

Introduction to the semantics of questions

Radek Šimík
University of Potsdam, SFB 632
simik@uni-potsdam.de

EGG summer school, July 25–29, 2011, České Budějovice

Contents

1	Introduction	5
1.1	Questions and truth-conditions	5
1.2	Goals of the class	5
1.3	Structure of the class	6
1.4	Theoretical background	6
1.4.1	Set theory	6
1.4.2	Proposition logic	7
1.4.3	Predicate logic	7
1.4.4	Possible worlds	8
1.4.5	Basic concepts in formal semantics	8
1.5	Exercises	10
2	Theories of interrogative meaning	13
2.1	Embedding approaches	14
2.1.1	Performative embedding approach	14
2.1.2	Imperative-epistemic embedding approach	14
2.2	Propositional approaches	16
2.2.1	Hamblin’s original proposal	16
2.2.2	Karttunen: True answers	18
2.2.3	Groenendijk & Stokhof: Strong exhaustivity, partitions	20
2.3	Categorial approaches	24
2.3.1	General shape of the account	24
2.3.2	Structured meaning approach	26
2.4	Exercises	26
3	Broadening the empirical range	29
3.1	A typology of reactions to questions	29
3.1.1	Formal classification	30
3.1.2	Semantic classification	31
3.1.3	Pragmatic classification	34
3.1.4	Summary	35
3.2	A typology of questions	35
3.2.1	What is the syntactic status of a question?	36
3.2.2	Where in the question is the information gap and how is it represented?	36
3.2.3	Does a question seek information?	37
3.2.4	What kind of information does a question seek?	39
3.2.5	Summary	40

3.3	Multiple wh-questions	41
3.3.1	Baseline	41
3.3.2	Pair-list readings	43
3.3.3	Single-pair readings	46
3.4	Exercises	48

Lecture 1

Introduction

1.1 Questions and truth-conditions

The basic problem

- Truth-conditional semantics (e.g. Tarski 1944; Hedde's class)
 - (1) *Meaning of a sentence*
To know the meaning of a sentence is to know the conditions under which the sentence is true.
- Declarative sentences (assertions) can be judged true or false
 - (2) Jupiter has 64 moons
 - a. is **true** iff Jupiter has 64 moons
 - b. and **false** otherwise
- Questions, on the other hand, cannot
 - (3) How many moons does Jupiter have?
- **Problem:** How can we characterize the meaning of questions within truth-conditional semantics?
- The most wide-spread and well-accepted solution (e.g. Hamblin 1958)
 - (4) *Meaning of a question*
To know the meaning of a question is to know the conditions under which the question is answered.
- ...and: answers are declarative sentences!

1.2 Goals of the class

- Being able to read papers on question semantics and pragmatics

- Understanding terminology
- Understanding the basic formalisms
- Knowing the typology of questions and answers
- Knowing the conceptual, theoretical, and empirical issues which have had impact on theory-building

1.3 Structure of the class

- Day 1: Background in set theory, logic, and formal semantics
- Day 2: Theories of interrogative meanings, and their workings shown on a fragment of simple questions
- Day 3/4: Broadening the empirical range, providing a classification of questions, terminology, and also showing how the theories introduced can account for the various types of questions
- Day 4/5: Questions in discourse, how can the theories of questions outlined be used for the understanding of some pragmatic phenomena

Further things to note:

- Exercises

A terminological note: Questions and/vs. interrogatives

- These two terms are mostly used interchangeably
- Some linguists use questions for the semantic/pragmatic level (assertions) and interrogatives for the syntactic/formal level (declaratives)

1.4 Theoretical background

1.4.1 Set theory

- set $\{\dots\}$
- ordered set $\langle \dots \rangle$
- element/member of a set \in
- (proper) subset $\subseteq (\subset)$
- (proper) superset $\supseteq (\supset)$
- union \cup
- intersection \cap
- sets of sets $\{\{\dots\}\}$
- singleton set
- the empty set \emptyset

1.4.2 Proposition logic

- truth and falsity 1, 0
 - (5) John is sleeping.
- negation \neg
 - (6) John is not sleeping.
- conjunction \wedge
 - (7) John is sleeping and Mary is running.
- disjunction \vee
 - (8) John is sleeping or Mary is running.
- implication \rightarrow
 - (9) If John is sleeping then Mary is running.

Table 1.1: Truth value table

p	q	$p \wedge q$	$p \vee q$	$\neg p$	$p \rightarrow q$
1	1	1	1	0	1
1	0	0	1	0	0
0	1	0	1	1	1
0	0	0	0	1	1

- entailment \Rightarrow
 - (10)
 - a. John has a VW.
 \Rightarrow / \Leftarrow
 - b. John has a car.

1.4.3 Predicate logic

- constants
 - (11)
 - a. John $\rightsquigarrow j$
 - b. sleep $\rightsquigarrow S$
 - c. John is sleeping $\rightsquigarrow S(j)$
 - d. John is sleeping and Mary is running $\rightsquigarrow S(j) \wedge R(m)$
- variables
 - (12)
 - a. x
 - b. P

- one-place predicate \leftrightarrow property \leftrightarrow set of elements

- (13)
- sleep $\rightsquigarrow \{x : \text{sleep}'(x)\}$
 - chair $\rightsquigarrow \{x : x \text{ is a chair}\}$
 - expensive lunch $\rightsquigarrow \{x : x \text{ E}(x) \wedge \text{L}(x)\}$

- n -place predicate \leftrightarrow relation (between n elements) \leftrightarrow set of ordered n -tuples of elements

- (14)
- watch $\rightsquigarrow \{\langle x, y \rangle : \text{watch}'(y, x)\}$
 - give $\rightsquigarrow \{\langle x, y, z \rangle : x \text{ gives } y \text{ to } z\}$

- existential and universal quantification

- (15)
- Some student is sleeping $\rightsquigarrow \exists x[x \text{ is a student and } x \text{ is sleeping}]$
 - Every chair is occupied $\rightsquigarrow \forall x[\text{C}(x) \rightarrow \text{O}(x)]$

1.4.4 Possible worlds

- What are propositions? One place world-predicate \leftrightarrow property of worlds \leftrightarrow a set of worlds.

(16) It is a property of our world that...

(17) It is a property of John that he...

- A proposition is true or false **with respect to some world** (typically our, actual world).
- A proposition is a set of possible worlds in which it is true.
- Entailment in possible-world semantics equals the subset/superset relation:

- (18) *Proposition logic*
- John has a VW.
 \Rightarrow / \Leftarrow
 - John has a car.

