7.5.2.2. Predicting the universal FC inferences

Wh-items are standardly treated as existential indefinites. Thus in (7.37a), repeated below, the prejacent proposition of *dou* is a disjunction, and the sub-alternatives are the disjuncts. Applying *dou* affirms the prejacent and negates the exhaustification of each disjunct, yielding a universal FC inference. In a word, *dou* turns a disjunction into a conjunction.

(7.39) [Shei] *(**dou**) has taught Intro Chinese.
(*Consider only two individuals a and b.*)

a. $[\![\text{shei has taught IC}]\!] = f(a) \vee f(b)$ $\qquad f = \lambda x.\textit{has-taught-IC}(x)$

b. $\textsc{Sub}(\textit{shei has taught IC}) = \{f(a), f(b)\}$

c. $[\![\textbf{dou}\ [\text{shei has taught IC}]]\!]$
$= [f(a) \vee f(b)] \wedge \neg Of(a) \wedge \neg Of(b)$
$= [f(a) \vee f(b)] \wedge [f(a) \rightarrow f(b)] \wedge [f(b) \rightarrow f(a)]$
$= [f(a) \vee f(b)] \wedge [f(a) \leftrightarrow f(b)]$
$= f(a) \wedge f(b)$

Now, a problem arises as to why disjunctions are treated as sub-alternatives. In section 7.4.2, I defined sub-alternatives as weaker alternatives, namely, the alternatives that are not excludable and are distinct from the prejacent. But, in (7.39), the disjuncts are stronger than the disjunction, how can they be treated as sub-alternatives? This problem can be solved by a minor revision from "excludability" to "innocent (I-)excludability," a notion coined by Fox (2007) for deriving FC inferences via exhaustifications. As schematized in (7.40), an alternative is I-excludable iff it is included in every maximal set of alternatives A such that affirming the prejacent is consistent with negating all the propositions in A.[86]

(7.40) a. **Innocently (I)-excludable alternatives** (Fox 2007)
$\textsc{IExcl}(p) = \bigcap\{A : A \text{ is a maximal subset of } \textsc{Alt}(p) \text{ s.t. } A^{\neg} \cup \{p\} \text{ is consistent}\}$,

[86] Another commonly seen definition of I-excludable alternatives is (i), which is however inadequate. For example, in sentence "EVERY student came," where the prejacent is the strongest among the alternatives and thus has no excludable alternative, the condition underlined in (i) is vacuously satisfied; therefore, the definition in (i) predicts that every alternative of p is I-excludable, which is apparently implausible.

(i) $\textsc{IExcl}(p) = \{q : q \in \textsc{Alt}(p) \wedge \neg\underline{\exists q' \in \textsc{Excl}(p)[[p \wedge \neg q] \rightarrow q']}\}$
(The set of alternatives p such that affirming p and negating q does not entail any excl-alternatives)

where $A^{\neg} = \{\neg q : q \in A\}$

(The intersection of the maximal sets of alternatives of p such that the exclusion of each such maximal set is consistent with p.)

b. **Sub-alternatives**
$\textsc{Sub}(p) = (\textsc{Alt}(p) - \textsc{IExcl}(p)) - \{p\}$
(The set of alternatives excluding the I-excludable alternatives and the prejacent itself)

In (7.39), the disjuncts are not I-excludable to the disjunction: affirming the disjunction and negating both of its disjuncts yield a contradiction (formally: $\{f(a), f(b)\}^{\neg} \cup \{f(a) \vee f(b)\}$ is inconsistent, because $[f(a) \vee f(b)] \wedge \neg f(a) \wedge \neg f(b) = \bot$). Hence, by the revised definition, the sub-alternatives of a disjunction are the disjuncts.

Weaker alternatives are clearly not I-excludable: affirming a prejacent and negating a weaker alternative yield a contradiction. Hence, for basic cases where *dou* is associated with an individual or a generalized conjunction, the new definition of sub-alternatives in (7.40b) yields the same consequence as what the previous one in (7.23) does.

Now, we can summarize the definition of *dou* as follows:

(7.41) a. **Semantics of *dou***
$[\![dou]\!](p) = \exists q \in \textsc{Sub}(p).\lambda w[p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)[O(q)(w) = 0]]$
i. Presupposition: p has some sub-alternatives.
ii. Assertion: p is true, while the exhaustification of each sub-alternative of p is false.

b. **Sub-alternatives**
i. Strong Definition
$\textsc{Sub}(p) = (\textsc{Alt}(p) - \textsc{Excl}(p)) - \{p\}$
(The set of alternatives that are not excludable and are distinct from the prejacent)
ii. Weak Definition
$\textsc{Sub}(p) = (\textsc{Alt}(p) - \textsc{IExcl}(p)) - \{p\}$
(The set of alternatives that are not I-excludable and are distinct from the prejacent)

We now have two definitions of sub-alternatives. The strong definition (7.41b-i) only yields the quantifier-distributor use of *dou*, while the weak definition (7.41b-ii) also captures the ∀-FCI licenser use of *dou*. There are two possible ways to understand the semantics of *dou* and sub-alternatives, as described in the following:

- **The uniform approach**

  Sub-alternatives are uniformly as weak as in (7.41b-ii). The stronger definition in (7.41b-i) is not an independent entry, but rather a special case of (7.41b-ii) where all the I-excludable alternatives happen to be excludable.

- **The weakening approach**

  Sub-alternatives are primarily as strong as in (7.41b-i); while the weaker entry in (7.41b-ii) is employed when a semantic weakening from non-excludability to non-I-excludability is licensed. This weakening operation should be partial. For example, it is licensed only when the associate of *dou* is an existential quantifier or a disjunction.

These two options yield different predictions with respect to the derivational paths of the uses of *dou*. Under the uniform approach, the quantifier-distributor use and the ∀-FCI licenser use are both primary. In contrast, under the weakening approach, the quantifier-distributor use of *dou* is primary, while the ∀-FCI licenser use is secondary and should come much later than the quantifier-distributor use.

The weakening approach is more preferable than the uniform approach for the following two reasons. First, empirically, the quantifier-distributor use of *dou* emerged as early as the Eastern Han Dynasty (25AC-220AC) (Gu 2015), while the other uses of *dou* came much later. So far, there hasn't been any reliable evidence showing that *dou* could function as a ∀-FCI licenser or a scalar marker before Ming Dynasty. Second, theoretically, the scalar marker use of *dou* can be derived easily by weakening the strong definition of sub-alternatives in (7.41b-i), but not the weak definition in (7.41b-i). I will get back to this point in section 7.6.

