2

A theory of questions and answers

This chapter develops a theory of questions and answers that provides a reference point for the rest of the book. Chapter 1 introduced the rudiments of an account of questions and classified it as a Hamblin–Karttunen account. Under this view, a question denotes a set of propositions and an answer is the conjunction of the true members of that set. Here I provide the historical context for this view, clarifying in what sense it is a blend of the two theories. I refine the analysis in a number of ways, incorporating insights from later research into the semantics of questions and answers.

We start with a discussion of three papers, Hamblin (1973), Karttunen (1977), and Groenendijk and Stokhof (1982), which form the basis of most current work on the topic. In addition to the view of questions as denoting sets of propositions, the idea of questions as partitions on possible worlds is introduced. Whether an answer merely needs to denote the true propositions (weak exhaustiveness) or whether it must also rule out the false ones (strong exhaustiveness) is of particular relevance to the construction of an adequate theory of questions. The proper interpretation of the common noun inside the wh phrase is also significant.

We present possibilities for bridging the different positions in these three papers, providing ways of synthesizing insights from all of them. Crucial to this enterprise is the possibility of separating the question denotation from an *answerhood* operation that takes questions as argument. The possibility of more than one type of answerhood operator, capturing weak and strong exhaustiveness, is explored. The possibility of moving the truth requirement from the question denotation to the answerhood operator, and allowing answers to be restricted on the basis of properties other than truth is discussed.

We introduce the notion of maximality, something not entertained in the early theories of questions. Maximality plays a role in the interpretation of number morphology in wh phrases as well as in the definition of the *answerhood* operator, capturing presuppositions about existence and informativity associated with questions and answers.

We end with a snapshot of a baseline theory of questions and answers. While subsequent chapters will suggest many possible ways of refining and rethinking various aspects of the semantics and pragmatics of questions, the theory endorsed here should provide a reasonable backdrop for evaluating those proposals.

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2.1 The classics

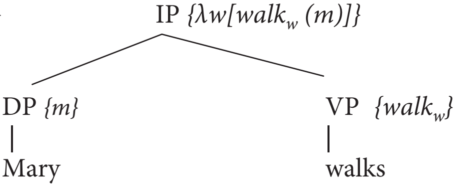
This section summarizes the three papers that can be considered classics in the field: Hamblin (1973), Karttunen (1977), and Groenendijk and Stokhof (1982), henceforth Gr&S. In discussing these works, I will use as far as possible a uniform syntactic structure for interrogatives of the kind presented in Chapter 1 (Heim 1989; Bittner 1994; von Stechow 1996). I will stay largely faithful to the original semantics, except for the uniform use of Ty2 (Gallin 1975) to facilitate comparison of theories.[1]

2.1.1 Questions as sets of propositions

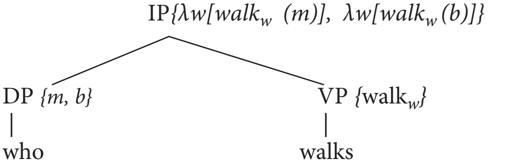
In five pages of a short paper, Hamblin (1973) laid out a semantics for questions that has proven extremely influential. He took on the challenge of showing that Montague's program for "the construction of a theory of truth ... as the basic goal of serious syntax and semantics" was not limited to declaratives, an idea that seems obvious to current day semanticists but was still in need of defense in the early 1970s. There are two primary modifications to Montague's semantics that Hamblin proposes in order to make this extension: a shift from denotations to denotation sets for natural language expressions, and the interpretation of wh expressions as multi-membered sets.[2] He posits a recursive definition for combining denotation sets, which results in the distinction between declaratives (singleton denotation sets) and interrogatives (multi-membered denotation sets). The following derivations show how this is accomplished, assuming that Bill and Mary are the two individuals in the domain:

(1)

a. $[\![\text{Mary walks}]\!] = \{\lambda w\, [\text{walk}_w\,(\text{m})]\}$



b. $[\![\text{Who walks}]\!] =$
$\{\lambda w[\text{walk}_w\,(\text{m})],\ \lambda w[\text{walk}_w\,(\text{b})]\}$



[1] Ty2 allows for explicit quantification over worlds. The subscripts on predicates in these derivations indicate world variables: P_w, the extension of P at w, is equivalent to $P(w)$. See Chapter 1 fn 9 for connections with Montague's system.

[2] See Dowty et al. (1981) for an introduction to Montague Grammar. A noteworthy feature inherited by the papers discussed is that each rule has distinct syntactic and semantic components. To keep the presentation accessible I do not reproduce the original rules, merely showing their contribution to the syntax–semantic mapping adopted here.

Trees (1a)–(1b) show that the denotation sets of lexical items combine through point-wise functional application. The compositional procedure anticipates the account of focus in Rooth (1992).[3] The fact that a proper name denotes a singleton set while a wh expression denotes a set with as many individuals as there are entities of the relevant type projects upwards. Thus, a declarative comes to denote a set with one proposition in it, and is identified with that proposition, while an interrogative denotes a set with as many propositions as there are entities in the domain.

The system generalizes to multiple constituent questions in the expected way ((2a)). Hamblin also defines the adverb "is it the case that" as the set with the identity function on the question nucleus and its negation for polar questions ((2b)):

(2) a. $[\![\text{Who likes who?}]\!] =$
$\{\lambda w[\text{likes}_w\,(m,m)], \lambda w[\text{likes}_w\,(m,b)], \lambda w[\text{likes}_w\,(b,m)], \lambda w[\text{likes}_w\,(b,b)]\}$

b. $[\![\text{Is it the case that Mary walks?}]\!] = \{\lambda w\,[\text{walk}_w\,(m)], \lambda w\,\neg[\,\text{walk}_w\,(m)]\}$

Hamblin briefly addresses the role of the common noun in complex wh expressions, such as *what N*. Although he entertains the notion that the restriction to entities in the denotation of *N* may be a presupposition, he seems to lean towards the view that this membership is asserted. Mono-morphemic wh expressions, *who* and *what*, are treated as implicitly restricted to humans and non-humans, respectively.

Questions for Hamblin, then, denote the set of possible answers. He does not explicitly discuss what counts as an actual answer to a question. From his comment, "pragmatically speaking a question sets up a choice-situation between a set of propositions, namely, those propositions that count as answers to it" (Hamblin 1973: 254), one infers that the subset of possible answers that would count as acceptable in a given situation is contextually determined.

2.1.2 Questions as sets of true propositions

Hamblin's theory is based on a consideration of full answers to questions. As a consequence, questions of all types, single/multiple constituent questions, questions about individuals, times or manners, polar questions, etc, all have a uniform semantic type, as opposed to a multitude of types based on the category and number of wh expression(s). While Hamblin only considered direct questions, this aspect of his theory is particularly attractive in the context of indirect questions, the starting point for Karttunen (1977). Question embedding predicates, for the most part, do not distinguish between various question types, so a uniform semantics for questions leads to a simpler semantics for embedding predicates (see Chapter 5 on indirect questions).

[3] Rooth (1992: 84) acknowledges Dietmar Zaefferer for making the connection between his earlier work on focus (Rooth 1985) and Hamblin's semantics for questions. See also Chapter 8.

Karttunen's interest in indirect questions leads to a significant modification of Hamblin's theory of questions, namely the restriction of question denotations to true propositions. The following verbs of communication prompt this revision: *tell*, *show*, *indicate*, *inform*, *disclose*. Take, for illustration, *tell* and *indicate*. These verbs are non-factive when embedding declaratives, but lead to veridicality when embedding interrogatives:

(3) a. John told Mary that Bill and Susan left.
b. John indicated that Bill and Susan left.

(4) a. John told Mary who left.
b. John indicated who left.

Sentences (3a)–(3b) can be true even if the embedded declaratives are false; (4a)–(4b) cannot be true if John told/indicated that Bill and Susan left when that is not the case. Since the restriction to truth cannot come from the embedding verb, Karttunen concludes, it must come from the question itself.

Another argument for introducing truth into the denotation of questions rests on verbs like *depend on:*

(5) Who is elected depends on who is running.

Karttunen points out that it is simpler to define the meaning of the matrix verb on the basis of true answers to the two embedded questions than on the basis of possible answers to them.

Karttunen's modification of Hamblin's theory is cast within the general framework of natural language quantification in Montague grammar and is also informed by insights from transformational analyses in Katz and Postal (1964), Baker (1968), and Chomsky (1975). Although Karttunen follows Hamblin in taking interrogatives to denote sets of propositions, declaratives are interpreted at their normal semantic type as propositions. Wh expressions are treated as existential generalized quantifiers, adjusted to apply to interrogative level meanings. Crucial to Karttunen's proposal is the shift from declarative to interrogative meaning, mediated through the formation of *proto-questions* (Karttunen 1977:13). The output of the proto-question rule does not correspond to any natural language question but it serves two crucial purposes. It shifts the meaning to a set of propositions and it introduces the truth requirement on propositions.

In our syntactic framework, the proto-question rule can be ascribed most naturally to the $C^0_{[+WH]}$ node. Let us try to understand Karttunen's proto-question rule with reference to constituent and polar questions:

(6) a.

C' $\lambda q\, \lambda p[p_w \wedge p = q]\ (\lambda w\, [walk_w(m/x_i)])$

$\Rightarrow \lambda p[p_w \wedge\ p = \lambda w\, [walk_w(m/x_i)]]$

$C^0_{[+WH]}$ $\lambda q\, \lambda p[p_w \wedge p = q]$ — IP $walk_w(m/x_i)$

Mary /t_i walks

b. $[\![C']\!]$ = $\{\lambda w[walk_w(x_i)]\}$ *for constituent questions*;
$\{walk_w(m)]\}$ or $\varnothing$ *for polar questions.*

With constituent questions, C′ denotes a set of true propositions, whose determination requires the binding of the free variable inside the nucleus. With polar questions, C′ denotes either the singleton set or the empty set, depending on the facts in the evaluation world. C^0[–WH] would be a simple identity function on propositions: *λp[p]*, as in a standard graft of Montague's semantics to this syntactic structure.[4]

Karttunen proposes further operations on proto-questions in order to generate meanings associated with actual natural language questions. Let us consider the *Yes/No Question Rule* first (Karttunen 1977:15). For our purposes, we can encode the content of the rule in a null operator in SpecCP, as in (7a). Karttunen's *Y/N Ques* rule is complicated by the truth requirement in the proto-Ques rule. Thus two separate cases must be considered, one in which C′ denotes a set with the single true proposition (7b), and one in which the set is empty (7c):[5]

(7) a. $[\![OP_{Y/N}]\!] = \lambda \mathbb{Q}\ \lambda p[\mathbb{Q}(p) \vee [\neg\exists q\ \mathbb{Q}(q) \wedge p = {}^\wedge\neg\exists q\ \mathbb{Q}(q)]]$ *ℚ: type <<s,t>,t>*

b. $[\![C']\!] = \{\lambda w[walk(w)(m)]\}$
$[\![[_{CP}\ OP_{Y/N}\ C']]\!] = \{\lambda w[walk(w)(m)]\}$

c. $[\![C']\!] = \varnothing$
$[\![[_{CP}\ OP_{Y/N}\ C']]\!] = \{\lambda w\ \neg[walk(w)(m)]\}$

In (7b), the question denotes the set with the true proposition, because of the first condition in (7a). The second condition in (7a) takes care of the case where the nucleus proposition is false. The question now includes the set of worlds in which the question nucleus does not hold. For direct questions, it seems reasonable to adopt a null operator with the relevant meaning, as we have done. For indirect questions, the same could be taken as the meaning of *whether/if*. The procedure is often simplified in later accounts by interpreting $C^0_{[+WH]}$ in polar questions as $\lambda q\ \lambda p\ [p_w \wedge p = q \vee p = \lambda w\ \neg q_w]$.