- (19) *Possible world semantics*
- $\{w : \text{John has a VW in } w\}$
 $\subseteq / \not\subseteq$
 - $\{w : \text{John has a car in } w\}$

1.4.5 Basic concepts in formal semantics

- **Object language vs. metalanguage** Tarski's (1944 T-sentences:

- (20)
- Every EGG student loves semantics *object language*
is true iff
 - Every EGG student loves semantics (= 1) *metalanguage*

- With (20), we'd be done very quickly; we know object language is structured (sentences are composed of parts); also our metalanguage is slightly more elaborate—propositional and predicate logic

$$(21) \quad \begin{array}{ll} \text{a.} & [\text{VP} [\text{DP} \text{Every} [\text{NP} \text{EGG student}]] [\text{V}' \text{loves} [\text{DP} \text{semantics}]]] \quad \textit{object language} \\ & \textit{is true iff} \\ \text{b.} & \forall x[\text{EGG.student}'(x) \rightarrow \text{loves}'(s, x)] (= 1) \quad \textit{metalanguage} \end{array}$$

- The **interpretation function** $\llbracket \cdot \rrbracket^{M,w,g}$ sends object language expressions to metalanguage expressions

$$(22) \quad \begin{array}{ll} \text{a.} & \llbracket \text{John} \rrbracket = j \\ \text{b.} & \llbracket \text{smokes} \rrbracket = \text{smokes}' = \{x : \text{smokes}'(x)\} \\ \text{c.} & \llbracket \text{loves} \rrbracket = \text{loves}' = \{\langle x, y \rangle : \text{love}'(x, y)\} \\ \text{d.} & \llbracket \text{John smokes} \rrbracket = 1 \text{ iff } \text{smokes}'(j) = 1 \end{array}$$

- **Lambda notation**; sets can be represented as functions from (potential) set-members to truth-values

$$(23) \quad \begin{array}{ll} \text{a.} & \llbracket \text{smokes} \rrbracket = \lambda x[\text{smokes}'(x)] \\ \text{b.} & \llbracket \text{loves} \rrbracket = \lambda \langle x, y \rangle [\text{loves}'(x, y)] = \lambda y \lambda x [\text{loves}'(x, y)] \end{array}$$

- **Function application** is used for computing the meaning of complex expressions

$$(24) \quad \begin{array}{ll} \text{a.} & f(a) = b \\ \text{b.} & \text{The function } f \text{ maps } a \text{ (an element in its domain) to } b \text{ (i.e. } f(a)) \text{ (an element in its range).} \end{array}$$

$$(25) \quad \begin{array}{ll} \text{a.} & \lambda x[\text{smokes}'(x)](j) = 1 \text{ (iff } \text{smokes}'(j) = 1) \\ \text{b.} & \text{The function } \text{smokes}' \text{ maps } j \text{ (an element in its domain) to } 1 \text{ (an element in its range).} \end{array}$$

- **Lambda conversion/reduction**: (i) take the argument of a function (j), (ii) put it into all the position of the variable “bound” by the outer-most lambda (x), (iii) remove the lambda along with the variable:

$$(26) \quad \begin{array}{ll} \text{a.} & \lambda x[\text{smokes}'(x)](j) \quad \textit{by function application} \\ \text{b.} & \text{smokes}'(j) \quad \textit{by lambda reduction} \end{array}$$

$$(27) \quad \begin{array}{ll} \text{a.} & [\lambda x \lambda y [\text{loves}'(x, y)](s)](j) \quad \textit{by function application} \\ \text{b.} & \lambda y [\text{loves}'(y, s)](j) \quad \textit{by lambda reduction} \\ \text{c.} & \text{loves}'(j, s) \quad \textit{by lambda reduction} \end{array}$$

- **Type theory**; semantic types divide expressions in the metalanguage into categories

$$(28) \quad \begin{array}{ll} \text{Primitive types} & \\ \text{a.} & t \quad \text{the type of truth-values} \\ \text{b.} & e \quad \text{the type of entities/individuals} \\ \text{c.} & s \quad \text{the type of possible worlds} \end{array}$$

- (29) Basic functional types
- $\langle e, t \rangle$ the type of functions from individuals to truth values (one-place individual predicates)
 - $\langle e, \langle e, t \rangle \rangle$ the type of functions from individuals to one-place individual predicates
 - $\langle s, t \rangle$ the type of functions from possible worlds to truth values (propositions)

• **Domains** of expressions of particular types

- (30)
- D_t is the domain of all expressions of type t (i.e. $\{1, 0\}$)
 - D_e is the domain of all expressions of type e (e.g. j, s)
 - $D_{\langle e, t \rangle}$ is the domain of all expressions of type $\langle e, t \rangle$ (e.g. *smokes'*)
 - ...

1.5 Exercises

1. Look at the statements in (31) and fill in the right part of the equation in (32) (careful: not all are defined)

- (31)
- Let $A = \{a, b, c\}$ and $B = \{a, \{b, c\}, d\}$.
 - Let $a, b, c, d \in D_e$.
 - Let $p = \text{John is asleep}$ and $q = \text{Mary is jogging}$.
 - Let $p, q \in D_t$.
 - Let $p = 1$ and $q = 0$.

- (32)
- $p \wedge q =$
 - $A \cap B =$
 - $B \cup p =$
 - $\neg q =$
 - $A \cup B =$
 - $q \vee c =$
 - $p \vee q =$
 - $p \rightarrow q =$

2. Provide metalanguage expressions for the following object language expressions, i.e. “feed” the expressions into the interpretation function $\llbracket \cdot \rrbracket$ and provide the value of the function.

- (33)
- Mary
 - student
 - bigger than
 - know

3. Convert set-notation to lambda-notation

- (34)
- $\{x : \text{pen}'(x)\}$
 - $\{a, b, c\}$
 - $\{\langle x, y \rangle : x \text{ is taller than } y\}$

4. Convert lambda-notation to set-notation

- (35) a. $\lambda x \lambda y [\text{saw}'(y, x)]$
b. $\lambda z [\text{Mary likes to read } z]$
c. $\lambda w [\text{George Bush was never elected President in } w]$

5. Reduce the following lambda-terms (so that you end up with lambda-free (truth-value denoting) expressions)

- (36) a. $\lambda x [x \text{ spoke with } p](k)$
b. $\lambda P [P(m)](\lambda x [\text{sleep}'(x)])$

6. Come up with a statement which entails (37). Come up with a statement which is entailed by (37).

- (37) Mary went to New York.

Lecture 2

Theories of interrogative meaning

Problem

- Non-assertive sentences, particularly questions, do not straightforwardly map to standard assertive sentential meanings, i.e. truth values.

Goal

- Come up with an intuitively appealing, empirically accurate, and, from the perspective truth-conditional semantics, familiar meaning of questions.