Readers who are familiar with the grammatical view of exhaustifications might find that *dou* is similar to the operation of recursive exhaustifications proposed by Fox (2007). The recursive exhaustification (abbreviated as 'O_R') has two major characteristics. First, exhaustification negates only alternatives that are innocently excludable. Second, exhaustification is applied recursively. Using the notations in (7.41), we can re-formulate the semantics of O_R as follows:

(7.42) $O_R(p) = \lambda w[p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)[O(q)(w) = 0] \wedge \forall q' \in \textsc{IExcl}(p)[q'(w) = 0]]$

It can be easily observed that *dou* is semantically weaker than O_R: *dou* does not negate the I-excludable alternatives, and therefore applying *dou* to a disjunction does not generate an exclusive inference. For instance, the sentence (7.36a) 'John or Mary *dou* can teach Intro Chinese' does not imply the exclusive inference that only John and Mary can teach Intro Chinese. For a more detailed comparison of the exhaustifiers that have been employed for deriving FC, see §2.7.

7.5.2.3. Explaining the licensing conditions of Mandarin ∀-FCIs

Recall the two licensing conditions of Mandarin ∀-FCIs. First, to license the ∀-FCI use of a pre-verbal *wh*-item, *dou* must be present and associated with this *wh*-item. Second, the ∀-FCI use of a pre-verbal disjunction (probably also that of a *wh*-item) is only licensed in a pre-*dou*+◇ environment. This section explains these two conditions.

I. Why is it that the presence of *dou* is mandatory in a $wh_{\forall\text{-FCI}}$-declarative?

(7.43) [Shei] *(**dou**) jiao -guo jichu hanyu.
who DOU teach -EXP intro Chinese.
'Everyone has taught Intro Chinese.'

Following Liao (2011) and Chierchia and Liao (2015), I assume that the sub-alternatives associated with a Mandarin *wh*-word are obligatorily activated when this *wh*-word takes a non-interrogative use, and that these sub-alternatives must be used up via employing a c-commanding exhaustifier.[87]

[87] In the case of disjunctions or existential indefinites, sub-alternatives are simply what usually call "domain alternatives," evoked by domain widening (Krifka 1995; Lahiri 1998; Chierchia 2006, 2013).

Hence, if the particle *dou* is absent, these sub-alternatives would be have to used by a basic O-exhaustifier, as in (7.44b). Nevertheless, as to be shown in the following, the application of an O-exhaustifier has an undesired semantic consequence.

(7.44) [Shei] *(**dou**) has taught Intro Chinese.

a. The LF in presence of *dou*:
dou [shei$_{[+D]}$ has taught Intro Chinese]

b. The LF in absence of *dou*:
O [shei$_{[+D]}$ has taught Intro Chinese]

Compare the computation in (7.46) with (7.39). In (7.39), applying *dou* to a disjunction returns a conjunction. While in (7.46), applying an O-exhaustifier to a disjunction affirms this disjunction and negates both of its disjuncts, yielding a contradiction and making the *wh*-declarative ungrammatical.

(7.45) $O(p) = \lambda w[p(w) = 1 \wedge \forall q \in \textsc{Excl}(p)[q(w) = 0]]$ (Chierchia et al. 2012)

(7.46) *(Consider only two individuals a and b.)*

a. $[\![\text{shei has taught IC}]\!] = f(a) \vee f(b)$ $\quad f = \lambda x.\textit{has-taught-IC}(x)$

b. $\textsc{Sub}(\textit{shei has taught IC}) = \{f(a), f(b)\}$

c. $[\![O\ [\text{shei has taught IC}]]\!] = [f(a) \vee f(b)] \wedge \neg f(a) \wedge \neg f(b) = \bot$

The case of disjunctions is a bit different. Unlike those of *wh*-items, the sub-alternatives of disjunctions are not mandatorily activated (Chierchia 2006, 2013). Hence, in absence of *dou*, a sentence with a pre-verbal disjunction will simply take an (inclusive or exclusive) disjunctive interpretation.

The explanation above faces the following challenge: why it is that the sub-alternatives of a *wh*-declarative cannot be used by a covert pre-exhaustification exhaustifier, such as the $O_{\textsc{dou}}$-operator proposed in section 2.7? A covert $O_{\textsc{dou}}$-operator cannot be placed here due to a fundamental principle for the architecture of human languages, roughly, "Language-particular choices win over universal tendencies" or "Don't do covertly what you can do overtly." (Chierchia 1998). We consider an exhaustification over the sub-alternatives of a polarity item as a grammatical operation. Given that *dou* must be associated with a preceding item in most declaratives, we predict the following distributional pattern of covert and covert *dou*, illustrated by the polarity item *renhe* 'any':

(7.47) a. ∀-FC

Ni [renhe-ren] *(**dou**) keyi jian.
You any-person DOU can meet.
'You can meet anyone.'
^{OK}*dou*/*$O_{\textsc{dou}}$ [you can meet anyone]

b. ∃-FC

Ni (***dou**) keyi jian [renhe-ren].
You DOU can meet any-person
'You can meet anyone.'
**dou*/$^{\text{OK}}O_{\textsc{dou}}$ [you can meet anyone]

If *renhe* appears in or can be overtly raised to a pre-verbal position, the sub-alternatives of *renhe* can be exhaustified by the overt particle *dou*, which therefore blocks the use of a covert $O_{\textsc{dou}}$-operator, as exemplified in the ∀-FC sentence in (7.47a). In contrast, when an exhaustification operation cannot be done by *dou* due to other syntactic constraints (such as that *dou* in general cannot be associated

with an item appearing on its right side), a covert pre-exhaustification exhaustifier would be feasible, as exemplified in the ∃-FC sentence in (7.47b). In one word, since *dou* is Mandarin-particular, the covert O_{DOU} cannot be used whenever the overt *dou* can be used.