Karttunen's treatment of constituent questions is a straightforward adaptation of Montague's quantification rule for indefinites, since he treats the wh phrase as an existential. Proto-questions, with an indexed free variable, feed into the *Wh Quantification Rule* and the *Wh Phrase Rule* (Karttunen 1977: 19, 24–5). We can keep the meaning of the wh determiner as an ordinary existential quantifier (8a), and capture quantifying into questions with the schema in (8b):

(8) a. $[\![which]\!] = \lambda P\ \lambda Q\ \exists x\ [P(x) \wedge Q(x)]$ *P and Q: type <e,t>*

b. $[\![[_{CP}\ [_{DP\text{-}n}\ which\ N]\ C']]\!] = \lambda p\ [\,[\![which\ N]\!](\lambda x_n[\,[\![C']\!](p)]]$

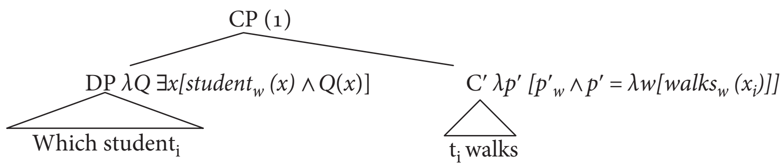
[4] Recall from Chapter 1 that IP meanings are shifted from type *t* to type *<s,t>* at C′, enabling functional application with $[\![C^0]\!]$. See also *Intensional Functional Application* in Heim and Kratzer (1998: 308).

[5] The relationship between the second clause of (7a) and (7c) is not transparent, but hopefully, the discussion in Section 2.2.1 will help.

The quantifying-in rule in (8b) involves the following steps. First, the $[\![C']\!]$ is converted into type *t* by saturating the lambda expression denoted by C′with the variable *p*. Then the individual variable is abstracted over, producing an expression of type <*e,t*>. This combines with the generalized quantifier denoted by the wh expression. By abstracting over *p* again, we get back a set of propositions as the meaning of the question. If Mary and Bill are the only students who walk in the actual world, though there may well be other individuals under consideration, we get sets such as (9c) for the single constituent question in (9a). Analysis (9b) provides the steps of the derivation, all involving simple functional application:[6]

(9) a. Which student walks?

b.



$$[\![1]\!] = \lambda p\ [\lambda Q\ \exists x[student_w(x) \wedge Q(x)]\ (\lambda x_i[\boldsymbol{\lambda p'}[\mathbf{p'}_w \wedge \mathbf{p'} = \lambda w[walks_w(x_i)]](\mathbf{p})])]$$
$$\Rightarrow \lambda p[\boldsymbol{\lambda Q}\ \exists x[student_w(x) \wedge \mathbf{Q}(x)]\ (\boldsymbol{\lambda x_i}[\mathbf{p_w} \wedge \mathbf{p} = \boldsymbol{\lambda w}[\mathbf{walks}_w(\mathbf{x_i})]]])]$$
$$\Rightarrow \lambda p[\exists x[student_w(x) \wedge \boldsymbol{\lambda x_i}[p_w \wedge p = \lambda w[walks_w(\mathbf{x_i})]](\mathbf{x})]$$
$$\Rightarrow \lambda p[\exists x[student_w(x) \wedge p_w \wedge p = \lambda w[walks_w(x)]]$$

c. $[\![\text{which student walks}]\!] = \{\lambda w[walks_w(m)], \lambda w[walks_w(b)]\}$

Since the wh question rule is recursively defined, multiple wh questions are easily accommodated. If Mary's reading of *Emma* and Bill's reading of *Persuasion* exhaust the readings of books by students in the world of evaluation, a multiple constituent question is interpreted as (10):

(10) a. $[\![\text{which student read which book}]\!] =$
$$\lambda p \exists y[book_w(y) \wedge \exists x[student_w(x) \wedge p_w \wedge p = \lambda w'[read_{w'}(x,y)]]]$$
b. $\{\lambda w[read_w(m,E)], \lambda w\ [read_w(b, P)]\}$

A standard simplification, one that was adopted in Chapter 1, is to leave the proposition *p* as a free variable at C^0 and abstract over it at the top node. This makes the procedure for interpreting multiple constituent questions more user friendly while achieving the same results.

The final piece of Karttunen's theory involves the embedding of questions. The question embedding rule (Karttunen 1977: 17) takes the intension of the interrogative meaning as its internal argument. The nature of the embedding predicate determines whether the intension or the extension of this argument will be relevant in the final computation. The internal argument of *wonder* is a function from worlds *w′* to the set of propositions *p* that are true at *w′* (11). By contrast, the internal argument of *know* takes the extension of the question (12) and yields the set of propositions that are true at the world of evaluation *w*:

6 I use bold font to indicate the key elements of the lambda expression that is to be resolved in the next step of the derivation.

(11) a. [John ***[wonders what Bill bought]***]
b. $[\![\text{wonder}]\!] = \lambda\mathbb{Q}_{<s,<<s,t>,t>>}\ \lambda y[\text{wonder}_w(y,\mathbb{Q})]$
c. $[\![\text{wonder what Bill bought}]\!] =$
$\boldsymbol{\lambda\mathbb{Q}}\lambda y[\text{wonder}_w(y,\boldsymbol{\mathbb{Q}})]\ (\boldsymbol{\lambda w'\ \lambda p\ \exists x\ [p_{w'} \wedge p = \lambda w''[\text{bought}_{w''}\ (b, x)]]})$
$\Rightarrow\lambda y[\text{wonder}_w(y, \lambda w'\ \lambda p\ \exists x\ [p_{w'} \wedge p = \lambda w''[\text{bought}_{w''}\ (b, x)]]])]$

(12) a. [John ***[knows what Bill bought]***]
b. $[\![\text{know}]\!] = \lambda\mathbb{Q}_{<s,<<s,t>,t>>}\ \lambda y[\text{know}_w\ (y,\mathbb{Q}(w))]$
c. $[\![\text{know what Bill bought}]\!] =$
$\boldsymbol{\lambda\mathbb{Q}}\lambda y[\text{know}_w(y,\mathbb{Q}(w))]\ (\boldsymbol{\lambda w'\ \lambda p\ \exists x\ [p_{w'} \wedge p = \lambda w''[\text{bought}_{w''}\ (b, x)]]})$
$\Rightarrow\lambda y[\text{know}_w(y, \boldsymbol{\lambda w'}\ \lambda p\ \exists x\ [p_{w'} \wedge p = \lambda w''[\text{bought}_{w''}\ (b, x)]](\mathbf{w}))]$
$\Rightarrow\lambda y[\text{know}_w(y, \lambda p\ \exists x[p_w \wedge p = \lambda w''[\text{bought}_{w''}\ (b, x)]])]$

Karttunen further relates question embedding verbs with their proposition embedding counterparts by a *Meaning Postulate* (Karttunen 1977: 18 ff):[7]

(13) $\forall x\ \forall\mathbb{Q}\ \square\ [\text{know}_Q(x, \mathbb{Q}) \leftrightarrow$
$[\forall p\ [\mathbb{Q}(p) \rightarrow \text{know}_t(x,p)] \wedge [\neg\exists q\ \mathbb{Q}(q) \rightarrow \text{know}_t(x, \wedge\ \neg\exists q\mathbb{Q}(q))]]]$

This licenses inferences from question denotations to propositions, for verbs like *know*, *tell*, etc. It guarantees that if someone stands in the *know/tell* relation to a question, then they must stand in the *know/tell* relation to every proposition in that question. And if the question denotes the empty set, then the individual stands in that relation to the proposition that there are no true propositions of the relevant sort. In the case of (12), if Bill bought *Emma* and *Persuasion*, knowing *what he bought* is tantamount to knowing *that Bill bought Emma and Persuasion*, and, if he bought nothing, to knowing *that Bill bought nothing*. This makes it explicit that Karttunen takes an answer to a question to be the conjunction of all the propositions in the question denotation. And, in case the question denotation is empty, as the proposition that states this fact.

2.1.3 Questions as partitions

Gr&S (1982) respond to Karttunen, arguing that the basic type of a question is the same as that of a declarative, a proposition. A question is *index-dependent* so the proposition denoted varies from world to world while a declarative is *index-independent* and denotes the same proposition at every world. A question, then, determines a partition on possible worlds. A similar proposal is made in Higginbotham and May (1981) and Higginbotham (1996). I focus on Gr&S's version as an exemplar of this general perspective on questions.

The treatment of questions as propositions is motivated by the fact that it is possible to conjoin them with ordinary declaratives. If conjunction requires syntactic and semantic parallelism, an analysis of questions as propositions is appealing:

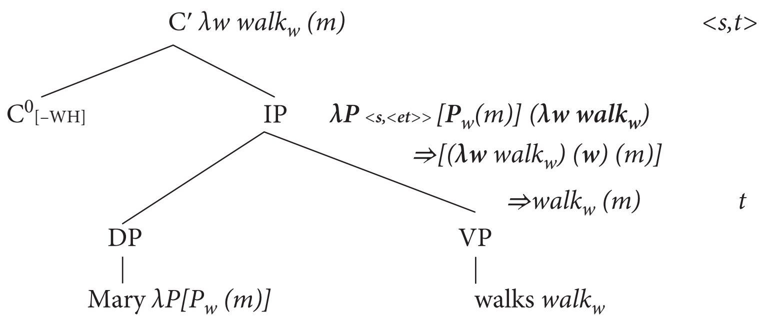
[7] Meaning Postulates, first proposed by Carnap (1947), are used in Montague Grammar to capture language specific lexical properties by placing constraints on admissable models (Dowty, Wall and Peters 1981: 224; Chierchia and McConnell-Ginet 2000: 448–449).

(14) a. John knows *that Peter has left for Paris*, and also *whether Mary has followed him*.
b. Alex told Susan *that someone was waiting for her*, but not *who it was*.

As in the case of a uniform meaning for different question types, a move in the direction of uniformity between interrogatives and declaratives also allows for a simpler semantics for verbs that can embed either. It bears mentioning, though, that such co-ordination is ungrammatical under question embedding verbs: **John wondered/asked whether Peter has left for Paris and that Mary has followed him.*

Mapping Gr&S's interpretive procedure onto a GB-style syntax and adapting the original rules (Gr&S 1982: 192), we get the following for a declarative:

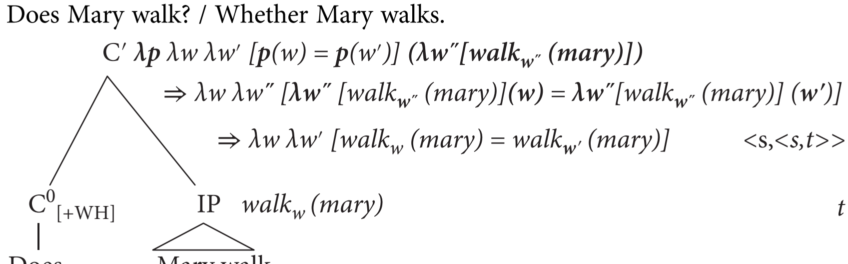
(15) a. (that) Mary walks
b.