Three types of theories:¹

1. **Embedding approaches** Questions are hidden assertions/imperatives.

- (1) a. $\llbracket \text{Who came?} \rrbracket = \llbracket \text{I ask who came} \rrbracket$ or $\llbracket \text{Tell me who came} \rrbracket$
b. $\llbracket \text{Did John come?} \rrbracket = \llbracket \text{I ask whether John came} \rrbracket$ or $\llbracket \text{Tell me whether John came} \rrbracket$

2. **Propositional approaches** An interrogative maps to a (set of) proposition(s) which correspond to its answer(s).

- (2) a. $\llbracket \text{Who came?} \rrbracket = \{\text{Karen came, Laura came, Mary came, } \dots \}$
b. $\llbracket \text{Did John come?} \rrbracket = \{\text{John came, John didn't come}\}$

3. **Categorial approaches** An interrogative maps to a function from (short) answers to propositions.

- (3) a. $\llbracket \text{Who came?} \rrbracket = \{\text{Karen, Laura, Mary}\}$
b. $\llbracket \text{Did John come?} \rrbracket = \{\text{yes, no}\}$

Before we move on:

- For now we don't want our theories to do very much—an account of a fragment of the empirical field is satisfactory.
- Yes-no questions, wh-questions
- Embedded/indirect questions, Root/matrix questions

¹This tripartite classification has its source in Groenendijk and Stokhof (1984b) and Berman (1991). It is good to keep in mind that these classes are not clear-cut and have a lot of intersections.

2.1 Embedding approaches

General idea

- Questions never stand alone, they are always embedded, and it is the whole expression which is assigned a truth-value.

2.1.1 Performative embedding approach

Lewis (1970), among others

- Questions are embedded under covert performative predicates such as I-ASK

- (4)
- a. Who came?
 - b. I-ASK [who came]
 - c. ‘I ask who came’ is **true** iff I ask who came.

Problems:

- Shifting the problem away: What is the meaning of the embedded part?
- The approach has nothing to tell about questions embedded under non-performative predicates (e.g. *I know who came*).
- The question comes out as trivially true; it is verified automatically by the act of asking (which is not a problem *per se*.)
- A parallel approach to declaratives, however, leads to a serious problem:

(5)

 - a. John came.
 - b. I-SAY [John came]
 - (i) ‘I say that John came’ is **true** iff I say that John came.
- (5) comes out as trivially true—being verified by the very act of saying that John came; yet, if I say that John came, it is not automatically true that John came.

2.1.2 Imperative-epistemic embedding approach

Hintikka (1974, 1976, 1983); Boër (1978), among others

- Questions embedded under two covert operators:

1. BRING-IT-ABOUT (*imperative*)
2. I-KNOW (*epistemic*)

- (6) *Yes-no question*
- a. Did John come?
 - b. BRING-IT-ABOUT

<i>if John actually came</i>	I-KNOW [John came]
and	
<i>if John actually didn't come</i>	I-KNOW [John didn't come]

- (7) *Suppose that the fact is that John came, then (a) means (b)*
- a. Did John come?
 - b. BRING-IT-ABOUT [I-KNOW [John came]]
- (8) *Wh-question*
- a. Who speaks Icelandic?
 - b. BRING-IT-ABOUT
 - (i) $\forall x$ [x actually speaks Icelandic] [I-KNOW [x speaks Icelandic]]
or (depending on pragmatics)
 - (ii) $\exists x$ [x actually speaks Icelandic] [I-KNOW [x speaks Icelandic]]
- (9) *Suppose that Karen, Laura, and Mary (and nobody else) speak Icelandic, then (a) means (b-i) under (8b-i) and (b-ii) under (8b-ii):*
- a. Who speaks Icelandic?
 - b. (i) BRING-IT-ABOUT [I-KNOW [Karen speaks Icelandic] **or** I-KNOW [Laura speaks Icelandic] **or** I-KNOW [Mary speaks Icelandic]]
 - (ii) BRING-IT-ABOUT [I-KNOW [Karen speaks Icelandic] **and** I-KNOW [Laura speaks Icelandic] **and** I-KNOW [Mary speaks Icelandic]]
- ≡
BRING-IT-ABOUT [I-KNOW [Karen, Laura, and Mary speak Icelandic]]

Some virtues

- Questions defined in terms of (embedded) propositions: a familiar semantic object (sets of possible worlds)
- The analysis straightforwardly extends to questions embedded under epistemic verbs:

- (10)
 - a. I know who speaks Icelandic.
 - b. $\forall x$ [x speaks Icelandic] [I know that x speaks Icelandic]
 - or
 - c. $\exists x$ [x speaks Icelandic] [I know that x speaks Icelandic]

Some problems

- Questions are characterized in terms of imperatives, which is also a hard nut for truth-conditional semantics.
- Not completely clear how to analyze questions embedded under verbs which embed no propositions or questions in subject positions:

- (11)
 - a. I wonder whether John speaks Icelandic.
#If John speaks Icelandic then I wonder that he speaks Icelandic.
 - b. Who came depends on who called. Karttunen (1977)

- Some of these problems can be tackled by verb decomposition; (12) \approx (11a):

(12) I want to know whether John speaks Icelandic.
If John speaks Icelandic then I want to know that John speaks Icelandic.

- Conceptual problem: A lot of covert structure is needed. Paradoxically, root questions are structurally more complex than embedded questions (along with their embedders).

2.2 Propositional approaches

General idea

- A question characterizes the set of its answers.
- Hamblin postulates (Hamblin 1958)
 1. an answer to a question is a statement
 2. knowing what counts as an answer is equivalent to knowing the question
- Answerhood-conditions: Questions characterize the conditions under which they are answered.²

Development of the propositional approach^{3,4}

- Hamblin (1958) comes up with the idea⁵
- Hamblin (1973) provides compositional Montague semantics
- Karttunen (1977) extends the empirical coverage of the propositional approach; introduces the notion of the *true/weakly exhaustive answer*
- Groenendijk and Stokhof (1984b) work out a particular version of the propositional version based on the notion of a *partition* of the set of possible worlds; introduce the notion of the *strongly exhaustive answer* and *partial answer*

2.2.1 Hamblin's original proposal

Hamblin (1973)

- A question denotes a set of statements which count as **possible answers** to that question.
- Statements count as possible answers irrespective of whether they are true or false. The important thing is that they address the question (in an intuitive sense).

(13) *Yes-no question*

²Compare Truth-conditions: Declaratives characterize the conditions under which they are true.

³Obviously, this is very simplified.

⁴See Groenendijk and Stokhof (1984b: p. 70, footnote 38), who suggest that there is no substantial difference between Hamblin's (1973) and Karttunen's (1977) analysis. The difference is only apparent and arises from a terminological confusion.