II. Why is it that the licensing of a ∀-FC disjunction is subject to modal obviation?

(7.48) a. * [Yuehan huozhe Mali] **dou** jiao -guo jichu hanyu.
John or Mary DOU teach -EXP intro Chinese
Intended: 'Both Johan and Mary have taught Intro Chinese.'

b. [Yuehan huozhe Mali] **dou** keyi jiao jichu hanyu.
John or Mary DOU can/must teach intro Chinese
Intended: 'Both John and Mary can teach Intro Chinese.'

c. * [Yuehan huozhe Mali] **dou** bixu jiao jichu hanyu.
John or Mary DOU can/must teach intro Chinese
Intended: 'Both John and Mary can teach Intro Chinese.'

First of all, let us see why the ∀-FCI use of a disjunction is not licensed in an episodic sentence like (7.48a). Disjunctions, as weak scalar items, evoke scalar implicatures. Hence, in presence of *dou*, the episodic sentence (7.48a) yields two inferences that contradict each other, as stated in the following:

(7.49) John or Mary **dou** taught Intro Chinese.
a. FC inference: *John and Mary have taught Intro Chinese*
b. Scalar implicature: *Not both John and Mary have taught Intro Chinese.*

The contradiction between these two inferences makes the *dou* unable be used in (7.48a) (à la Chierchia's (2013) explanation on the licensing of English FCI *any*). In absence of *dou*, the sub-alternatives of a disjunction are not activated, and then (7.48a) simply means that John or Mary but not both has taught Intro Chinese.

Next, what about the modal obviation effect in (7.48b)? In particular, why is it that an existential modal obviates the ungrammaticality while a universal modal does not? There have been a plenty of discussions on modal obviation involved in licensing ∀-FCIs.

I propose that the scalar implicature of a pre-verbal disjunction can be assessed with a circumstantial modal base: the modal base is restricted to the set of worlds where the scalar implicature is satisfied. For instance, the ◇-sentence in (7.48b) intuitively suggests that the speaker is only interested in cases where exactly one person teaches Intro Chinese. To be more concrete, assume that the property *teach Intro Chinese* denotes the set of the three world-individual pairs in (7.50a). For instance, the pair $\langle w_1, \{j\}\rangle$ is read as 'only John teaches Intro Chinese in w_1.' The scalar implicature evoked by the pre-verbal disjunction restricts the modal base M to the set of worlds where **not** both John and Mary teach Intro Chinese. In an existentially modalized context, employing *dou* yields the ∀-FC inferences in (7.50c), which is true relative to M. In contrast, in a universally modalized context, employing *dou* yields the inference in (7.50d), which is false under M.

(7.50) a. $f = \{\langle w_1, \{j\}\rangle, \langle w_2, \{m\}\rangle, \langle w_3, \{j, m\}\rangle\}$
b. $M = \{w_1, w_2\}$

c. $[\![dou]\!]\ [\Diamond f(j) \vee \Diamond f(m)] = \Diamond f(j) \wedge \Diamond f(m)$ True under M

d. $[\![dou]\!]\ [\Box f(j) \vee \Box f(m)] = \Box f(j) \wedge \Box f(m)$ False under M

More broadly, there is no eligible modal base, except the empty one, under which the FC inference in (7.50d) is true. Therefore, universal modals cannot obviate the contradiction between the FC inference and the scalar implicature.

Alternative approaches of modal obviation in the realm of exhaustifications include Dayal (2009) and Chierchia (2013). Dayal assumes a *Fluctuation Constraint*: in an *any*-sentence, the intersection of the restriction and the scope that verifies the sentence should not be constant across the accessible worlds. Chierchia assumes a *Modal Containment Constraint*: the FC implicature and the scalar implicature are assessed based on different modal bases; in particular, the one for the FC implicature is a proper subset of the one for the scalar implicature. This dissertation is not in a position to do full justice to these discussions, but just adds one more accessible story to the market.

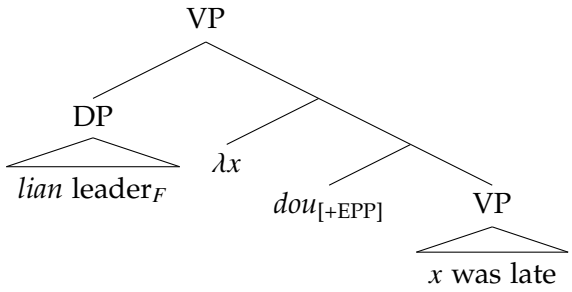
7.5.3. The [(*lian*) ... *dou* ...] construction

The [(*lian*) Foc *dou* ...] construction has an *even*-like reading, as exemplified in (7.51).

(7.51) **Lian** [LINGDAO]$_F$ **dou** chidao -le.
LIAN leader DOU late -ASP
'Even the leader was late.'

I assume a toy surface structure for the [(*lian*) Foc *dou* ...] construction as in (7.52). In this structure, *dou* selects for the entire VP, and *lian* is a focus marker which takes the focused phrase (or a phrase that contains the semantic focus) as its complement. To check off the [+EPP] feature of *dou*, *lian* together with the focused phrase (or the focus-containing phrase) moves to the left edge of VP.

(7.52)



In the following, I will start with the semantics of English *even*, and then derive the *even*-like reading of the [*lian* Foc *dou* ...] construction based on the proposed semantics of *dou*. In section 7.5.4, I will also show how this approach accounts for the minimizer-licensing effect of the [*lian* MIN *dou* ...] construction.

7.5.3.1. The semantics of *even*

There are two popular views on the semantics of the English particle *even*, different with respect to whether the scalar presupposition of *even* is universal or existential. One view, initiated by Karttunen and Peters (1979), assumes that *even* has a universal scalar presupposition and a vacuous assertion,

as schematized in (7.53): *even* asserts the truth of its propositional argument, and presupposes that the propositional argument of *even* is the less likely than **all** of its contextually relevant alternatives. Here the variable C is a set of contextually relevant alternatives.

(7.53) **Semantics of** *even* (Karttunen and Peters 1979)
$[\![even]\!](p) = \forall q \in C[p \neq q \rightarrow q >_{\text{likely}} p].p$
($[\![even]\!](p)$ is defined only if p is less likely than *all* of its alternatives that are not identical to it; when defined, $[\![even]\!](p) = p$)

Nevertheless, the universal scalar presupposition seems to be too strong. The following examples taken from Kay (1990) show that *even*-sentences can also describe non-extreme cases:

(7.54) a. Not only did Mary win her first round match, she even made it to the semi-finals.
b. The administration was so bewildered that they even had lieutenant colonels making policy decisions.