Simplifying somewhat, *Mary* denotes the set of properties $P_{<s,<e,t>>}$ that characterize the individual Mary at world *w*, and $walk_w$ the extension of the property *walk* at the same world. By *Intensional Functional Application* we have the formula $walk_w(m)$ which is true or false, depending on the facts at *w*. The specification on C^0 being [−WH], the world variable is abstracted over at C′ and the result is a proposition, the set of worlds where Mary walks.

A C^0 specified[+WH], conversely, creates index dependence in the proposition, (16c). Instead of abstracting over the world of evaluation *w*, it looks for worlds *w′* having the same value as *w* with respect to the question nucleus. The relevant rule (Gr&S 1982: 192) derives the interrogative version of (15a):

(16)
a. Does Mary walk? / Whether Mary walks.
b.



c. $[\![C^0{}_{+WH}]\!] = \lambda p_{<s,t>}\ \lambda w\ \lambda w'\ [p(w) = p(w')]$

Let us parse (16c) to see how index-dependence is achieved. C^0 takes a proposition and creates a relation between the world of evaluation *w* and a proposition in the following way. Saturating the world variable in the proposition with the world of evaluation *w* yields, on the left of side of the equation, the extension of the proposition at *w*, either true or false. Saturating the world variable on the right side of the equation with a different variable *w′*, collects all the worlds in which the extension of the proposition on the right matches the extension of the proposition on the left, that is, at the world of evaluation. We thus get a partition that defines an equivalence relation on worlds. At each world *w*, the question denotes the set of worlds *w′* that is equivalent to *w* with respect to the question.

Though interrogatives and declaratives denote the same semantic type at a given world, that is, propositions (type <*s,t*>), they are clearly different. No matter which world we interpret a declarative at, it denotes the same set of worlds. The interpretation of the interrogative varies depending on the facts at the world of evaluation. To make this concrete, consider the following model:

(17) a. M: W = {w1, w2, w3, w4};

$$\text{Walk} = \begin{bmatrix} \text{w1} \rightarrow \{\text{mary, sue}\} \\ \text{w2} \rightarrow \{\text{bill, mary}\} \\ \text{w3} \rightarrow \{\text{sue}\} \\ \text{w4} \rightarrow \varnothing \end{bmatrix}$$

b. Does Mary walk?

Extension at w2: $\lambda w\ \lambda w'\ [\text{walk}_w\ (m) = \text{walk}_{w'}\ (m)]\ (w2) = \{w1, w2\}$
the set of worlds in which Mary walks

Extension at w3: $\lambda w\ \lambda w'\ [\text{walk}_w\ (m) = \text{walk}_{w'}\ (m)]\ (w3) = \{w3, w4\}$
the set of worlds in which Mary doesn't walk

Example (17) illustrates the difference between the intension and extension of a question. The intension of a polar question denotes a partition of worlds with two cells, one where Mary walks, one where she doesn't. The extension of the question varies with worlds. At *w2*, for example, we get the proposition *that Mary walks,* at *w3* the proposition *that Mary doesn't walk.*[8]

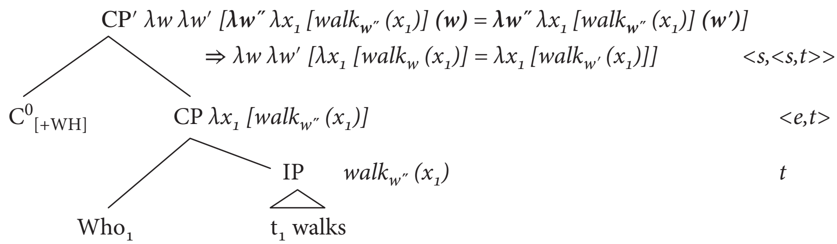
Turning to constituent questions, an important step in interpretation is the creation of an abstract. The rules for abstract formation and abstract constituent complement formation (Gr&S 1982: 196) translate into derivations like (18). Note that this semantics requires interpreting wh phrases lower in the structure than C^0:

[8] The intension of a proposition: $\lambda w\ \lambda w' [walk(w')(m)]$ yields the same proposition at every world since the variable *w* does not occur inside the nucleus—the facts in the world of evaluation are not relevant to the proposition. Here, it would be the set *{w1, w2}*, whether evaluated at *w2* or *w3*.

(18)

a. Who walks?

b.



The argument position associated with the wh expression is interpreted as an indexed variable, and the wh expression as a lambda abstractor over it. Since abstraction has to happen below the point at which index dependence is introduced, wh expressions adjoin below C^0, at the lower CP. The only adjustment needed in the semantics is to allow index dependency to apply to categories of type *<s,<e,t>>*, not just type *<s,t>*. The lower CP meaning can then feed into the meaning of C^0, after the requisite intensionalization. This yields a function from worlds *w* to the set of worlds *w′* in which the set of walkers are the same as in *w*: $\lambda w\, \lambda w'\, [\lambda u[walk_w\, (u)] = \lambda u\, [walk_{w'}\, (u)]]$. Once again, we have an equivalence relation on worlds, this time with respect to the set of walkers. Schematically, if there are two entities in the domain, a question intension represents a partition with four cells, exhausting the space of possibilities:

(18) c.

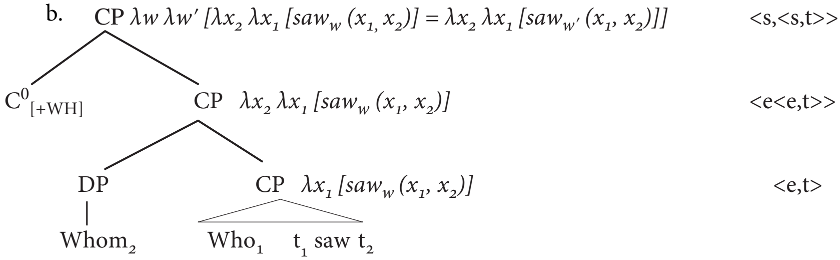
a	b
a,b	

At any world, the question denotes exactly one cell, the proposition that is its complete answer.

The rule for abstract formation generalizes to multiple constituent questions. Each wh expression in (19a) abstracts over one argument position (19b). The schema in (19c) represents the partition induced by this question, with a two-member domain of entities and an irreflexively interpreted predicate:

(19) a. Who saw whom?

b.



c.

<a,b> <b,a>	
<a,b>	<b,a>

The rule for embedding applies without modification to interrogatives, since they have the same semantic type as declaratives (Gr&S 1982: 192). The type of the internal argument starts out intensional. As in Karttunen, embedding verbs vary along the intensional/extensional dimension. Verbs like *tell/know* are extensional, while verbs like *wonder/ask* are intensional. For completeness, I include an embedded declarative in the first class:

(20) a. [John ***[knows that Mary walks]***]
b. $\text{know}_w\ (j, \lambda w \lambda w'\ [\text{walk}_{w'}\ (m)]\ (w))$
$\Rightarrow \text{know}_w\ (j, \lambda w'\ [\text{walk}_{w'}\ (m)])$

(21) a. [John ***[knows whether Mary walks]***]
b. $\text{know}_w\ (j, \lambda w \lambda w'\ [\text{walk}_w\ (m) = \text{walk}_{w'}\ (m)]\ (w))$
$\Rightarrow \text{know}_w\ (j, \lambda w'\ [\text{walk}_w\ (m) = \text{walk}_{w'}\ (m)])$

(22) a. [John ***[knows who walks]***]
b. $\text{know}_w\ (j, \lambda w \lambda w'\ [\lambda u[\text{walk}_w\ (u)] = \lambda u[\text{walk}_{w'}\ (m)]](w))$
$\Rightarrow \text{know}_w\ (j, \lambda w'\ [\lambda u[\text{walk}_w\ (u)] = \lambda u[\text{walk}_{w'}\ (u)]])$

(23) a. [John ***[wonders who walks]***]
b. $\text{wonder}_w\ (j, \lambda w \lambda w'\ [\lambda u[\text{walk}_w\ (u)] = \lambda u\ [\ \text{walk}_{w'}\ (u)]])$

The crucial point is that extensional verbs relate to a proposition (*type <s,t>*), while intensional verbs relate to a propositional concept, a function from worlds to propositions (*type <s, <s,t>>*).

2.1.4 Advantages of questions as partitions

We have seen the core of Gr&S's theory, and the points of departure from Karttunen's. We will now review those aspects that, according to Gr&S, favor their theory.

The first is the distinction between *weak* and *strong exhaustiveness*. The main point of difference can be illustrated schematically:

(24)

w1 *a b c*	w2 *a*	w3 *b*	w4 *c*
w5 *a b*	w6 *a c*	w7 *b c*	w8

Assume we are in a world where *a* and *b* walk, say *w5*. Karttunen's theory requires that the propositions $\lambda w[a\ \textit{walks}_w]$ and $\lambda w[b\ \textit{walks}_w]$ be in the question denotation. And knowing the question in such a world requires knowing the conjunction of these two propositions. This will include worlds in which *a* and *b* both walk, but also worlds where *c* walks as well: *{w1, w5}*. Gr&S's theory, however, singles out the set of worlds in which *a* and *b* are the only individuals who walk: *{w5}*. That is, under Karttunen's theory the attitude holder may have false beliefs or no beliefs about non-walkers at *w5*. Gr&S term this *weak exhaustiveness* and argue that the *strong exhaustiveness* their theory delivers is required. Consider the following inference patterns.

(25) a. John believes that Bill and Suzy walk
<u>Only Bill walks</u>
John doesn't know who walks

b. <u>John knows who walks</u>
John knows who doesn't walk

Gr&S claim that if only Bill walks, but John believes falsely of Suzy that she also walks, speakers do not judge *John knows who walks* true. Similarly, they argue that if John knows who walks, and knows who the set of individuals are, then he must know who doesn't walk. Since neither of these follows under weak exhaustiveness, they claim that questions must encode strong exhaustiveness.

A second respect in which Gr&S claim their theory to be superior to Karttunen's has to do with the interpretation of the common noun inside wh phrases. They take embedded questions like (26) to be ambiguous between a *de dicto* and a *de re* reading:

(26) John knows which student walks.

If *a* and *b* are the two students who walk in the world of evaluation, (26) can be taken to mean that John knows that *a* and *b* are students who walk. If asked, *do you know which students walk?* he would answer in the affirmative. This is the *de dicto* reading. Alternatively, it is possible for John to know that *a* and *b* walk without knowing that they are students. If asked *do you know who walks?* he would answer affirmatively and pick out *a* and *b*, but if asked *do you know which students walk?* he might say he doesn't. This is the *de re* reading. This distinction is shown below, focusing on the direct question counterpart of (26) and skipping the obvious steps in the derivations (Gr&S 1982: 198–9):

(27) a. Which student walks?