⁵Hiž (1978) also cites Stahl (1956).

- a. Does Obama speak Bahasa Indonesia?
 b. {Obama speaks Bahasa Indonesia, Obama doesn't speak Bahasa Indonesia}
 c. $\lambda p[p = \text{Obama speaks Bahasa Indonesia} \vee p = \text{Obama doesn't speak Bahasa Indonesia}]$
- (14) *Wh-question*
- a. Which American presidents spoke German?
 b. {Washington spoke German, Jefferson spoke German, Lincoln spoke German, Roosevelt spoke German, Wilson spoke German, ...}
 c. $\{p : p = x \text{ spoke German} \mid x \in \text{American.president}'\}$
 d. $\lambda p \exists x[\text{American.president}'(x) \wedge p = x \text{ spoke German}]$

Compositionality: Hamblin's denotation of wh-words

- Hamblin has nothing interesting to say about yes-no questions, but his proposal for wh-words has been extremely influential, giving rise to a whole paradigm called *Hamblin semantics*.⁶
- Let us first consider the derivation of the truth-conditions of a simple declarative. Proper names like *Karen* denote individuals (15a) and one-place predicates like *came* denote functions from individuals to truth-values (15b). If we compose the two by function application and apply the rule of lambda conversion, we arrive at the truth-value (15c)—1 (true) iff Karen came and 0 (false) otherwise.

- (15) Karen came
- a. $\llbracket \text{Karen} \rrbracket = k \quad \in D_e$
 b. $\llbracket \text{came} \rrbracket = \text{came}' = \lambda x[\text{came}'(x)] \quad \in D_{\langle e,t \rangle}$
 c. $\llbracket \text{Karen came} \rrbracket$
 = 1 iff Karen came $\in D_t$
 = $\llbracket \text{came} \rrbracket(\llbracket \text{Karen} \rrbracket)$
 = $\lambda x[\text{came}'(x)](k)$ (by function application)
 = $\text{came}'(k)$ (by lambda conversion)

- Now for an interrogative. Hamblin's main idea is that question words like *who* denote **sets of individuals** (16a). In standard semantics, *who* cannot compose with one-place predicates like *came* because it is not of the right type (it is not an individual, but rather a set of individuals). Therefore, we need a composition new rule—the rule of **pointwise function application**. The input to this rule is not *who* itself, but, in a “pointwise” (step-by-step) fashion all the individuals contained in the denotation of *who*. This, then, gives rise to the derivation of a set of propositions: each member of the set being the result of a function application of one of the individuals with the predicate.⁷

- (16) Who came?
- a. $\llbracket \text{who} \rrbracket = \{x : \text{human}'(x)\}$ (e.g. {k, l, m}) $x \in D_e$

⁶Versions of Hamblin semantics have been used extensively for the semantics of focus (e.g., Rooth 1985, 1992), for the semantics of indefinites (e.g., Ramchand 1996, 1997; Kratzer and Shimoyama 2002; Menéndez-Benito 2005), or disjunction (Alonso-Ovalle 2006).

⁷In fact, Hamblin generalizes his set-semantics to all denotations, assuming that proper names and other non-logical constants denote singleton sets. This assumption has also been adopted e.g. by Kratzer and Shimoyama (2002).

- b. $\llbracket \text{came} \rrbracket = \text{came}' = \lambda x[\text{came}'(x)] \in D_{\langle e,t \rangle}$
- c. $\llbracket \text{Who came?} \rrbracket$
 $= \{p : p \text{ can be an answer to } \textit{Who came?}\}$
 $= \llbracket \text{came} \rrbracket(\llbracket \text{who} \rrbracket)$
 $= \lambda x[\text{came}'(x)](\{k, l, m\})$ (by pointwise function application)
 $= \{\lambda x[\text{came}'(x)](k), \lambda x[\text{came}'(x)](l), \lambda x[\text{came}'(x)](m)\}$
 $= \{\text{came}'(k), \text{came}'(l), \text{came}'(m)\}$ (by lambda conversion)

2.2.2 Karttunen: True answers

Karttunen (1977)

- A question denotes a set of statements which count as **true answers** to that question
- Each of the statements in the set is a **partial** true answer and the conjunction of all partial true answers is the **complete** true answer. Of course, it is possible that the complete answer is either a singleton set (there is a single statement in the answer set) or even that it is the empty set (there is no true statement in the answer set).
- Karttunen deals mainly with embedded interrogatives; for root interrogatives, he would adopt some embedding approach.

(17) Notation: $\forall p = p(w_0)$ iff $p(w_0) = 1$, where w_0 is the actual world

(18) *Yes-no question*

- ... whether Obama speaks Bahasa Indonesia.
- $\{\text{Obama speaks Bahasa Indonesia}\}$
- $\lambda p[\forall p \wedge [p = \text{Obama speaks Bahasa} \vee p = \text{Obama doesn't speak Bahasa}]]$
- $\lambda p[p = \text{Obama speaks Bahasa}]$

(19) *Wh-question*

- ... which American presidents spoke German.
- $\{\text{Franklin Roosevelt spoke German, Woodrow Wilson spoke German}\}$
- $\{p : \forall p \wedge p = x \text{ spoke German} \mid x \in \text{American.president}'\}$
- $\lambda p \exists x[\text{American.president}'(x) \wedge p : \forall p \wedge p = x \text{ spoke German}]$

- A question-embedding verb then selects for a question—an expression of type $\langle \langle s, t \rangle, t \rangle$, a set of true propositions, which is the set of sets of possible worlds such that each of those sets contains the actual world.

(20) John found out whether Obama speaks Bahasa Indonesia.

=

John found out that Obama speaks Bahasa Indonesia.

(21) John found out which American presidents spoke German.

= John found out that Franklin Roosevelt and Woodrow Wilson spoke German.