Hence, I adopt the alternative view by Bennett (1982) and Kay (1990) that the scalar presupposition of *even* is existential. This presupposition says that the propositional argument of *even* is less likely than **some** of its contextually relevant alternatives.

(7.55) **Semantics of** *even* (Bennett 1982; Kay 1990)
$[\![even]\!](p) = \exists q \in C[q >_{\text{likely}} p].p$
($[\![even]\!](p)$ is defined only if p is more likely than *some* contextually relevant alternative; when defined, $[\![even]\!](p) = p$)

7.5.3.2. Deriving the *even*-like interpretation

When *dou* is associated with a *lian*-DP, the measurement used for ordering alternatives gets shifted from logical strength to likelihood. This shift brings changes to both the meaning of sub-alternatives as well as the exhaustifier encoded within the lexicon of *dou* used for pre-exhaustification. First, since a proposition logically weaker is more likely, sub-alternatives are thus the alternatives that are more likely than the prejacent propositional argument of *dou*. Second, the pre-exhaustification effect of *dou* is realized by the inclusive scalar exhaustifier JUST (rather than the exclusive O-exhaustifier). As schematized in (7.74b), analogous to the O-operator, JUST affirms the prejacent p and further states a scalar exhaustivity condition that no true alternative of p is more likely than p. Hence, when *dou* occurs in a [*lian* Foc *dou* ...] construction, its semantics would be adapted to (7.56c).

(7.56) **Semantics of** *dou* (for the [*lian* Foc *dou* ...] construction)
a. $\textsc{Sub}(p) = \{q : q \in \textsc{Alt}(p) \wedge q >_{\text{likely}} p\}$
(The set of alternatives of p that are more likely than p)
b. $\textsc{just}(q) = \lambda w[q(w) = 1 \wedge \forall r \in \textsc{Alt}(q)[r(w) = 1 \rightarrow p \geq_{\text{likely}} r]]$
(q is true, and q is the most likely proposition among its true alternatives.)
c. $[\![dou]\!](p) = \exists q \in \textsc{Sub}(p).\lambda w[p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)[\textsc{just}(q)(w) = 0]]$
($[\![dou]\!](p)$ is defined only if p has at least one sub-alternative. When defined, $[\![dou]\!](p)$ means 'p, and for any sub-alternative q, not just q.')

As schematized in (7.57), we can further simplify the assertion of *dou*. The anti-exhaustification condition provided by the *not just*-clause (underlined in (7.57)) that 'every alternative that is more likely than p is more likely than some true alternative of p,' is asymmetrically entailed by the rest asserted part that 'p is true.' [Proof: Whenever p is true, then any alternative of p that is more likely than p is less likely than some true alternative r, where $r = p$. End of proof.] Hence, the asserted component of *dou* simply affirms its propositional argument, or equivalently, is vacuous. Finally, we get a *dou* semantically equivalent to *even*: the additive presupposition of *dou* is equivalent to the existential scalar presupposition of *even*, and the assertion is vacuous.

(7.57) $[\![dou]\!](p)$
$= \exists q \in \textsc{Sub}(p).\lambda w[p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)[\textsc{just}(q)(w) = 0]]$
$= \exists q \in \textsc{Sub}(p).\lambda w[p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)\exists r \in \textsc{Alt}(q)[r(w) = 1 \wedge q >_{\text{likely}} r]]$
$= \exists q \in \textsc{Alt}(p)[q >_{\text{likely}} p].$
$\lambda w[p(w) = 1 \wedge \underline{\forall q \in \textsc{Alt}(p)[q >_{\text{likely}} p \rightarrow \exists r \in \textsc{Alt}(q)[r(w) = 1 \wedge q >_{\text{likely}} r]]}]$
$= \exists q \in \textsc{Alt}(p)[q >_{\text{likely}} p].p$
($[\![dou]\!](p)$ is defined only if p is less likely than at least one of its contextually relevant alternatives; when defined, $[\![dou]\!](p) = p$.)
$= [\![even]\!](p)$

Thus, it is plausible to say that the *even*-like interpretation of the [*lian* Foc *dou* ...] construction comes from the additive presupposition of *dou* (Portner 2002, Shyu 2004, Paris 1998, Liao 2011, Liu 2016c), while that the particle *lian* is simply a focus marker and is present just for syntactic purposes. I define the semantics of *lian* as follows: it asserts the denotation of its argument, and presupposes that this argument is focused.

(7.58) $[\![lian(\alpha)]\!] = [\![\alpha]\!]$, defined iff $[\![\alpha]\!]^f \neq \{[\![\alpha]\!]^0\}$.

7.5.4. Minimizer-licensing

Minimizers (including also emphatic weak scalar items such as *YI-ge ren* 'ONE person') can occur at the focal position in the [*lian* Foc *dou*...] construction. Usually, to license a minimizer, a post-*dou* negation must be present, as exemplified in (7.59). But, there are also cases where the post-*dou* negation is optional, as seen in (7.60).

(7.59) Yuehan (lian) [YI-ge ren]$_F$ **dou** *(bu) renshi.
John LIAN one-CL person DOU NEG know
'John doesn't know anyone.'

(7.60) Yuehan (lian) [YI-fen qian]$_F$ **dou** (bu) yao.
John LIAN one-cent money DOU NEG request
Without negation: 'John doesn't even want one cent. (≈ John doesn't want any money.)'
With negation: 'John wants it even if it is just one cent. (≈ John wants any amount of money, however small amount it is.)'

In what follows, I will show that the distributional pattern of Mandarin minimizers in [*lian* MIN *dou*...] constructions mirrors the distributional pattern of English minimizers and emphatic weak

scalar items in *even*-sentences. Next, I extend Crnič (2011, 2014a)'s analysis of minimizer-licensing in English *even*-sentences to minimizer-licensing in Mandarin [*lian* ... *dou* ...] constructions.

7.5.4.1. Monotonicity

There are three basic monotonicity patterns, including downward-entailing, upward-entailing, and non-monotonic. An environment is downward-entailing if it supports downward inferences, and is upward-entailing if it supports upward inferences. An environment is non-monotonic if it supports neither downward nor upward inferences.