CP $\lambda w\, \lambda w'\, [\boldsymbol{\lambda w''}\, \lambda x_o\, [student_{w''}(x_o) \wedge walk_{w''}(x_o)]\, \boldsymbol{(w)} = \boldsymbol{\lambda w''}\, \lambda x_o\, [student_{w''}(x_o) \wedge walk_{w''}(x_o)]\boldsymbol{(w')}]$

$\Rightarrow \lambda w\, \lambda w'\, [\lambda x_o\, [student_w(x_o) \wedge walk_w(x_o)] = \lambda x_o[student_{w'}(x_o) \wedge walk_{w'}(x_o)]]$

$C^o_{[+WH]}$ CP $\lambda x_o\, [student_{w''}(x_o) \wedge walk_{w''}(x_o)]$

DP $student_{w''}$ IP $walk_{w''}(x_o)$

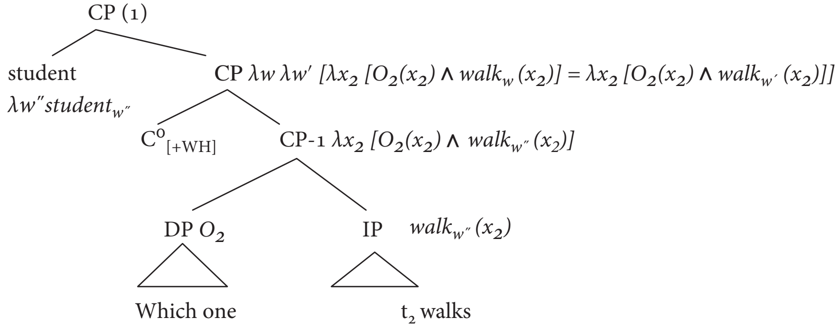
Which student t_o walks

The common noun is interpreted at the point where the abstract is formed. Thus, when the abstract combines with C^0 and the interrogative meaning is obtained, the denotation of the common noun varies on two sides of the equation. We get the set of worlds w' in which the set of student-walkers are the same as the set of student-walkers in the world of evaluation w. To know this proposition is to know the set of student-walkers in the actual world, the *de dicto* reading.

The second option differs crucially in having the common noun enter the derivation after question formation has taken place:[9]

(27)

b.



$$[\![1]\!] = \lambda w_@ [\lambda O_2 [\mathbf{\lambda w} \lambda w' [\lambda x_2 [O_2(x_2) \wedge walk_w(x_2)] = \lambda x_2 [O_2(x_2) \wedge walk_{w'}(x_2)]] (\mathbf{w_@})] (\mathbf{\lambda w''} student_{w''} (\mathbf{w_@}))]$$

$$\Rightarrow \lambda w_@ [\mathbf{\lambda O_2} [\lambda w' [\lambda x_2 [\mathbf{O_2}(x_2) \wedge walk_{w@}(x_2)] = \lambda x_2 [\mathbf{O_2}(x_2) \wedge walk_{w'}(x_2)]]] (\mathbf{student_{w@}})]$$

$$\Rightarrow \lambda w_@ \lambda w' [\mathbf{\lambda x_2} [student_{w@}(x_2) \wedge walk_{w@}(x_2)] = \lambda x_2 [student_{w@}(x_2) \wedge walk_{w'}(x_2)]]]$$

There are two important steps here. First, there is a place-holder for the common noun at the point of abstract creation: O_2 of type *<e,t>*. After interrogative formation, this place-holder is replaced through lambda abstraction and conversion with the denotation of the common noun in the actual world: $student_{w@}$. When this happens, the property-in-extension replaces O_2 on both sides of the equation. We now have the set of worlds w' such that the set of walkers in w' are the same as the set of student-walkers in the world of evaluation, the *de re* reading. Their status as students in w' is not relevant.

It is easy enough to see how these two ways of deriving common noun meanings will yield the perceived ambiguity of questions when they are embedded under attitude verbs. Gr&S point out that Karttunen's theory only captures *de re* readings because the existential quantifier is interpreted outside the scope of the propositional variable where the question nucleus is interpreted. Their system, instead, allows for the required flexibility.

[9] The use of $w_@$ in the final step has no significance and could be replaced with w to get the familiar looking question intension. The important point is that the world variable on O_2 be anchored to the same world as the predicate on the left side of the equation.

2.1.5 Section summary

In this section I have presented the key features of three seminal papers. Among the issues highlighted are the possibility of a uniform analysis of direct and indirect questions, an explicit connection between question denotations and possible answers regarding true propositions, and a distinction between weak/strong exhaustiveness. In presenting these ideas, I took liberties with the syntax but stayed faithful to the semantics, except for the use of Ty2 across the board and the simplification of certain details of Montague grammar. The goal of this section was two-fold, to provide the relevant historical background for the particular semantics we are adopting and to pave the way for later developments in the theory.

2.2 Answerhood operators

The previous discussion was restricted to arguments made by the authors themselves. In this section we will present suggestions for incorporating insights from the different approaches into a single theory of questions. We will first see how two key insights of Gr&S's theory can be incorporated into Karttunen's. We will then see how Karttunen's insights can be incorporated into Hamblin's theory. We will settle upon a blend that has broad acceptance in current work, the Hamblin–Karttunen theory of questions. Central to the enterprise is the introduction of an operator that mediates between question denotations and answers.

2.2.1 Exhaustiveness and Ans-H

Heim (1994) addresses the criticism made by Gr&S that the set of propositions approach fails to capture strong exhaustiveness. In a theory like Karttunen's, an extensional question embedding verb like *know/tell* relates individuals to the set of true propositions denoted by the question (cf. (13)). If the facts are such that John and Bill walk, then (28a) is true iff Mary stands in the *know* relation to (the conjunction of) the two propositions in (28b), underlined to indicate that they are true in the world of evaluation. But what if no one walks? Then the embedded question will denote the empty set (28c). The intersection of the empty set is the tautological proposition, which one cannot fail to believe, regardless of how ignorant one is. That is, (28a) will be automatically true if no one walks, even if Mary is totally unaware of the relevant fact since any rational person can be assumed to know a tautology:

(28) a. Mary knows who walks.
b. If john and bill are the individuals that walk in w,
$[\![\text{who walks}]\!](w) = \{\underline{\lambda w\ \text{walks}_w\ (j)}, \underline{\lambda w\ \text{walks}_w\ (b)}\}$
c. If no one walks in w, $[\![\text{who walks}]\!](w) = \varnothing$

Karttunen, we saw, provides a disjunctive semantics for *know* to cover the two cases. Heim taps into Karttunen's solution and proposes two notions of answerhood within his theory, which she dubs Ans_1 and Ans_2 (Heim 1994: 136). I add H to indicate authorship of the idea:

(29) a. $\text{Ans-H}_1(\alpha, w) = \cap [\![\alpha]\!]_K(w)$
b. $\text{Ans-H}_1(w)$ (who walks) $= \cap (\lambda p\ \exists x\ [p_w \wedge p = \lambda w' walk_{w'}\ (x)])$
c. John and Bill walk.

(30) a. $\text{Ans-H}_2(\alpha,w) = \lambda w'\ [\text{Ans-H}_1(\alpha,w') = \text{Ans-H}_1(\alpha,w)]$
b. $\text{Ans-H}_2(w)$ (who walks) $= \lambda w'\ [\cap (\lambda p\ \exists x\ [p_w \wedge p = \lambda w' walk_{w'}\ (x)]) = \cap (\lambda p\ \exists x\ [p_{w'} \wedge p = \lambda w' walk_{w'}\ (x)])$
c. Only John and Bill walk.

Ans-H_1 delivers the weak exhaustiveness of Karttunen's original theory. Assuming that Bill and John are the only individuals who walk, it yields the conjunction of the two propositions denoted by the question at the world of evaluation. It admits worlds where there are no other walkers, as well as worlds with extra walkers. Ans-H_2 imports the strong exhaustiveness that Gr&S championed. It picks out all the worlds in which the answer to the question matches the answer in the world of evaluation. Effectively, proposition (30c).

Heim notes that with this enrichment, Karttunen's theory becomes a richer system since it allows for the possibility of weak as well as strong exhaustiveness, while Gr&S's is rigidly bound to strong exhaustiveness. The upshot is that the choice between the two theories must turn on empirical considerations. If there are natural language phenomena corroborating the existence of weakly exhaustive questions, Karttunen's theory, supplemented with Ans-H_2, is to be preferred over an alternative that only has the power of Ans-H_2. We will return to this issue in Chapter 3, but what Heim establishes is that strong exhaustiveness is not a knockdown argument against the set of propositions theory of questions.

Implicit in this discussion is also an answer to the argument in Gr&S from the conjoinability of interrogatives and declaratives. If the interpretation of an indirect question is mediated through $\text{Ans-H}_1/\text{Ans-H}_2$, which involve the intersection of the propositions in the set, the conjunction facts are no longer a challenge:

(31)
a. Bill knows what Mary bought and that Sue danced.
b. $\text{know}(\text{bill}, [\underbrace{\cap[\lambda p\ \exists x[p(w) \wedge p = \lambda w\ \text{bought}(w)(\text{mary},x)]]}_{<s,t>} \cap \underbrace{\lambda w[\text{danced}(w)(\text{sue})]}_{<s,t>}])$
c. *Bill wonders what Mary bought and Sue danced.

In fact, it has the potential advantage of accounting for (31c), on the view that question embedding verbs do not have access to this type-shift (see also Uegaki 2015).

Heim also notes the problem of incorporating *de dicto* readings in Karttunen's theory. Her suggestions are picked up by Beck and Rullman (1999) and Sharvit (2002) who capture *de dicto/de re* ambiguities using Ty2:

(32) a. Which student walks?
b. $\lambda p\ \exists x\ [student_w\ (x) \wedge p_w \wedge p = \lambda w'(walk_{w'}\ (x))]$
c. $\lambda p\ \exists x\ [p_w \wedge p = \lambda w'[student_{w'/w}\ (x) \wedge walk(w')(x)]]$

Formula (32b) is Karttunen's original version with the common noun outside the question nucleus. Its world variable is obligatorily anchored to the actual world, resulting in the *de re* reading. The crucial move involves interpreting the common noun in the base position (32c).[10] Its world variable can be bound or remain free, in the spirit of Enç (1986). When bound, the set has propositions of the form *λw′ [x is a student in w′and walks in w′]*, the *de dicto* reading of the question. When free, propositions are of the form *λw′[x is a student in w and walks in w′]*, referring to those *x*'s who are students in the actual world, the *de re* reading. Setting aside some intricacies related to the selection of *de dicto/de re* readings of questions, this ambiguity is easily captured in this straightforward extension of Karttunen's theory.

The three arguments from Gr&S against Karttunen, we see, are tractable under reasonable modifications of the latter. The real contribution of Gr&S's paper, then, is in enriching the empirical desiderata for a theory of questions rather than in motivating a shift from questions as sets of propositions to questions as (index-dependent) propositions.

2.2.2 Truth and Ans-D_{PRELIM}

The idea that an operator mediates between question denotation and embedding predicates is also proposed by Dayal (1994). The primary argument comes from the truth requirement that Karttunen introduced into question denotations and which is hard-wired into Gr&S's theory. The proposal is to shift this requirement into the *answerhood operator*, allowing questions to denote Hamblin sets. The motivation comes from an analysis of a construction known variously in the literature as *scope marking, partial wh movement*, and *expletive wh construction.* Initially, this construction was thought not to exist in English, but we now know that a variant of it is found in spoken English (Dayal 1996). This makes it convenient for purposes of demonstration.