Some virtues:

- Why does Karttunen decide to single out the set of true answers from the set of (Hamblin's) possible answers? Some verbs clearly select for true answers, ignoring the false ones:

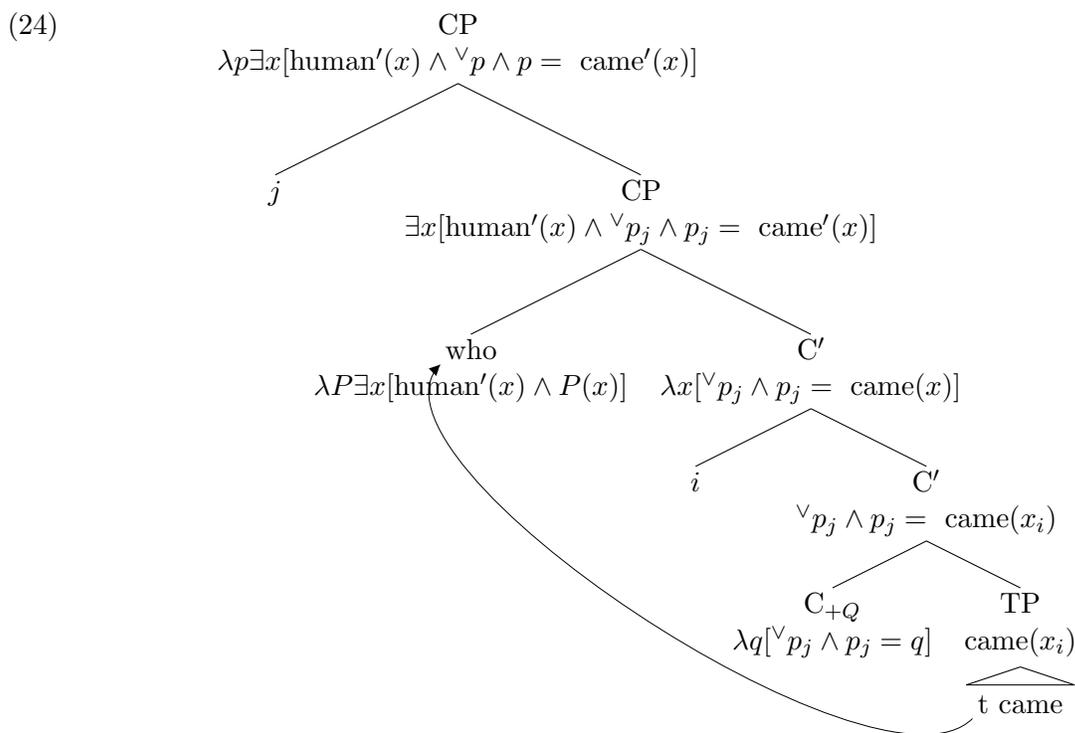
(22) Who comes depends on who is invited.

- This is especially striking with verbs which select for true propositions when they embed questions (23b), but are indifferent with respect to the truth of their declarative complements (23a).

(23) a. John told Mary that Susan passed the test.
b. John told Mary who passed the test.

Karttunen’s compositional semantics

- Karttunen is a representative of another influential stream in wh-semantics. He assumes that wh-phrases are essentially existential quantifiers—being related to indefinites (cf. *where – somewhere*). The set semantics therefore comes from an independent source—a specialized question operator.
- Below is a “modernized” compositional version of Karttunen’s proposal, along with a plausible syntactic analysis (an interrogative complementizer, wh-movement).⁸



A problem:

- **Absence of *de dicto* readings** Groenendijk and Stokhof (1984b) point out that Karttunen’s semantics is not capable of deriving *de dicto* readings of nominals contained in the wh-phrase.⁹

(25) John knows which stamp-collectors showed up.

⁸Karttunen’s involves non-compositional elements, as well as an old-fashioned notation, both of which would make it more difficult to understand.

⁹See also Heim (1994); Beck and Rullmann (1999); Sharvit (2002); among others, for a discussion of this issue.

- (26) *Suppose that Karen and Mary are the only stamp-collectors who showed up and John knows that*
- a. John knows which stamp-collectors showed up = **true**
- (27) *Suppose that Karen and Mary are the only stamp-collectors who showed up and John knows that they showed up but he has no idea that they collect stamps*
- a. John knows which stamp-collectors showed up = **true** *de re reading*
- b. John knows which stamp-collectors showed up = **false** *de dicto reading*

- Karttunen doesn't derive the false reading in (27b). This is because the phrase *which stamp collectors* is interpreted outside of the scope of the proposition. In order to see this, we need to use more complete representations than we have used so far, i.e. ones with explicit world variables; see (28). Notice that stamp-collector'(w)(x) is too "high" for its world variable w to get bound by the world variable w', introduced by the proposition p.

- (28) *Karttunen's de re interpretation of (25)*
 $\lambda w \lambda p \exists x [\text{stamp-collector}'(w)(x) \wedge p = \lambda w' [\text{showed.up}'(w')(x)] \wedge p(w) = 1]$

- What is needed is the following:¹⁰

- (29) *A de dicto interpretation of (25)*
 $\lambda w \lambda p \exists x [p = \lambda w' [\text{showed.up}'(w')(x)] \wedge \text{stamp-collector}'(w')(x) \wedge p(w) = 1]$

2.2.3 Groenendijk & Stokhof: Strong exhaustivity, partitions

Embedded questions (Groenendijk and Stokhof 1982, 1984b)

- An embedded question denotes the proposition which counts as the **single complete answer** (in the actual world).¹¹
- Consider **yes-no** questions:

- (30) *Yes-no questions*
- a. ... whether John came.
- b. $\lambda w [\text{came}'(j) \text{ in } w = \text{came}'(j) \text{ in } w_0]$
- c. In prose: The set of possible worlds at which the truth-value of 'John came' is identical to the truth-value of 'John came' in the actual world.
- (31) *Suppose that in fact (in the actual world) John didn't come, then (a) is identical to (b)*
- a. I know whether John came.
- b. I know that John didn't come.

- **Wh-questions**

- (32) *Wh-questions*

¹⁰Hamblin's (1973) analysis allows for the *de dicto* reading, since it assumes an in-situ interpretation of wh-phrases.

¹¹Strictly speaking, this only holds for *extensional* embedding verbs such as *know* or *tell*. *Intensional* embedding verbs (*ask*, *wonder*, *depend on*, etc.) embed *propositional concepts*, i.e. expressions of type $\langle s, \langle s, t \rangle \rangle$.

- a. ... who came.
- b. $\lambda w[\lambda x[\text{came}'(x) \text{ in } w] = \lambda x[\text{came}'(x) \text{ in } w_0]]$
- c. In prose: The set of possible worlds at which the set of people that came is identical to the set of people that came in the actual world.

(33) *Suppose that in fact John came and nobody else came (in the actual world), then (a) is identical to (b)*

- a. I know who came.
- b. I know that John came and that nobody else came.

The use of this

- **Exhaustivity** Consider the following entailment pattern, which Groenendijk and Stokhof (1984b:85) argue is valid:

- (34) a. John believes that Bill and Suzy walk.
b. Actually, only Bill walks.

c. John doesn't know who walks.

- Karttunen's truth-conditions are **weakly exhaustive**: they capture what actually happened, but remain silent about what actually did *not* happen. Hence, the entailment in (34) comes out as false under Karttunen.

- (35) a. John knows who walks.
is true iff
b. About all the people who actually walk (*Bill*), John knows that they walk, and...
c. ...it doesn't matter what John believes about people who actually don't walk (*Suzy*).