For instance, observe an upward inference holds from a set *semanticist* to its superset *linguist* in the positive sentence (7.61a), while a downward inference from *linguist* to its subset *semanticst* holds under the semantic scope of negation, as in (7.61b). Hence, we say that "Mary is a P" is upward-entailing with respect to P, while "Mary isn't a P" is downward-entailing with respect to P. Moreover, since negation reverses the entailment direction of its propositional argument, we call negation a downward-entailing operator. In comparison, as shown in (7.61c), neither inferences hold in the second argument of *iff*, which suggests that *iff* is non-monotonic in its second argument.

(7.61) a. Upward-entailing
  i. Mary is a linguist.
  $\Uparrow$
  ii. Mary is a semanticist.
b. Downward-entailing
  i. Mary isn't a linguist.
  $\Downarrow$
  ii. Mary isn't a semanticist.
c. Non-monotonic
  i. We will invite Mary iff she is a linguist.
  $\not\Uparrow$ $\not\Downarrow$
  ii. We will invite Mary iff she is a semanticist.

Following von Fintel (1999) and Gajewski (2007), I define downward-entailing environments as in (7.62), where the arrow '$\Rightarrow$' stands for generalized entailment.[88] Upward-entailing and non-monotonic functions and environments are defined analogously.

[88]Generalized entailment is cross-categorically defined for items of any *entailing type*. Entailing types are defined recursively as in (i). Accordingly, t, $\langle e,t\rangle$, $\langle e,et\rangle$, and any type of the form $\langle ... \ t\rangle$ are entailing types.

(i) **Entailing type** (Chierchia 2013: 204)
  a. t is a basic entailing type.
  b. If τ is an entailing type, then for any type σ, $\langle\sigma,\tau\rangle$ is an entailing type.

(ii) **Generalized entailment '$\Rightarrow$'** (von Fintel 1999)
  a. If ϕ, ψ are of type t, then: $\phi \Rightarrow \psi$ iff ϕ is false or ψ is true.
  b. If β, γ are of an entailing type $\langle\sigma,\tau\rangle$, then: $\beta \Rightarrow \gamma$ iff for all α such that α is of type σ: $\beta(\alpha) \Rightarrow \gamma(\alpha)$.

The basic case (iia) is defined based on truth values: a truth-value entails another iff it is not the case that the first is true and the second is false. In a generalized case, as schematized in (iib), a function entails another iff the result of applying the first function to any argument entails the result of applying the second function to the same argument. For example, *smart student* and *student* are functions of type $\langle e,t\rangle$. *smart student* $\Rightarrow$ *student*, because for any x of type e,

(7.62) a. **Downward-entailing functions**
A function f of type $\langle\sigma,\tau\rangle$ is is downward-entailing iff
for all x and y of type σ such that $x{\Rightarrow}y$: $f(y){\Rightarrow}f(x)$.

b. **Downward-entailing environments**
If α is of type δ and **A** is a constituent that contains α, then **A** is downward-entailing with respect to α iff the function $\lambda x.[\![\mathbf{A}[\alpha/\mathbf{v}_\delta]]\!]^{g[v_\delta\rightarrow x]}$ is downward-entailing.
[$\mathbf{A}[\alpha/\mathbf{v}]$ is the result of replacing α with trace **v** in **A**.]

For example, since *semanticist* ⇒ *linguist*, the entailment pattern in (7.61b) suggests that the function $\lambda P.[\![\text{Mary isn't a } \mathbf{v}_{\langle e,t\rangle}]\!]^{g[\mathbf{v}_{\langle e,t\rangle}\rightarrow P]}$ is downward-entailing, and hence that "Mary isn't a P" is downward-entailing with respect to the predicate P. Moreover, since *Mary is a semanticist* ⇒ *Mary is a linguist*, the entailment pattern in (7.61b) also suggests that the function $\lambda p.[\![\text{not } \mathbf{v}_{\langle s,t\rangle}]\!]^{g[\mathbf{v}_{\langle s,t\rangle}\rightarrow p]}$ is downward-entailing, and hence that "not p" is downward-entailing with respect to the proposition p.

7.5.4.2. Minimizer-licensing in *even*-sentences: scalar presupposition + operator movement

In English, a minimizer (including canonical minimizers such as *lift a finger* as well as emphatic weak scalar items like *ONE video*) can appear under the scope of *even* only if the propositional complement of *even* is downward-entailing or non-monotonic with respect to this minimizer (Crnič 2014a, 2011). Consider the distribution of the emphatic weak scalar item *ONE video* in *even*-sentences for illustration. It is licensed only if the *even*-sentence involves a downward-entailing operator such as negation *n't*, as in (7.63b), or a non-monotonic predicate such as the desire predicate *hope*, as in (7.63c).

(7.63) a. * John made even ONE video.
b. John did**n't** make even ONE video.
c. I **hope** to someday make even ONE video of that quality.

Crnič (2014a, 2011) adopts the semantics of *even* from Bennett (1982) and Kay (1990), repeated below, and argues that the distributional pattern of minimizers in *even*-sentences is a consequence of the existential scalar presupposition of *even*.

(7.64) **Semantics of** *even* (Bennett 1982; Kay 1990)
$[\![even]\!](p) = \exists q \in C[q >_{\text{likely}} p].p$
($[\![even]\!](p)$ is defined only if p is more likely than *some* contextually relevant alternative; when defined, $[\![even]\!](p) = p$)

Further, Crnič bridges logical strength and likelihood with the following principle:

(7.65) Entailment and scalarity (Crnič 2011: 15)
If $p \subset q$, then $p <_{\text{likely}} q$.
(if a proposition p asymmetrically entails a proposition q, then p is less likely than q.)

---

smart student(x) ⇒ *student*(x). All these cases can also be understood from a set-theoretic perspective: for any two sets A and B, $A \Rightarrow B$ iff A is a subset of B (written as '$A \subseteq B$').

According to the above principle, to satisfy the existential scalar presupposition of *even*, the propositional prejacent of *even* must have at least one alternative that does not entail the prejacent.

This prediction immediately accounts for the ungrammaticality of (7.63a). With a focus-mark on the weak scalar item *ONE*, the focus alternatives of the prejacent proposition of *even* are formed by replacing *ONE* with other positive intergers: $C = \{$*John made n videos* : n is a number$\}$. Hence, the scalar presupposition of *even* requires the prejacent proposition to be more likely than, and thus not entailed by, at least one of the focus alternatives. Nevertheless, this requirement cannot be satisfied, because the prejacent is entailed by all of its alternatives, leaving the use of *even* infelicitous and the minimizer unlicensed.