To get a feel for the construction, consider a sequence of questions like (33a):

(33) a. Where did you go? What did you buy?
b. What do you think? What should we buy?
c. What do you think we should buy?

A good answer to (33a) specifies values for places and objects: *I went to the store. I bought apples*, *I went to the store and bought apples*, or perhaps *I went to the store to buy apples.* That is, we would interpret the sequence as a conjunction of two

[10] This can be accomplished by reconstruction of the common noun at LF or, assuming the copy theory of movement, by interpreting the common noun at the tail of the movement chain, or through the use of choice functions, as favored by Beck and Rullmann.

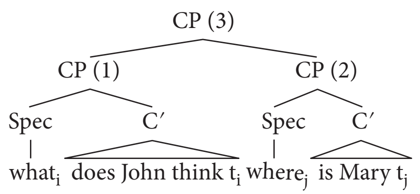
questions. We are more likely to interpret the sequence in (33b), instead, as a single question and answer it by specifying a value for objects: *I think we should buy apples.* In that sense, it seems equivalent to (33c), which involves extraction of the embedded wh to matrix SpecCP. The intonational contour differentiates between a sequence interpreted as a conjunction of two questions (33a) and one interpreted as a single question (33b).

There is a vast literature on scope marking but broadly speaking it separates into two categories, dubbed *direct dependency* and *indirect dependency* in Dayal (1994). Briefly, the direct dependency approaches align scope marking with long distance extraction like (33c). I refer the reader to my earlier work as well as to recent surveys such as Fanselow (2005), Dayal (2013), Dayal and Alok (2016), and references cited therein for arguments against the direct dependency approach. We will be concerned only with sequential scope marking here which cannot be analyzed through direct dependency. This makes it possible to focus on the truth requirement in questions without getting bogged down in that controversy.[11]

A concrete example shows the workings of the indirect dependency approach and highlights the implications for a choice between Karttunen and Hamblin:[12]

(34)
a. What does John think? Where is Mary?

b.



$[\![1]\!] = \lambda p\ \exists p'\ [T(p') \wedge p = \lambda w'\ (\text{think}_{w'}\ (j,p'))]$

$[\![2]\!] = \lambda q\ \exists x\ [\text{place}_w\ (x) \wedge q = \lambda w''\ (\text{in}_{w''}\ (m,x))]$

$[\![3]\!] = \lambda T_{<<s,t>,t>}\ [\![CP1]\!]\ (\,[\![CP2]\!]\,)$

$\Rightarrow \lambda p\ \exists p'\ [\lambda q\ \exists x\ [\text{place}_w\ (x) \wedge q = \lambda w''(\text{in}_{w''}\ (m,x))]\ (p') \wedge p = \lambda w'\ (\text{think}_{w'}\ (j, p'))]$

$\Rightarrow \lambda p\ \exists p'\ [\exists x\ [\text{place}_w\ (x) \wedge p' = \lambda w''(\text{in}_{w''}\ (m,x))] \wedge p = \lambda w'\ (\text{think}_{w'}\ (j, p'))]$

[11] The absence of syntactic subordination is shown by the impossibility of variable binding across the two questions: *What does everyone$_i$ think? What should he$*_i$ do?* Extraction cannot, therefore, apply across these clauses. Additionally, scope marking is possible with co-ordination, which is resistant to extraction. The following, based on Höhle (2000) and discussed in Dayal (2000), is relevant: Ques: *What do you think? When will Mary come and what will she bring?* Ans: *I think she'll come around 10 and bring pasta.*The two questions combine as follows: $\lambda p\ [p = \lambda w\ \exists q \in Q1\ \exists q' \in Q2\ [q(w) \wedge q'(w)]$.

[12] Dayal (1994, 1996) assumes the syntactic structure given here for scope marking generally. Dayal (2000), however, argues for variation in the syntax of scope marking but a uniform semantics cross-linguistically. The structure in (34) applies to English. The intonational contour that clubs the two questions together may be taken as a reflex of the syntactic adjunction of two CPs.

Each question is interpreted as a Hamblin set. There are two points worth noting. First, since *think* takes propositional complements, the first question must quantify over propositions. Second, the variable quantified over has a (covert) restriction, just like individual variables that *what/who* and *which N* bind. We can think of this restriction as the Topic. It follows that if the quantification is over variables of type $<s,t>$, the restriction must be of type $<<s,t>,t>$. Nothing special so far, but it paves the way for combining the two questions through standard functional application, as shown in (34b). The net effect is that CP3 only denotes those propositions that John believes and furthermore are in the denotation of CP2. That is, John's beliefs about the weather or about Sue's whereabouts are eliminated from consideration. We have sets such as (35a) for the question in (34a):

(35) a. $\{\underline{\lambda w\ think_w\ (j, \lambda w'\ in_{w'}\ (m,L))}, \lambda w\ think_w\ (j, \lambda w'\ in_{w'}\ (m, P))\}$
b. John thinks Mary is in London.

What is the result if Mary happens to be in Paris in the world of evaluation? It turns out that (35b) is a perfectly legitimate truthful answer to (34a). This can only be if questions denote Hamblin sets (36a), not Karttunen sets (36b):

(36) a. $[\![CP2]\!] = \{\lambda w'\ in_{w'}\ (m,L), \underline{\lambda w'\ in_{w'}\ (m, P)}\}$
b. $[\![CP2]\!] = \{\underline{\lambda w'\ in_{w'}\ (m, P)}\}$

But what about Karttunen's original motivation for enforcing truth inside the question denotation? Dayal's solution (Dayal 1994: 163) is to disassociate the truth requirement from the question denotation and move it to the answerhood operator in (37a). We get Hamblin sets at the CP level and Karttunen sets when a CP is directly embedded under a predicate or when a CP is a matrix question. The crucial distinctions are shown for scope marking (37b) and embedded questions (37c):

(37) a. $\text{Ans-D}_{PRELIM}\ (Q) = \lambda w\ \lambda p\ [p_w \wedge p \in Q]$ *to be revised in (48a)*
b. $\text{Ans-D}_{PRELIM}\ ([\![[_{CP3}$ what does John think? Where is Mary?$]]\!])$
$\Rightarrow \text{Ans-D}_{PRELIM}\ (\lambda p\ [\exists q \in \{\lambda w'\ in_{w'}\ (m,L), \underline{\lambda w'\ in_{w'}\ (m,P)}\} \wedge p = think_w\ (j,q)])$
$\Rightarrow \text{Ans-D}_{PRELIM}\ (\{\underline{\lambda w\ think_w\ (j, \lambda w'\ in_{w'}\ (m,L))}, \lambda w\ think_w\ (j, \lambda w'\ in_{w'}\ (m, P))\})$
$\Rightarrow \lambda w\ think_w\ (j, \lambda w'\ in_{w'}\ (m,L))$
c. John knew/told Bill where Mary is.
$= \lambda w\ knew_w\ /\ told_w\ (j, b, (\text{Ans-D}_{PRELIM}\ [\![\text{where Mary is}]\!]))$
$\Rightarrow \lambda w\ knew_w\ /\ told_w\ (j, b, (\text{Ans-D}_{PRELIM}\ (\{\lambda w'\ in_{w'}\ (m,L), \underline{\lambda w'\ in_{w'}\ (m, P)}\})))$
$\Rightarrow \lambda w\ knew_w\ /\ told_w\ (j, b, \lambda w'\ in_{w'}\ (m, P))$

What Ans-D_{PRELIM} does is to sift out those propositions from the Hamblin set that are true at the world of evaluation to yield Karttunen sets. Since scope marking structures do not involve direct embedding of CP2 under the matrix predicate, Ans-D_{PRELIM} does not come into play in its interpretation. It only applies at the matrix level. This captures the fact that truth with respect to John's beliefs matters but not with respect to Mary's location. When the same question is embedded under extensional verbs, as in (37c), Ans-D_{PRELIM} requires truth with respect to Mary's location.[13]

An unsatisfactory aspect of Ans-D_{PRELIM} is that it still requires a shift from sets of propositions to propositions in embedded contexts. This will be addressed in revising Ans-D_{PRELIM} in Section 2.3. For now, focusing on the truth requirement, we note that it is quite easy to import the effect of Heim's solution to the exhaustiveness problem:

(38) a. $Ans_1\text{-}D_{PRELIM}\ (Q) = \lambda w \cap [\lambda p\ [p_w \wedge p \in Q]]$
b. $Ans_2\text{-}D/H_{PRELIM}\ (Q) = \lambda w\ \lambda w'[Ans_1\text{-}D\ (w)\ (Q) = Ans_1\text{-}D\ (w')\ (Q)]$

These versions of Ans-D_{PRELIM} apply to Hamblin sets and derive weakly/strongly exhaustive Karttunen sets, respectively.

2.2.3 Beyond truth

Another advantage of separating the truth requirement from question denotations is that it allows different embedding predicates to encode different relations to their internal argument. Although Karttunen listed a number of embedding predicates that do not show veridicality with embedded questions, he was influenced by non-factive predicates like *tell/indicate* that become veridical when they embed wh questions. From that perspective, the conclusion that the locus of veridicality is the question denotation seemed plausible enough. But as Lahiri (1991, 2000, 2002a) has discussed at length, other predicates like *be certain/agree on* do not show discernible veridicality:

(39) a. John is certain who was at the party.
b. John and Mary agree who was at the party.

Neither (39a) nor (39b) entails that if Bill and Sue were at the party John should be certain about their presence or that he and Mary should agree about their presence. To accommodate such facts, Lahiri takes a proposition *p* as an answer to a question *Q*, iff it is in the Hamblin set denoted by the question and in the set of propositions *C* (Lahiri 2002a: 99–100):

(40) a. $Ans(p, Q) = C(p) \wedge Q(p)$
b. $\forall x$ [x is the agent of V-ing $\rightarrow C \subseteq \lambda p[\text{consider-likely}_w / \text{possible}_w\ (x,p)]$) (*be certain*)
c. $C \subseteq \lambda p[p_w]$ (*tell, communicate, know etc.*)

[13] Dayal (1994) suggests that Ans-D_{PRELIM} is also present when embedded under intensional embedding predicates like *wonder/ask*, as functions from worlds to propositions. See Chapter 4 for scope marking with question embedding verbs and Chapter 5 for a general discussion of embedding.

C is partly determined by the lexical semantics of the embedding predicate, which can impose specific requirements based on its presuppositions (cf. 40b). The truth requirement is a default option for predicates that do not have relevant lexical presuppositions (cf. 40c).

The notion of a default, then, is a way of navigating between Hamblin and Karttunen denotations for direct questions and for some indirect questions as well. A point that is obvious enough, but still bears emphasizing, is that some restriction on the Hamblin set is required to ensure that question–answer paradigms vary across worlds.[14] Such variation is essential to deriving the distinction between interrogatives as speech acts of questioning and declaratives as speech acts of assertion.