- Groenendijk and Stokhof's truth-conditions are **strongly exhaustive**: they capture both what actually happened and what actually did *not* happen. Hence, the entailment in (34) comes out as true under G&S.

- (36) a. John knows who walks.
is true iff
b. About all the people who actually walk (*Bill*), John knows that they walk, and...
c. ...about all the people who actually didn't walk (*Suzy*), John knows that they didn't walk.

- **Coordination** The assumption that questions denote propositions rather than sets of propositions receives support from the fact that embedded declaratives and interrogatives can be coordinated (data from Groenendijk and Stokhof 1984b:93):¹²

- (37) 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].

¹²Assuming some version of the "rule of coordination of likes" (e.g. Sag et al. 1985).

- **Wh-questions** divide the set of possible worlds into 2^n cells, where n is the cardinality of the set of individuals denoted by the wh-word. Suppose that *what* in (41a) ranges over tea and coffee (and nothing else); this gives rise to $2^2 = 4$ partition cells in the representation of the question.

(41) *Wh-question*

- What does John drink?
- $\{ \text{drink}'(j,t) \wedge \text{drink}'(j,c),$
 $\text{drink}'(j,t) \wedge \neg \text{drink}'(j,c),$
 $\neg \text{drink}'(j,t) \wedge \text{drink}'(j,c),$
 $\neg \text{drink}'(j,t) \wedge \neg \text{drink}'(j,c) \}$

- **Answers** Besides complete answers, the partition semantics allows for a natural characterization of partial answers. Consider once more the question above.

– *Complete answer* is any answer which removes all but one cell of the partition denoted by the question. (42) gives the array of all possible complete answers to (41).

- (42)
- John drinks nothing (neither tea nor coffee).
 - John drinks only tea.
 - John drinks only coffee.
 - John drinks both tea and coffee.

– *Partial answer* is any answer which removes at least one cell (but not all cells) of the partition denoted by the question. (43a) removes the cells where John doesn't drink tea. (43b) removes the single cell where John drinks both tea and coffee. (43c) removes the cells where John drinks coffee.

- (43)
- John drinks tea, though I'm not sure about coffee.
 - John definitely doesn't drink both of them.
 - John doesn't drink coffee.

Compositionality issues

- The partition semantics of root questions corresponds very nicely to the proposition semantics of embedded questions. All that is needed is a **propositional concept**, i.e. a proposition evaluated with respect to a world variable.¹⁵ In effect, root questions denote a relation between two worlds (a function of type $\langle s, \langle s, t \rangle \rangle$), particularly an **equivalence relation**—a direct correlate of a partition. The particular equivalence relation denoted by a question is characterized by the descriptive content of the question.
- In function-talk, a root question is a function which takes a world w and returns a set of worlds w' which are equivalent to w from the perspective of the question description.
- Below is a “modernized” example, again; the question *Who walks?* is a function from some world w (e.g. the actual world) to a set of worlds which are equivalent in the set of people who came.

¹⁵Groenendijk and Stokhof (1984b) argue that the propositional concept semantics is also needed for questions embedded under intensional verbs like *ask* or *wonder*.

- (48) *Wh-question*
 a. What did John have for dinner?
 b. λx [John had x for dinner]
- (49) *A question applied to an answer*
 a. – What did John have for dinner? – Salad.
 b. (i) λx [John had x for dinner](s)
 (ii) John had s for dinner *(by lambda reduction)*

Compositionality

- Categorical approaches need by far the least machinery to derive their question meanings. There is no need for a question operator. Wh-phrases are usually treated as logical lambdas (cf. Groenendijk and Stokhof 1984b).



The use of this

- It was argued that short answers are the “real” answers; for a collection of arguments, see Jacobson (2009), who, for instance, argues that (51B) undoubtedly entails that John is a professor, while (51B') has the opposite inference.

- (51) A Which professor came to the party?
 B John. *(John is surely a professor)*
 B' John came to the party. *(John is probably not a professor)*

Some problems

- **Semantic type non-uniformity** The semantic type of a question depends on the semantic type of the answer.

- (52)
- | | | | |
|----|---------------------|--------------------------------------|---|
| a. | Who came? | λx [came'(x)] | $\in D_{\langle e,t \rangle}$ |
| b. | When did John come? | λt [came'(j)(t)] | $\in D_{\langle i,t \rangle}$ |
| c. | What did John do? | λP [P(j)] | $\in D_{\langle \langle e,t \rangle, t \rangle}$ |
| d. | Why did John come? | λp [p caused John's coming] | $\in D_{\langle \langle s,t \rangle, t \rangle}$ |
| e. | Did John come? | λf [f(John came)] | $\in D_{\langle \langle \langle s,t \rangle, t \rangle, t \rangle}$ |

- This has rather serious consequences e.g. for **question-embedding** (question-embedding verbs must be multiply ambiguous) and **question coordination** (coordination of non-likes would have to be allowed).

2.3.2 Structured meaning approach

General idea (von Stechow 1982; von Stechow and Zimmermann 1984; Krifka 2001a)

- The structured meaning approach is the most worked-out and very popular variant of the categorial approach.
- Questions denote ordered pairs $\langle Q, D \rangle$, where Q is the denotation of a question under the categorial approach and D is the domain containing all the possible short answers to the question.

- (53) *Yes-no question*
- Is Mary happy?
 - $\langle \lambda f[f(\text{Mary is happy})], \{\text{yes, no}\} \rangle$
- (54) *Wh-question*
- What did Mary see?
 - $\langle \lambda x[\text{Mary saw } x], \text{thing}' \rangle$ ¹⁶

The use of this

- The structured meaning approach is particularly well-suited to the treatment of **question-answer congruence**. This is because also declaratives lend themselves to a structured meaning analysis. A declarative is analyzed as a pair $\langle B, F \rangle$, consisting of a background B —corresponding to the question Q above—and of a focus F —corresponding to the answer domain D above. Notice also that the application of the background to the focus yields standard propositional semantics—(55c) and (56c).

- (55) *Who slept?*
- JOHN slept.
 - $\langle \lambda x[\text{slept}'(x)], j \rangle$
 - $B(F) = \text{slept}'(j)$
- (56) *What did John do?*
- John SLEPT.
 - $\langle \lambda P[P(j)], \text{slept}' \rangle$
 - $B(F) = \text{slept}'(j)$

- In the end questions and answers (interrogatives and declaratives) receive a unified treatment, similarly as e.g. in the partition approach of Groenendijk and Stokhof (1984b) (where declaratives can also be treated as a subcase of interrogatives) and some embedding approaches (Hintikka 1976).