(7.66) *John made even ONE video. Upward-entailing

a. Even$_C$ [John made one$_F$ video]

b. The prejacent of *even* is weaker than all the other alternatives, and hence is **more likely** than the other alternatives:

John made 1 video.	$\supset$ John made 2 videos.
	$\supset$ John made 3 videos.
	$\supset$ John made n videos. ($n > 1$)

As for the grammatical cases in (7.63b-c), Crnič proposes that the LFs of these sentences involve a movement of the focus-sensitive operator *even*. This operator movement does not leave a trace, but makes *even* interpreted with a wide scope. When *even* is associated with a minimizer across a downward-entailing operator, its scalar presupposition gets trivially satisfied: the prejacent is logically stronger than any other alternatives, and hence is less likely than the other alternatives.

(7.67) John did**n't** make even ONE video. Downward-entailing

a. Even$_C$ [**not** [~~even~~$_C$ [John made one$_F$ video]]]

b. The prejacent of *even* is stronger than all the other alternatives, and hence is **less likely** than the other alternatives:

not [John made 1 video].	$\subset$ not [John made 2 videos].
	$\subset$ not [John made 3 videos].
	$\subset$ not [John made n videos]. ($n > 1$)

When *even* is associated with a minimizer across a non-monotonic operator, the prejacent is logically independent from other alternatives, and it can be less likely than (at least some of) the other alternatives in proper context.

(7.68) I **hope** to someday make even ONE video of that quality. Non-monotonic

a. Even$_C$ [I **hope** to [~~even~~$_C$ [someday make one$_F$ video of that quality]]]

b. The prejacent of *even* is logically independent from all the other alternatives. In a proper context, it can be **less likely** than (some of) the other alternatives:

I **hope** to [... make 1 video ...].	$\not\subseteq \not\supseteq$ I **hope** to [... make 2 videos ...].
	$\not\subseteq \not\supseteq$ I **hope** to [... make 3 videos ...].
	$\not\subseteq \not\supseteq$ I **hope** to [... make n videos ...]. ($n > 1$)

7.5.4.3. Minimizer-licensing in [*lian* ... *dou*] constructions: scalar presupposition + focus reconstruction

Similar to the minimizer-licensing condition in English *even*-sentences, in Mandarin, the minimizer in a [*lian* MIN *dou*...] construction is licensed iff the prejacent clause of *dou* is downward-entailing or non-monotonic with respect to this minimizer. Briefly, the post-*dou* negation in (7.59) provides a downward-entailing environment, while the desire predicate *yao* 'want' in (7.60) provides a non-monotonic environment.

Since *dou* is semantically identical to *even* in [*lian*...*dou*...] constructions, we can easily extend Crnič's (2011, 2014) analysis of minimizer-licensing in English *even*-sentences to minimizer-licensing in Mandarin [*lian*...*dou*...] constructions. Briefly, the minimizer-licensing condition is a logical consequence of the additive presupposition of *dou*, which requires the propositional argument of *dou* to be less likely than some of the alternatives, and hence not to be weakest proposition among the alternatives. The only difference between my treatment and Crnič's is the following: while Crnič assumes an operator movement of the particle *dou* over the non-upward-entailing operator, I assume that the minimizer undergoes reconstruction and gets interpreted below the non-upward-entailing operator.

In (7.59), this requirement forces the minimizer *YI-ge ren* 'one person' to take reconstruction and get interpreted below negation, as shown in (7.69): 'there is at least one person that John didn't invite' is weaker than alternatives of the form 'there are at least n people that John didn't invite' where $n > 1$; while 'not [John invited at least one person]' is stronger than alternatives of the form 'not [John invited at least n people]' where $n > 1$. Hence, without negation or if the minimizer scopes above negation, the propositional argument of *dou* is logically the weakest among its alternatives, leaving the presupposition of *dou* unsatisfied.

(7.69) Yuehan (lian) [YI$_F$-ge ren] **dou** *(bu) renshi.
John LIAN one-CL person DOU NEG know
'John doesn't even know ONE person.'

a. * **Dou** [$_{\text{UE}}$ [**lian** (**one**$_F$ **person**)]$_i$ NOT [John knows t_i]] MIN > NEG
for any $n > 1$: $\exists 1x\neg[\text{know}'(j,x)] \Leftarrow \exists nx\neg[\text{know}'(j,x)]$

b. **Dou** [$_{\text{DE}}$ NOT [John knows **lian** (**one**$_F$ **person**)]] NEG > MIN
for any $n > 1$: $\neg\exists 1x[\text{know}'(j,x)] \Rightarrow \neg\exists nx[\text{know}'(j,x)]$

The reconstruction analysis is supported by the ungrammaticality of (7.70): a minimizer cannot be licensed if it cannot be reconstructed to a position below negation. In (7.70), the minimizer *YI-ge ren* 'one person' serves as the subject, whose surface position and reconstructed position are both higher than negation, and hence the ungrammaticality of (7.70) cannot be salvaged by reconstruction.

(7.70) * (Lian) [YI-ge ren]$_F$ **dou** bu renshi Yuehan.
LIAN one-CL person DOU NEG know John.
Intended 'no one knows John.'

The optional presence of a post-*dou* negation in (7.60) can also be accounted for in the same way. The desire predicate *yao* 'want to have' is a non-monotonic operator (Heim 1992, a.o.). Hence, if the minimizer takes scope below *xiang*, as in (7.71b), the alternatives of the propositional argument of

dou are semantically independent. In a proper context, such as that John is unlikely to be interested in a small amount of money, the prejacent *John wants to have one cent* is less likely than alternatives such as *John wants to have two cents*. Therefore, the additive presupposition of *dou* can be satisfied even in absence of the post-*dou* negation.

(7.71) a. Yuehan (lian) [YI-fen qian]$_F$ **dou** yao.
John LIAN one-cent money DOU want
'John wants to have even one cent.
(Intended: John wants any money, however little money it is.)'

b. [**dou** [John$_i$ wants$_{\text{NM}}$ [**lian (one$_F$-cent)** λx [e_i has x]]]]

7.5.5. Association with a scalar item

Associating *dou* with a scalar item implies that the prejacent ranks relatively high with respect to some contextually relevant measurement.