We have seen arguments here for repackaging the Hamblin and Karttunen approaches to questions. We have Hamblin sets as question denotations across the board, moving the truth requirement into an answerhood operator. To incorporate Lahiri's insight, we would replace p_w in Ans-D$_{\text{PRELIM}}$ with *C(p)*, with *C* as in (40b)–(40c). Making the truth requirement a default for a contextually parameterized restriction, we create the flexibility that different question embedding predicates require. Obviously, this flexibility is not there in Karttunen, which builds the restriction to truth into the proto-question rule, nor is it there in Gr&S, where propositions are anchored to the facts of the world of evaluation. Of course, one could take Karttunen's theory to include the variable *C* instead of the default truth requirement, as he may have intended it to. Note that such a move would not help with the problem of scope marking discussed in Section 2.2.2 which requires the restriction to be separate from the question denotation.

2.2.4 Section summary

In this section I discussed the developments that allow us to incorporate key insights from three different approaches to questions within a single theory. Taking Hamblin sets as question denotations and building into a separate answerhood operator a contextual restriction with a default setting for the truth requirement, we capture the variation in inferences licensed by different embedding predicates. Having a basic answerhood operator that delivers weak exhaustiveness and defining another operator that picks out worlds where the answerhood operator gives the same value, we derive strong exhaustiveness.[15] Finally, interpreting the common noun inside the question nucleus and allowing for flexibility in the binding of its world variable we capture the *de dicto/de re* ambiguity in embedded contexts.

[14] Keeping a fixed domain of quantification, a Hamblin denotation remains constant across worlds. If the domain varies, the Hamblin denotation will vary but not in a way that can represent a speaker's ignorance about the nucleus proposition.

[15] Some recent approaches derive Hamblin sets by optionally building in strong exhaustivity within the question nucleus (George 2011 and Nicolae 2013). They also illustrate the general point made here, that it is possible to mix and match various theories in different ways (see Chapter 3 for details).

2.3 Maximality in question–answer paradigms

We will now consider the role of number morphology in interrogative phrases, something that does not feature in the three classics discussed so far in this chapter. We will consider different proposals for importing the semantics of number into the semantics of questions and explore their impact on the relationship between questions and answers. While we will see further support for question denotations as Hamblin sets, the answerhood operator will be revised radically to capture number sensitive inferences.

2.3.1 Number in wh expressions

Dayal (1991a, 1991b, 1996), draws attention to the following paradigm where singular, plural, and mono-morphemic wh expressions differ on the felicity of possible answers:

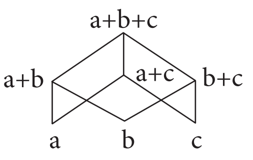
(41) a. Which woman does John like?
b. Which women does John like?
c. Who does John like?

(42) a. John likes Mary.
b. John likes Mary and Sue.

Sentence (41a) can be felicitously answered only by (42a), which names a single woman, while (41b) can be answered only by (42b), which names a plurality of women. Sentence (41c) can be answered by either (42a) or (42b). These data establish that the analyses of questions and number must intersect. Intuitively, it is easy enough to describe what is at issue. The choice between a singular and a plural wh reflects the expectations of the speaker regarding the number of individuals who should be named in the answer. In the case of a mono-morphemic wh phrase, with no discernible number specification, no such expectation is in evidence. Capturing this fact, however, turns out to be non-trivial.

Dayal adopts the view, due to Sharvy (1980) and Link (1983), and by now widely accepted, that the domain of discourse includes atomic as well as plural individuals. Schematically:

(43)



The domain of individuals is an atomic semi-lattice closed under sum formation, and partially ordered by the individual part-of ($\leq$) relation: $a \leq a + b$ and $a + b \leq a + b + c$. The elements at the bottom are the atoms, those with no proper parts:

there is no x s.t. $x \leq a$ *and* $x \neq a$. Given this, one can treat singular common nouns as denoting in the atomic domain, and plural common nouns as denoting in the full domain.[16]

Applied to wh expressions, we get an existential quantifier which ranges over atomic individuals for *which* N_{SING}, and an existential quantifier which ranges over atomic and sum individuals for *which* N_{PL}. For mono-morphemic wh expressions, we can either posit a null N, which could be singular or plural, or we can treat them as having a covert restriction which makes no reference to number. These moves, in and of themselves, do not deliver the presuppositions we are interested in, regardless of which theory we adopt, Hamblin, Karttunen, or Gr&S. Let us see why.

Assume three (atomic) women in the domain of discourse, Mary, Sue, and Betty. Then, (41a) will denote the Hamblin set in (44a), and (41b) the one in (44b):

(44) a. $\{\underline{\lambda w\ like_w\ (j,m)}, \underline{\lambda w\ like_w\ (j,s)}, \lambda w\ like_w\ (j,b)\}$
b. $\{\underline{\lambda w\ like_w\ (j,m)}, \lambda w\ like_w\ (j,s), \lambda w\ like_w\ (j,b),$
$\lambda w\ like_w\ (j,m+s), \lambda w\ like_w\ (j,m+b), \lambda w\ like_w\ (j,s+b),$
$\lambda w\ like_w\ (j,m+s+b)\}$

None of the answerhood operators we have looked at so far say anything about how many propositions in these sets can be true. If John liked Mary and Sue, for example, Ans-D_{PRELIM} when applied to (44a) would yield the answer in (42b) via the set: $\{\lambda w\ like_w\ (j,m), \lambda w\ like_w\ (j,s)\}$. Likewise, if John likes only Mary, Ans-D_{PRELIM} applied to (44b) would yield $\lambda w\ like_w\ (j,m)$, the answer in (42a). Similar problems arise with applying Ans-H_1 to Karttunen sets, which in the situations under discussion would denote subsets of (44a) and (44b) for the singular and the plural cases, respectively. Since both versions of strong answerhood operators build on the weak answerhood operator, the problem is inherited in the strongly exhaustive readings as well. And, as pointed out in Dayal (1991a, 1991b), the original theories of Karttunen and Gr&S face the same challenge. The problem is that, as things stand, the presuppositions about number that underlie our intuitions about felicitous answers to (41) do not play a role in determining the number of true propositions in the question denotation.

2.3.2 Maximality in wh expressions

There have been two attempts to address the problem outlined in Section 2.3.1, one using Karttunen sets, the other using Hamblin sets. I will review both but will settle on the latter, which is also in keeping with the conclusion reached in

[16] The plural domain could be argued not to include atoms (Chierchia 1998) but the consensus seems to have settled in favor of including them and treating the plurality requirement as an implicature (Sauerland 2003; Spector 2007b; Zweig 2009; Chierchia 2010). Note that the plurality implicature does not arise in all contexts. *Do you have children?* is neutral with respect to the number of children expected in the answer (Schwarzschild 1996).

Section 2.2. Dayal (1991a, 1991b) builds uniqueness/maximality presuppositions into Karttunen sets by encoding definiteness into the meaning of wh expressions:

(45) a. Which woman does John like?
b. $\lambda p\ \exists x\ [x = \max y[\text{woman}(y) \wedge \text{like}(j,y)] \wedge p_w \wedge p = \lambda w'\ \text{like}_{w'}\ (j,x)]$

Quantification is over those individuals *x* that maximally satisfy the common noun and the question nucleus, that is, individuals who are not themselves part of any other individual that satisfies these two conditions. Since the number restricts quantification to atomic individuals, the question presupposes that only a single woman is liked by John. The question becomes, in effect, one of establishing her identity. The resulting Karttunen set is a singleton. Assuming that natural language quantification presupposes non-empty quantificational domains, the question is undefined in contexts where more than one individual meets the relevant conditions because the domain of quantification is empty.

For questions with plural wh expressions, the proposition must name a unique maximal individual with that property. This can be an atomic individual or a plural individual. Crucially, though, the choice of a plural over a singular wh expression implicates that the singleton proposition will name a plural individual. Thus even though it is semantically possible for the plural version of (45a) *Which women does John like?* to denote a propositional set naming a single woman, it is ruled out, I suggest, because the question has an existence presupposition with a plurality implicature *John likes some women*. With *who*, instead, no such implicature arises because the expression is neutral with respect to number.[17] Thus the paradigm discussed in Section 2.3.1 is adequately captured. As would be obvious, this account is inspired by accounts of singular vs. plural definite descriptions (Sharvy 1980; Link 1983).

The non-standard part of the proposal is that the question nucleus contributes its meaning in two places. The primary motivation for this in Dayal's account concerns the fact that uniqueness for singular wh expressions is over-ridden in multiple wh questions: *Which man likes which woman?*, a topic taken up in Chapter 4. The results for single constituent questions in (45) can be replicated in the proposal for encoding definiteness in Rullmann (1995). And because multiple constituent questions are not considered there, Rullman's proposal works in a more straightforward way.

Following Jacobson's (1995) suggestions for extending her account of free relatives to questions, Rullmann builds maximality into Karttunen denotations inside the question nucleus. The question in (45a) would be interpreted as in (46a), with quantification restricted to atomic individuals. Its plural counterpart would be interpreted as in (46b), with quantification over atomic and plural individuals. The implicatures associated with number would be captured in a parallel fashion to the one in Dayal (1991a, 1991b):

[17] We will see in Section 3.2 that positing an ambiguity between a silent N_{SING} and a silent N_{PL} will not always yield the right results, so an analysis in which number remains unspecified is to be preferred.

(46) a. $\lambda p\, \exists x\, [\text{woman}(x) \wedge p_w \wedge p = \lambda w'\, [x = \max\, (\lambda y(\text{like}_{w'}\, (j,y)))]]$
b. $\lambda p\, \exists x\, [\text{women}(x) \wedge p_w \wedge p = \lambda w'\, [x = \max\, (\lambda y(\text{like}_{w'}\, (j,y)))]]$

Rullmann's use of maximality in wh expressions is particularly successful in explaining negative island effects, a major focus of his work:

(47) a. How tall is Marcus?
b. *How tall isn't Marcus?

The contrast in (47) follows from the fact that there does not exist a unique maximal degree in the negative extension of Marcus' height but one does exist in its positive extension (see also Chapter 6).

We have seen two very similar ways of interpreting wh expressions as definites, based on Karttunen's theory of questions. Building number sensitivity into the wh phrase is an important piece of the explanation, but something more has to be added to derive the results. And as noted, the list reading of multiple constituent questions introduces further complications. This suggests the need to consider alternative solutions to the problem.