2.4 Exercises

1. How would you analyze (57) in Hintikka's semantics? Is the simple approach sufficient or is the additional assumption of verb decomposition needed?

¹⁶Recall that $\text{thing}' = \lambda x[\text{thing}'(x)] = \{x : \text{thing}'(x)\}$.

- (57) I asked whether John smoked.
2. What is the relation between (58a) and (58b) under Karttunen's and under Groenendijk and Stokhof's account, respectively? Are they truth-conditionally distinct or equivalent? What does your intuition tell you? Can you find any empirical arguments in one position or the other?
- (58) a. John knows who walks.
b. John knows who doesn't walk.
3. Higginbotham (1996) notices that Karttunen (1977) makes the undesirable prediction that (59a) and (59b) have the same answerhood conditions—i.e. they denote the same set of true propositions, which in turn means that they are essentially one and the same question. Can you spell out how this problem arises? Does the account of Groenendijk and Stokhof (1984b) fare any better?¹⁷
- (59) a. Which people in the classroom are students?
b. Which students are in the classroom?
4. Write down a structured proposition analysis of the question in (60a) and the corresponding answer in (60b). What do the two representations share?
- (60) a. Where does John live?
b. John lives in Melbourne.
5. We haven't discussed so-called multiple wh-questions, i.e. questions containing more than one wh-phrase, e.g. (61). Could you come up with a simple analysis of such questions in one of the approaches discussed?
- (61) Who brought what to the party?

¹⁷Two hints: (i) construct a simple model universe, e.g. with 8 individuals (give them names), 4 students, 2 of whom are in the classroom, and 4 non-students, 2 of whom are in the classroom; (ii) in order to get neat minimal pairs, ignore the semantics of 'people'.

Lecture 3

Broadening the empirical range

For a start

- So far, we only looked at a very limited range of question and answer types

Goals

- How can various

3.1 A typology of reactions to questions

- Consider the question in (1) and the reactions in (1a) through (1o).

- (1) Which elementary particles make up a typical atomic nucleus?
- a. Protons and neutrons.
 - b. Protons and neutrons make up the nucleus.
 - c. Protons and neutrons do.
 - d. Protons do.
 - e. Electrons make up the nucleus.
 - f. Electrons don't make up the nucleus.
 - g. There are two of them.
 - h. Protons and neutrons, except for the nucleus of hydrogen, which has no neutrons.
 - i. I believe that protons and neutrons do.
 - j. What the nucleus is surrounded by are electrons.
 - k. The only particles that the nucleus doesn't contain are those with a negative charge.
 - l. Protons and neutrons make up the NUCLEUS.
 - m. We haven't learned that yet.
 - n. Every kid knows that.
 - o. I'll have salmon.

- We can distinguish three criteria of reaction classification:
 1. Formal: Is the reaction a sentence or not? What form does the sentence have?
 2. Semantic: Is the reaction an answer or not? What kind of an answer is it?
 3. Pragmatic: Is the reaction felicitous/appropriate or not?

3.1.1 Formal classification

Short vs. full answers¹

- A **short answer** is illustrated in (2a) and a **full answer** in (2b).²

- (2) Which elementary particles make up the nucleus?
- Protons and neutrons.
 - Protons and neutrons make up the nucleus.

- **Categorial approaches** Short answers are basic and full answers are derived. The question in (2) is analyzed as a function from individuals to truth values (one-place predicate), (3a), and the answers must therefore be analyzed as individual-denoting expressions, (3b), despite the appearance of (2b).

- (3) a. Question: $\lambda x[\text{particle}'(x) \wedge \text{make.up.nucleus}'(x)] \in D_{\langle e,t \rangle}$
 b. Answer: $p \oplus n \in D_e$

- *Accounting for the full answer* Strictly speaking, the full answer is not an answer at all in this approach. However, given a structured meaning account of propositions (see section 2.3.2, it can be accessed in the semantics—being the focus of the proposition (the second member of the $\langle B, F \rangle$ pair):

- (4) $\langle \lambda x[\text{particle}'(x) \wedge \text{make.up.nucleus}'(x)], p \oplus n \rangle$

- **Propositional approaches** Short answers derived and sentential answers are basic. The question in (3) is analyzed as a set of propositions (leaving partitions aside), (5a) and the answers in (3a)/(3b) must therefore be semantically propositions, (5b), despite the appearance of (3a).

- (5) a. Question: $\lambda p \exists x[\text{particle}'(x) \wedge p = \text{make.up.nucleus}'(x)] \in D_{\langle \langle s,t \rangle, t \rangle}$
 b. $\text{make.up.nucleus}'(p \oplus n) \in D_t$

- *Deriving the short answer* The form-meaning discrepancy is typically bridged by the means of (TP) ellipsis, where the elided material (*make up the nucleus*) is licensed contextually by the material in the question.

- (6) Protons and neutrons [~~TP make up the nucleus~~].

- If short answers correspond to non-subjects (the elided part does not correspond to a constituent), syntactic movement is needed.

- (7) a. Who did John invite?
 b. Mary [~~TP John invited t~~].
 ↑

¹Short answers are also called non-sentential, fragment, constituent, and term answers. Full answers can also be referred to as sentential answers.

²For an extensive discussion of short answers, see von Stechow and Zimmermann (1984).

- **Intermediate cases** such as (8c) are derived from full answers by the means of ellipsis (e.g. VP-ellipsis), cf. (9).

(8) Which elementary particles make up the nucleus?

c. Protons and neutrons do.

(9) Protons and neutrons do [~~VP make up the nucleus~~].

Direct vs. indirect answers (applicable mainly to full answers)

- A **direct answer** bears a close formal resemblance to the question. Examples are (10b) and (10f):

(10) Which elementary particles make up the nucleus?

b. Protons and neutrons make up the nucleus.

f. Electrons don't make up the nucleus.

- An **indirect answer** bears little formal resemblance to the question and yet, it provides an answer to it. An example is in (11).

(11) Which elementary particles make up the nucleus?

k. The only particles that the nucleus doesn't contain are those with a negative charge.

- Indirect answers prove the need for a fairly abstract representation of the meaning of questions, i.e. in terms of sets of (sets of) possible worlds, rather than formal descriptions of these.

3.1.2 Semantic classification

Complete vs. partial answers (in the partition approach of Groenendijk and Stokhof 1984b)

- Recall: An **answer** is a reaction to a question which removes at least one cell of the partition denoted by the question. Any other reaction is not an answer.
- Consider the question in (12a). It denotes the partition in (12b). This partition is graphically represented in Table 3.1. (Let $\text{make.up.nucleus}' = N$ and $\text{particle}' = \{p, n, e\}$.)