(7.72) a. It is **dou** FIVE o'clock! $\rightsquigarrow$ *It's too late.*

b. John **dou** has eaten THREE burgers! $\rightsquigarrow$ *John has eaten too much.*

A simple way of thought would be to order the alternatives based on the contextually relevant measurement, and to define the sub-alternatives as the ones that rank lower than the prejacent proposition with respect to this measurement. For instance, in (7.73), sub-alternatives are propositions that rank lower than the prejacent in chronological order. The pre-exhaustification effect of *dou* is realized by the scalar exhaustifier JUST. We thus get a definition of *dou* as schematized in (7.74) for its general scalar marker use.

(7.73) **Dou** [WU-dian] -le.
DOU five-o'clock -ASP
'It is **dou** [FIVE] o'clock.'

a. SUB(*it's 5 o'clock*) = {*it's 4 o'clock*, *it's 3 o'clock*, ...}

b. ⟦dou [it's 5 o'clock]⟧ = 'it's 5, not just 4, not just 3, ...'

(7.74) $[\![dou]\!](p) = \lambda w[\exists q \in \textsc{Sub}(p).p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)[\textsc{just}(q)(w) = 0]]$

a. $\textsc{Sub}(p) = \{q : q \in C \wedge q <_\mu p\}$
(The set of contextually relevant alternatives of p that rank lower than p w.r.t. μ)

b. $\textsc{just}(q) = \lambda w[q(w) = 1 \wedge \forall r \in Alt(p)[r(w) = 1 \rightarrow r \geq_\mu q]]$
(r is true; r ranks the highest w.r.t. μ among its true alternatives.)

To generate sub-alternatives and satisfy the additive presupposition of *dou*, the prejacent statement needs to be relatively strong among the quantificational statements. For instance, in (7.75), *dou* can be associated with 'many-NP' but not with 'few-NP'.

(7.75) [Duo/*Shao -shu -ren] **dou** lai -le.
many/less -amount -person DOU come -ASP
'Most/*few people **dou** came.'

7.6. Sorting the parameters

So far, I have provided three variants for the definition of sub-alternatives. The first two are based on logical strength, and the third is based on likelihood. Now we have a couple of urgent questions: how are these variants related, and which variant is primary?

(7.76) **Three definitions of sub-alternatives**

a. $\textsc{Sub}(p) = (\textsc{Alt}(p) - \textsc{Excl}(p)) - \{p\}$ *For distributor use*
$= \{q : q \in \textsc{Alt}(p) \wedge p \subset q\}$
(The set of alternatives that are not excludable and distinct from the prejacent; or equivalently, the set of alternatives that are weaker than the prejacent)

b. $\textsc{Sub}(p) = (\textsc{Alt}(p) - \textsc{IExcl}(p)) - \{p\}$ *For ∀-FCI-licenser use*
(The set of alternatives that are not I-excludable and distinct from the prejacent)

c. $\textsc{Sub}(p) = \{q : q \in \textsc{Alt}(p) \wedge q >_{\text{likely}} p\}$ *For even-like use*
(The set of alternatives that are more likely than the prejacent)

I argue that definition (a) is primary, while definitions (b) and (c) are derived from (a) by two independent semantic weakening operations, as illustrated in figure 7.6.

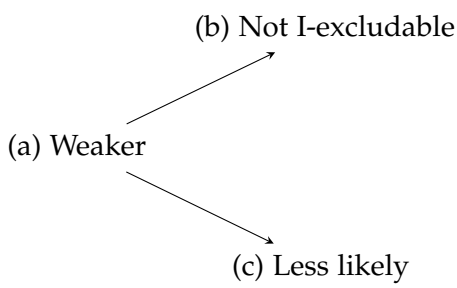


Figure 7.2: Development path for sub-alternatives

In particular, definition (b) is derived from definition (a) by a weakening from unexcludability to un-I-excludability. As seen in section 7.5.2.2, any alternative that is not excludable is not I-excludable, while not every un-I-excludable alternative is unexcludable. For example, in the case of a disjunction, the disjuncts are excludable but not I-excludable. Definition (c) is derived from (a) by a weakening from logical strength to likelihood. Due to Entailment-Scalarity Principle (7.77), any alternative that is logically weaker than the prejacent is also more likely than the prejacent, but a less likely alternative is not necessarily logically weaker. For example, if a proposition is logically independent from the prejacent, it can still be more likely (or less likely) than the prejacent.

(7.77) Entailment-Scalarity Principle (Crnič 2011: 15)
If $p \subset q$, then $p <_{\text{likely}} q$.

This proposed derivational path for sub-alternatives has two predictions. First, the distributor use of *dou* is primary, while the other uses are derived, as illustrated in figure 7.6. This prediction is supported by diachronic evidence: the two derived uses emerged much later than the primary use.

In particular, the distributor use of *dou* emerged as early as the Eastern Han Dynasty (25-220AC) (Gu 2015), while so far there is no reliable evidence to show that *dou* could function as an *even*-like scalar marker or a ∀-FCI licenser before the Ming Dynasty.[89]

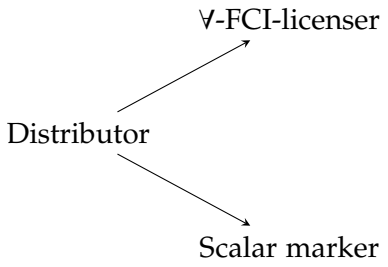


Figure 7.3: Development path for the uses of *dou*

Second, the likelihood-based semantics of *dou* should have a more limited distribution than the logical strength-based semantics of *dou*. More concretely, the logical strength-based semantics should be widely available, while the likelihood-based one is only licensed under particular syntactic or prosodic conditions, such as when *dou* appears in a [(*lian*) ... *dou* ...] construction or is associated with a stressed item. This prediction is supported by the following licensing conditions of *dou* in basic declaratives and [(*lian*) ... *dou* ...] constructions:

If the prejacent of *dou* is ...	Can the presupposition of *dou* be satisfied in ...	
	basic declaratives?	[(*lian*) ... *dou* ...] constructions?
stronger than some alternative(s)	Yes	Yes
the weakest alternative	No	No
if else	**No**	Yes

Table 7.1: Licensing conditions of *dou* in declaratives and [*lian*...*dou*...] constructions

Recall that *dou* presupposes that its propositional prejacent has at least one sub-alternative. On the one hand, if the prejacent is logically stronger than at least one alternative, then due to the Entailment-Scalarity Principle, the additive presupposition of *dou* is satisfied not only under the logical strength-based definition, but also trivially satisfied under the likelihood-based definition. For example, in (7.78), alternatives like *John can eat up two bowls of rice* are weaker as well as more likely than the prejacent *John can eat up three bowls of rice,* which therefore satisfies the presupposition of *dou* under both definitions of *dou*.[90]

(7.78) a. Yuehan [(zhe) san-wan fan] **DOU** chi-de-wan.
John DEM three-bowl rice DOU eat-mod-finish
'John can eat up (these) three bowls of rice.'