2.3.3 Maximality and Ans-D

Section 2.2 pointed out that scope marking constructions argue for Hamblin sets, with a separate answerhood operator for deriving Karttunen-like effects. The challenge of deriving the sensitivity to number morphology in question–answer paradigms using Hamblin sets is taken up in Dayal (1996). While number morphology on wh expressions is still interpreted as explicated in Section 2.3.1, number-based presuppositions are captured by defining the notion of a unique maximally informative answer. Definition (48a) replaces Ans-D_{PRELIM} (Dayal 1996: 116). As before, we adapt Heim's solution for capturing strong exhaustiveness. The operators are notated with subscript W for weak exhaustiveness and subscript S for strong exhaustiveness:

(48) a. $\text{Ans-D}_W\, (Q) = \lambda w\, \iota p[p_w \wedge p \in Q \wedge \forall p'\, [[p'_w \wedge p' \in Q] \rightarrow p \subseteq p']]$
b. $\text{Ans-D/H}_S\, (Q) = \lambda w\, \lambda w'\, [\text{Ans-D}_W\, (Q)(w) = \text{Ans-D}_W\, (Q)(w')]$

Applying (48a) to the singular case yields (49), where each proposition names an atomic individual and none of the propositions entails any other. In any situation where John likes exactly one woman, there will be a unique maximally informative answer. Otherwise, Ans-D_W will be undefined:

(49) a. Which woman does John like?
b. $\lambda p\, \exists x\, [\text{woman}_w\, (x) \wedge p = \lambda w'\, \text{like}_{w'}\, (j,x)]$
$\Rightarrow \{\underline{\lambda w\, \text{like}_w\, (j,m)}, \lambda w\, \text{like}_w\, (j,s), \lambda w\, \text{like}_w\, (j,b)\}$
c. $\text{Ans-D}_W\, (49b) = \lambda w\, \text{like}_w\, (j,m)$

The plural counterpart in (50) has quantification over singular and plural individuals:

(50) a. Which women does John like?

b. $\lambda p\ \exists x\ [\text{women}_w\ (x) \wedge p_w = \lambda w'\ \text{like}_{w'}\ (j,x)]$

$\Rightarrow \{\underline{\lambda w\ \text{like}_w\ (j,m)},\quad \lambda w\ \text{like}_w\ (j,s),\quad \underline{\lambda w\ \text{like}_w\ (j,b)},$

$\underline{\lambda w\ \text{like}_w\ (j,m+b)},\quad \lambda w\ \text{like}_w\ (j,m+s),\quad \lambda w\ \text{like}_w\ (j,b+s),$

$\lambda w\ \text{like}_w\ (j,m+b+s)\}$

c. Ans-D_W (50b) $= \lambda w\ \text{like}_w\ (j,m+b)$

If the situation has John liking Mary and Betty, there will be three true propositions in the question denotation, but only one of them will entail the other two. This is the one that Ans-D_W picks out. I assume, as before, that there is an existential presupposition behind the question, which is sensitive to the number on the wh: *John likes some women*. This captures the intuition that an answer naming a single individual is infelicitous.[18] If the wh expression is monomorphemic, the existential presupposition will be neutral in this regard, allowing the maximally informative answer to name an atomic or a plural individual. The shape of the explanation, once again, is exactly what we are familiar with from analyses of definite descriptions, this time framed within the Hamblin–Karttunen blend of theories.

Bittner (1998) points out an added advantage of this approach. Karttunen (1977: 12) observed that constituent and polar questions do not combine well:[19]

(51) a. *?Does John like which woman/women?

b. $\{\underline{\lambda w\ \text{like}_w\ (j,m)},\quad \lambda w\ \neg\ \text{like}_w\ (j,m)$

$\lambda w\ \text{like}_w\ (j,s),\quad \underline{\lambda w\ \neg\ \text{like}_w\ (j,s)}\}$

c. $\{\underline{\lambda w\ \text{like}_w\ (j,m)},\quad \underline{\lambda w\ \neg\ \text{like}_w\ (j,m)},$

$\lambda w\ \text{like}_w\ (j,s),\quad \underline{\lambda w\ \neg\ \text{like}_w\ (j,s)},$

$\lambda w\ \text{like}_w\ (j,m+s),\quad \underline{\lambda w\ \neg\ \text{like}_w\ (j,m+s)}\}$

Assume that there are exactly two women in the domain of discourse, Mary and Sue. With a singular wh expression and the domain restricted to atomic individuals, it is clear that there will be no maximally informative answer. For every individual, either the nucleus proposition or its complement will be true and there will be no unique proposition that entails the other. Bittner does not consider the plural case but the situation does not greatly improve. In (51c), for example, the proposition $\lambda w\ \neg like_w\ (j, m+s)$ will be true since John does not like Sue, but it does not entail the two true propositions: $\lambda w\ like_w\ (j, m)$ and $\lambda w\ \neg like_w\ (j,s)$. Ans-D_W (51c) is therefore undefined. Ans-D_W (Q_{PL}) will be defined only in situations where the nucleus holds positively for all the individuals in the domain. Since it is

18 Thanks to Mingming Liu for raising this issue and forcing me to clarify my assumptions.

19 See Chapter 1, fn 15, on how these denotations would be derived.

not defined for the general case, polar questions with wh expressions are deemed unanswerable, therefore deviant.

It is worth comparing the account above to a closely related, but ultimately distinct, proposal. Beck and Rullmann (1999) also start with Hamblin sets and have answerhood operators pick out maximally informative propositions. Adapting Heim's proposal, they define the following operators to capture weak and strong exhaustiveness (Beck and Rullmann 1999: 259, 268):

(52) a. $\text{Ans-BR}_1(w)(Q) = \cap\{p: Q(w)(p) \wedge p(w)\}$
b. $\text{Ans-BR}_2(w)(Q) = \lambda w'\ [\text{Ans-BR}_1(w')(Q) = \text{Ans-BR}_1(w)(Q)]$

Beck and Rullmann's starting point is the paradigm in (53), where upward scalar predicates like *be sufficient* call for the minimum number to be specified, while downward scalar predicates like *leave* call for the maximum number to be specified:

(53) a. How many eggs are sufficient to bake this cake?
b. {^one egg is sufficient, ^<u>two eggs are sufficient</u>, ^<u>three eggs are sufficient</u>…}
c. How many people left?
d. {^<u>one person left</u>, ^<u>two persons left</u>, ^<u>three persons left</u>…}

In a situation where two eggs are sufficient, it holds that for any *n* greater than two, *n*-many eggs are sufficient. In a situation in which three people left, it holds true for any *n* less than three, that *n*-many people left. By intersecting the true propositions, we get the proposition that entails all others.

Beck and Rullmann characterize their proposal as compatible with Dayal (1996) but there are crucial differences. Most significant is that they set aside the semantics of number morphology and do not build maximality into the definition of an answer. Example (52a) takes the subset of true propositions in a Hamblin denotation and intersects them. Consider a question with a wh expression over individuals, not degrees. With no lexically based entailment relations to appeal to, (52) fails in the same way as the earlier accounts discussed in Section 2.3.1 failed. If John likes Mary and Sue, regardless of whether the question *Which woman/women does John like?* has a singular wh expression or not, (52) will give us the proposition $\lambda w\ like_w(j, m{+}s)$. Similarly, if he likes only Mary it will give us the proposition $\lambda w\ like_w(j,m)$ even if the question uses a plural wh expression.

The need for combining maximality in the answerhood operator with a semantics for number in the interpretation of wh expressions is also seen in the following contrast:

(54) a. John knew only one answer to the question which Dutch Olympic athletes won a medal.
b. #John knew only one answer to the question which Dutch Olympic athlete won a medal.

Beck and Rullmann present (54a) as support for the view, originally suggested in Heim (1994), that Ans-H_1 is the lexical meaning of the common noun *answer*. The fact that it can combine with an indefinite determiner is argued by them to establish the reality of *mention-some* answers. They do not consider examples like (54b), however, which has a singular wh in the embedded question and is infelicitous. Chapter 3 will explore *mention-some answers*, but the relevant point here is that the shift from a plural to a singular term affects acceptability.[20] Once again, the vital connection between number morphology and felicity of answers is missed. Certainly, one could build number sensitivity into their account, but that would be tantamount to the proposal in Dayal (1996).

Let me mention two other phenomena where number specification on the wh plays a role, emphasizing that my goal in doing so is simply to show that number matters. The particular analyses for these paradigms will be discussed in Chapters 4 and 7. Examples (55a)–(55b) show that questions with universal quantifiers and definite plurals allow answers of the kind given in (55c), pairing men with women. Dayal (1992, 1996) and Krifka (1992) point out that the parallelism between universals and definite plurals breaks down when we replace *who* with a singular wh *which woman*. An answer to (55a) with *which woman* can still pair each man with a woman but the same does not hold for (55b) with *which woman*:

(55) a. Who does every man love?
b. Who do these men love?
c. Bill loves Mary and John loves Sue.

The second data set, (56a)–(56b), shows a similar sensitivity to number:

(56) a. Who knows where Mary bought which book?
b. Who knows where Mary bought these books?
c. Bill knows where Mary bought *Emma* and John knows where she bought *Persuasion*.

Baker (1968) argues that the possibility of answers specifying values for the matrix wh and the embedded wh in-situ (56c) shows that the wh in-situ has matrix scope. Kuno and Robinson (1972) point out that the structurally similar example (56b) also allows (56c) but is unlikely to involve matrix scope for the plural definite. Setting aside the implications for scope for now, we note an observation from Dayal (1996). Replacement of the matrix wh with singular *which student* does not affect the possibility of a pair-list answer for (56a) but it does for (56b). The significance of these facts in the present context is that they show the pervasive nature of number-based effects and argue for an answerhood operator like Ans-D that, in conjunction with the appropriate semantics for the wh phrase, delivers number sensitivity.

[20] See also Preuss (2001) for a more detailed discussion of Beck and Rullmann's proposal.

2.3.4 Existential presupposition and Ans-D

We have seen ample evidence that a constituent question with a singular wh expression is infelicitous in contexts where uniqueness is not satisfied. We will now examine the status of constituent questions in contexts where existence fails. Question–answer paradigms like (57a) are fully acceptable. This raises questions about the use of the *iota* operator in Ans-D, which would be undefined in such contexts:

(57) a. Speaker A: Who left the party?
Speaker B: No one.
b. #I'm not sure whether Mary likes any student. Which student does she like?

But the anomaly of (57b), from Karttunen and Peters (1976: 355), points to the reality of the existential commitment (see also Katz 1972; Keenan and Hull 1973; Comorovski 1989, 1996; Dayal 1991a, 1991b, 1996).[21] These data establish that existence can only ever be denied in cross-speaker exchanges. It is, of course, possible for a speaker to ask a question while overtly suspending the existential presupposition, as noted in Horn (1972):

(58) a. I'm not sure if anyone left the party but I'd like to know who, if anyone, did.
b. Who, if anyone, does Mary like?

Questions with clefts are interesting in this connection because they do not brook negative responses nor do they allow the speaker to suspend the existential commitment:

(59) a. Who was it that left the party?
#No one.
b. *Who, if anyone, was it that left the party.

As far as I know, this distinction between clefted and regular questions has not been investigated at any length.[22]

The status of the existence commitment in questions and the status of the existence commitment in clefted assertions have, however, been analyzed recently by Abusch (2010). She establishes that existence is a soft presupposition that can be canceled in the former, but it is a hard presupposition which cannot be canceled in the latter (see also Romoli 2013). In asking a question,

[21] Karttunen (1977: 20, fn 13) recognizes that the existential presupposition is not captured in his theory. It is also not built into Comorovski's (1989, 1996) assumptions about questions and answers.

[22] It is reported that many languages have obligatorily clefted questions but my preliminary and rather perfunctory investigations have not established that they are like English clefted questions in this regard.

we can assume that the speaker takes it to be answerable. That is, she expects Ans-D to be defined. The ordinary question has a soft presupposition about a positive answer to a prior polar question, making it, for all practical purposes, the conditional question: *Assuming that someone left, who did?* The hard presupposition of the cleft projects to its interrogative counterpart: *Someone left. Who did?* Schematically:

(60) a. Who left? Presupposes: $\text{I}_{\text{SPEAKER}}$ assume that someone left.
b. Who is it that left? Presupposes: $\text{We}_{\text{SPEAKER+HEARER}}$ believe that someone left.