[89] I thank Feng Gu and Guo Li for helpful discussions on the data in Ancient Chinese.

[90] There is a minor difference between the two examples in (7.78): *san-wan fan* 'three bowls of rice' receives a referential interpretation in the basic declarative (7.78a) but a generic interpretation in the [(*lian*) ... *dou* ...] sentence (7.78b).

b. Yuehan (lian) [SAN$_F$-wan fan] **dou** chi-de-wan.
John LIAN three-bowl rice DOU eat-mod-finish
'John can even eat up THREE bowls of rice.'

On the other hand, as illustrated in (7.79), if the prejacent is logically weaker than all the other alternatives, *dou* suffers a presupposition failure under both definitions.

(7.79) a. Yuehan [(zhe) *yi/san-ge ren] **dou** renshi.
John DEM one-CL person DOU know
'John knows all the *one/three people.'

b. Yuehan (lian) [YI$_F$-ge ren] **dou** *(bu) renshi.
John LIAN one-CL person DOU NEG know
'John does*(n't) even know ONE person.'

Crucially, however, under the "if else" condition that the prejacent is logically independent from every other alternative, *dou* can be felicitously used in [*lian*...*dou*...] constructions but not in basic declaratives. This contrast shows that the likelihood-based semantics of *dou*, which allows sub-alternatives to be logically independent from the prejacent, is unavailable in basic declaratives. Consider the following pairs of sentences for illustration:

(7.80) a. * John **dou** arrived.
b. (Lian) JOHN **dou** arrived.

(7.81) a. They **dou** bought houses. (#collective, √distributive)
b. (Lian) THEY **dou** bought houses. (√collective,√distributive)

The basic declarative (7.80a) is ungrammatical due to a presupposition failure: the prejacent of *dou* does not have a logically weaker alternative. In contrast, the [(*lian*) ... *dou* ...] sentence (7.80b) is grammatical, because propositions of the form "*x* arrived" can be less likely than the prejacent *John arrived* in proper contexts, which therefore satisfies the presupposition of *dou*. In (7.81), although both sentences are grammatical, the prejacent clause *they bought houses* admits a collective reading in (7.81b) but not in (7.81a). When taking a collective reading, the prejacent of *dou* is logically independent from all the alternatives, but it can be more likely than some of its alternatives in proper contexts.

Contra my view, Liu (2016c,b) treats the likelihood-based semantics as the default semantics of *dou*. He propose that *dou* primarily functions as *even*, while the distributor use is a special case where the scalar presupposition of *even* is trivially satisfied. But, if the likelihood-based semantics were the default semantics, *dou* should be licensed whenever the presupposition of its likelihood-based semantics is satisfied, and hence should have the same distribution in basic declaratives and [*lian* ... *dou* ...] constructions, contra fact. For example, for the basic declarative (7.81a), if *they bought houses together* is contextually more likely than *the others bought houses together*, the likelihood-based semantics of *dou* should have been defined even if the prejacent takes a collective reading.

7.7. Summary

This chapter offered a uniform semantics to capture the seemingly diverse functions of the Mandarin particle *dou*, including the quantifier-distributor use, the ∀-FCI-licenser use, and the *even*-like scalar use. I define *dou* as a special exhaustifier that operates on sub-alternatives and has a pre-exhaustification effect: *dou* presupposes the existence of at least one sub-alternative, asserts the truth of the prejacent and the negation of each pre-exhaustified sub-alternative. In particular, the pre-exhaustification effect is realized by either the basic exhaustifier O-operator or the scalar exhaustifier JUST, depending on whether the alternatives are ordered with respect to logical strength, or likelihood, or some other contextually determined measurement.

(7.82) a. If alternatives are ordered by logical strength:
$[\![dou]\!](p) = \lambda w[\exists q \in \textsc{Sub}(p).p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)[O(q)(w) = 0]]$

b. If alternatives are ordered under some other scale:
$[\![dou]\!](p) = \lambda w[\exists q \in \textsc{Sub}(p).p(w) = 1 \wedge \forall q \in \textsc{Sub}(p)[\textsc{just}(q)(w) = 0]]$

The semantics of *dou* exhibits minimal alternations caused by semantic weakenings on the definition of sub-alternatives, giving rise to different uses. By default, sub-alternatives are the alternatives that are weaker than the prejacent, or equivalently, the ones that are not excludable and distinct from the prejacent. Under this definition of sub-alternatives, *dou* obtains its primary use as a distributor. Further, with a weakening from unexcludability to un-I-excludability, *dou* gains its ∀-FCI licenser use. Alternatively, with a weakening from logical strength to likelihood, *dou* becomes semantically equivalent to English *even* and functions as a scalar marker. The derivational path for the functions of *dou* is supported by both diachronic and synchronic evidence.

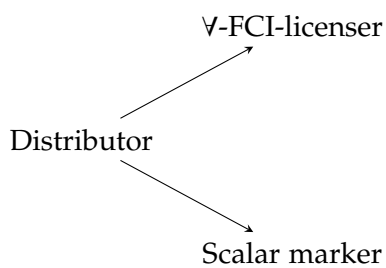


Figure 7.4: Derivational path for the functions of *dou*

The additive presupposition of *dou* explains the distributional pattern of *dou* and many of its semantic consequences, such as the requirements regarding to distributivity, plurality, and monotonicity, the *even*-like interpretation of the [*lian* Foc/Min *dou* ...] construction, the distributional pattern of the post-*dou* negation in licensing minimizers, and so on.

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