The distinction between the existence commitments of clefted and regular questions bears further investigation, of course, but the possibility of distinguishing them on the basis of soft and hard presupposition triggers is promising.

Let me end with a more general point. Answers denying the existential commitment behind the question should be carefully assessed in determining their import for the semantics of questions. For example, revisiting the inference pattern Gr&S (1982) present to argue for strong exhaustiveness, we arrive at a more nuanced picture:

(61) a. John knows who left the party.
No one left the party.
John knows that no one left the party.
b. #No one left so John knows who did/left.

While (61a) seems valid enough, it does not prepare us for the fact that (61b) is anomalous. The only difference between the two is that (61b) makes the connection between the question and the lack of existential commitment in the same sentence, that is, by one individual, the speaker.

2.3.5 Section summary

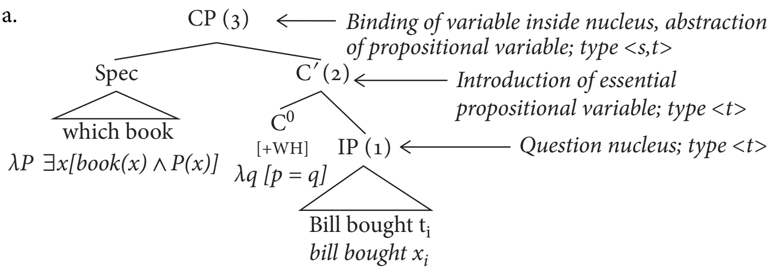
Importing the semantics of number into the denotation of questions is not a controversial move but most researchers have set it aside, taking the view that it is orthogonal to the issues they are concerned with. The result of such an omission, we saw, is not always benign since number-based effects are pervasive in question–answer paradigms. We reviewed two proposals to capture number sensitivity. We settled on the one framed within Hamblin's theory since Hamblin denotations were seen in Section 2.2 to provide greater empirical coverage. Uniqueness/maximality at the propositional level, encoded in the answerhood operator Ans-D, as well as the standard semantics of number for wh phrases are both needed to capture the facts. The existential presupposition, also encoded in Ans-D, was discussed in relation to differences between regular and clefted questions and was shown to be an integral part of the meaning of questions.

2.4 The baseline theory

In this concluding section I will pull together the conclusions reached in previous sections, without repeating the arguments for those conclusions or noting alternatives that have been proposed. The idea is to provide an account that is explicit enough to be used as a launching pad for the discussions to follow in the rest of the book.

We begin by recalling the analysis of questions given in Section 1.2:

(62) a.



$[\![2]\!] = \lambda q\ [p = q]\ (^\wedge bought(Bill, x_i))$ *Intensional Functional Application*

$[\![3]\!] = \lambda P\ \exists x\ [book(x) \wedge P(x)](\lambda x_i[p = {}^\wedge bought(Bill, x_i)])$ *Functional Application*

$\Rightarrow \exists x[book(x) \wedge \lambda x_i[p = {}^\wedge bought(Bill, x_i)](x)]$ *λ-conversion*

$\Rightarrow \exists x[book(x) \wedge [p = {}^\wedge bought(Bill, x)]$ *λ-conversion*

$\Rightarrow \lambda p \exists x\ [book(x) \wedge p = {}^\wedge bought(Bill, x)]$ *Abstraction over p*

b. {^Bill bought Emma, ^Bill bought Persuasion}

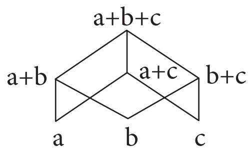
c. Set of Individuals = {b, j, b+j} Set of objects = {E, P, E+P}

We now know the sense in which this is a blend of the Hamblin–Karttunen analyses of questions. The mapping from syntax to semantics, following the lead of Heim (1989), Bittner (1994, 1998) and von Stechow (1996), is closely modeled after Karttunen. C^0 is the point in the structure where the question nucleus is determined and the shift to interrogative meaning effected. The wh phrase is interpreted as an existential quantifier binding a variable from outside C^0 into a position inside the nucleus.[23] Based on arguments in Dayal (1996), it removes reference to truth from the conditions placed on propositions, resulting in the kind of Hamblin sets seen in (62b).

An addition to this system is the interpretation of number in the wh phrase. Following Dayal (1991a, 1991b), we adopt the ontology of individuals from Sharvy (1980) and Link (1983): singular terms denote in the atomic domain while plural terms denote atomic and plural individuals. This gives rise to different Hamblin sets for singular, plural, and neutral wh terms:

[23] For recent developments in the syntax–semantics mapping for questions, see Fox (2012) and its presentation in Nicolae (2013).

(63) a.



b. {^Bill saw a, ^Bill saw b, ^Bill saw c} *for which N_{SING}, for what/who*

c. {^Bill saw a, ^Bill saw b, ^Bill saw c,
^Bill saw a+b, ^Bill saw b+c, ^Bill saw a+c,
^Bill saw a+b+c} *for which N_{PLURAL}, for what/who*

We also adopt from Dayal (1996) the answerhood operator in (64a), and incorporate into it Heim's (1994) proposal for a second answerhood operator, in (64b). These operators introduce Karttunen's truth requirement. They are defined to apply to Hamblin sets and, when defined, to pick out a unique maximally informative true proposition from that set:

(64) a. $\text{Ans-D}_W\ (Q) = \lambda w\ \iota p[p_w \wedge p \in Q \wedge \forall p'\ [[p'_w \wedge p' \in Q] \rightarrow p \subseteq p']]$

b. $\text{Ans-D/H}_S\ (Q) = \lambda w\ \lambda w'[\text{Ans-D}_W(Q)(w) = \text{Ans-D}_W(Q)(w')]$

The first operator captures weak exhaustiveness: knowing or telling a question, for example, merely requires the attitude holder to bear the relevant relation to the true propositions in the question denotation but says nothing about their relation to the false ones. The second operator captures strong exhaustiveness which requires the attitude holder to distinguish between the true and the false propositions in the set. For now, we remain neutral on whether both answerhood operators are needed in the grammar, noting only the flexibility afforded by the two operators.

The combination of questions as Hamblin sets, wh phrases restricted by the semantics of number, and answerhood operators, gives us the following question–answer paradigms. Assume a situation where Bill saw Alice but not Betty or Cal for (65), and a situation where Bill saw Alice and Betty but not Cal for (66):

(65) a. Which woman/who did Bill see?

b. Ans-D_W (63b): Bill saw Alice.

c. Ans-D/H_S (63b) = Bill saw only Alice

(66) a. Which women/who did Bill see?

b. Ans-D_W (63c): Bill saw Alice and Betty.

c. Ans-D/H_S (63c) = Bill saw only Alice and Betty.

If Bill saw no one or more than one woman, (65a) with a singular wh, is infelicitous because Ans-D is undefined. If Bill saw no one or only one woman, (66a) with the plural wh, is infelicitous. The source of the infelicity is different in the two cases. If he saw no one, Ans-D is undefined. If he saw only one woman, however, Ans-D is defined but the implicature of plurality that stems from the presupposition behind the question is not satisfied. As a consequence of the theory adopted here, the response *no one* is not a direct answer to the question and must be handled separately.

We also noted differences between ordinary and clefted questions and the possibility of differentiating them on the basis of soft vs. hard presupposition triggers, following Abusch (2010). A constituent question has a soft presupposition: (*Assuming that someone left*), *who left?* The clefted question has a hard presupposition: *(Someone left*), *who was it that left?*

Turning to embedded contexts, we followed Lahiri (1991, 2000, 2002a) in allowing answerhood operators to include other types of restrictions based on the lexical semantics of the embedding verb, while keeping the truth requirement as a default. We followed Beck and Rullmann (1999) and Sharvit (2002) in deriving the difference between *de dicto* and *de re* readings of wh phrases by interpreting the common noun inside the question nucleus and allowing its world variable to be bound within the nucleus, yielding *de dicto* readings, or to remain free and be identified with the world of evaluation, yielding *de re* readings. In the first case, the attitude holder recognizes the membership of the relevant individuals in the common noun predicate, in the second the attitude holder need not have this knowledge.

Examples (65) and (66) show that answerhood operators mediate between question–answer dialogues across speakers. They also mediate in embedded contexts such as the one in (67a). Since *know* is extensional, we get a relation between individuals and propositions (67b):

(67) a. [John knows [where Mary is]]
b. $\text{know}_w\ (j, \lambda w'\ \iota p(p_{w'} \wedge p \in Q \wedge \forall p'\ [[p'_{w'} \wedge p' \in Q] \rightarrow p \subseteq p'])\ (w))$
$\Rightarrow \text{know}_w\ (j, \iota p(p_w \wedge p \in Q \wedge \forall p'\ [[p'_w \wedge p' \in Q] \rightarrow p \subseteq p']))$

We have not addressed the precise status of these operators. The following possibilities suggest themselves (thanks to Gennaro Chierchia, p.c. for discussion):

(68) a. know(x,Q) $\leftrightarrow$ know (x, Ans-D(Q)) *via a Meaning Postulate*
b. $[\![\text{know}_Q]\!] = \lambda Q\ \lambda x$ [know (x, Ans-D(Q))] *via lexically triggered type-shift*
c. [know [OP_{ANS} [$_{\text{CP}}$ ...]]] *via a syntactically projected null OP*

We know we want a dependency between the presuppositions of the embedding predicate and the restrictions encoded in the answerhood operator. At this point, all three options appear plausible enough ways of capturing this dependency.

Let us end with two contexts where answerhood operators do not play a role. We saw that in scope marking constructions the second question must contribute pure Hamblin sets, without the mediation of Ans-D. The schema in (69a) has Ans-D associating with the Hamblin set denoted by the full structure, but not with the set denoted by CP2:

(69) a. $^{\text{OK}}$Ans-D(CP3) *Ans-D(CP2)
[$_{\text{CP3}}$ [$_{\text{CP1}}$what does John think?] [$_{\text{CP2}}$Where is Mary?]]]
b. [$_{\text{VP}}$ wonder/ask (?Ans-D) [$_{\text{CP}}$ where is Mary]]

We might also ask whether Ans-D is implicated in the case of predicates like *wonder* or *ask* that exclusively embed questions rather than questions and propositions (69b). It may well not come into play in such cases, thereby allowing the relation to hold directly with the Hamblin set denoted by the question. Alternatively, such predicates may also involve Ans-D but the predicates would not license the shift from a propositional concept to a proposition. This would maintain the distinction between intensional and extensional predicates going back to Karttunen, but would replicate Gr&S's (1982) distinction between type *<<s,<s,t>>,<e,t>>* for intensional predicates and type *<<s,t>,<e,t>>* for extensional ones.

This, then, is a snapshot of where we are at this point in the study of questions. If you have thought about questions at all you will most likely balk at the somewhat monolithic feel of this concluding section. But hopefully it will not stop you from reading on. If you haven't thought much about questions, consider this one possible take on a complex aspect of natural language, one that has been subjected to forty years of formal analysis. The picture presented here should help you get started on some of the rich history that will unfold in the pages to come.