(12) a. Which elementary particles make up a typical atomic nucleus?

b. $\lambda w \lambda w' [\lambda x [\text{particle}'(w)(x)] = \lambda x [\text{particle}'(w')(x)]]$

- A **complete answer** is an answer which removes all but one cell of the partition denoted by the question.
- An example of this answer is in (13b). The shaded cells in the partition 3.2 correspond to the cells that get “removed” after such an answer is uttered.

(13) Which elementary particles make up a typical atomic nucleus?

b. Protons and neutrons make up the nucleus [and no other particles do].

Table 3.1: The partition (12b)

$N(p)$	\wedge	$N(n)$	\wedge	$N(e)$
$N(p)$	\wedge	$N(n)$	\wedge	$\neg N(e)$
$N(p)$	\wedge	$\neg N(n)$	\wedge	$N(e)$
$\neg N(p)$	\wedge	$N(n)$	\wedge	$N(e)$
$N(p)$	\wedge	$\neg N(n)$	\wedge	$\neg N(e)$
$\neg N(p)$	\wedge	$N(n)$	\wedge	$\neg N(e)$
$\neg N(p)$	\wedge	$\neg N(n)$	\wedge	$N(e)$
$\neg N(p)$	\wedge	$\neg N(n)$	\wedge	$\neg N(e)$

Table 3.2: A complete answer

$N(p)$	\wedge	$N(n)$	\wedge	$N(e)$
$N(p)$	\wedge	$N(n)$	\wedge	$\neg N(e)$
$N(p)$	\wedge	$\neg N(n)$	\wedge	$N(e)$
$\neg N(p)$	\wedge	$N(n)$	\wedge	$N(e)$
$N(p)$	\wedge	$\neg N(n)$	\wedge	$\neg N(e)$
$\neg N(p)$	\wedge	$N(n)$	\wedge	$\neg N(e)$
$\neg N(p)$	\wedge	$\neg N(n)$	\wedge	$N(e)$
$\neg N(p)$	\wedge	$\neg N(n)$	\wedge	$\neg N(e)$

- A **partial answer** is an answer which removes some but not all cells of the partition denoted by the question.
- Examples of such an answer are in (14f) and (14g), represented graphically as 3.3 and 3.4, respectively.

- (14) Which elementary particles make up a typical atomic nucleus?
- Electrons don't make up the nucleus [but I have no idea which actually do].
 - There are two of them [though I have no idea which two].

Table 3.3: Partial answers under (14)f

$N(p)$	\wedge	$N(n)$	\wedge	$N(e)$
$N(p)$	\wedge	$N(n)$	\wedge	$\neg N(e)$
$N(p)$	\wedge	$\neg N(n)$	\wedge	$N(e)$
$\neg N(p)$	\wedge	$N(n)$	\wedge	$N(e)$
$N(p)$	\wedge	$\neg N(n)$	\wedge	$\neg N(e)$
$\neg N(p)$	\wedge	$N(n)$	\wedge	$\neg N(e)$
$\neg N(p)$	\wedge	$\neg N(n)$	\wedge	$N(e)$
$\neg N(p)$	\wedge	$\neg N(n)$	\wedge	$\neg N(e)$

True vs. false answers

- The **truth of a proposition** is evaluated with respect to an evaluation world, typically the actual world.

Table 3.4: The partial answer (14)g

$N(p)$	\wedge	$N(n)$	\wedge	$N(e)$
$N(p)$	\wedge	$N(n)$	\wedge	$\neg N(e)$
$N(p)$	\wedge	$\neg N(n)$	\wedge	$N(e)$
$\neg N(p)$	\wedge	$N(n)$	\wedge	$N(e)$
$N(p)$	\wedge	$\neg N(n)$	\wedge	$\neg N(e)$
$\neg N(p)$	\wedge	$N(n)$	\wedge	$\neg N(e)$
$\neg N(p)$	\wedge	$\neg N(n)$	\wedge	$N(e)$
$\neg N(p)$	\wedge	$\neg N(n)$	\wedge	$\neg N(e)$

- A proposition is **true** if the set of worlds that it denotes contains the actual world (the actual world is a member of the proposition) and it is **false** otherwise.
- (15b) is an example of a true answer and (15e) is an example of a false answer. Notice that false answer are still answers, as they remove at least one cell of a partition.

- (15) Which elementary particles make up a typical atomic nucleus?
- Protons and neutrons make up the nucleus.
 - Electrons make up the nucleus.

Over-informative vs. under-informative answers

- An **over-informative answer** is a subset which removes all but one cell from the partition that the question denotes and, in addition, a proper subset of the only cell left.
- (16b) is a complete answer to (16). The cell it leaves us with is one which is compatible with hydrogen containing neutrons. (16h) is over-informative, as it doesn't only provide us with the information about a *typical* atomic nucleus, but also about hydrogen which has a non-typical nucleus in that it contains no neutrons. Technically, the *except*-phrase in (16h) removes some worlds from the cell which the complete answer in (16b) yields.

- (16) Which elementary particles make up a typical atomic nucleus?
- Protons and neutrons make up the nucleus.
 - Protons and neutrons, except for the nucleus of hydrogen, which has no neutrons.

- An **under-informative answer** is, strictly speaking, not an answer at all.³ It is a reply which intuitively closely relates to the content of the question and is pragmatically relevant, but fails to remove any cell of the partition denoted by the question.
- (17i) and (17j) are examples. (17i) removes all the worlds where *I believe* that a typical nucleus contains something else than exactly protons and neutrons, but it doesn't us with information about what is *actually* the case. (17j) removes all the worlds where the nucleus is not surrounded by electrons, but doesn't tell us anything about the nucleus itself—which is what the question is about.

- (17) Which elementary particles make up a typical atomic nucleus?

³It is an oxymoron similar to “ungrammatical sentence”.

- i. I believe that protons and neutrons do.
- j. What the nucleus is surrounded by are electrons.

3.1.3 Pragmatic classification

Replies vs. inappropriate reactions

- A **reply** is a reaction which does not provide an answer to a question but is pragmatically relevant.
- We already saw an example of a reply in section 3.1.2—the under-informative “answer”. Further examples are in (18m) and (18n).

(18) Which elementary particles make up a typical atomic nucleus?

- m. We haven’t learned that yet.
- n. Every kid knows that.

- An **inappropriate reaction** is neither an answer nor a reply. An example is give in (19o).

(19) Which elementary particles make up a typical atomic nucleus?

- o. I’ll have salmon.

Congruent vs. incongruent answers

- **Question-answer congruence** If a language distinguishes the formal expression of new and old information in a sentence, the constituent(s) within the answer which correspond to the wh-phrase in a question must be marked as new (and vice versa). For instance, English marks the new-old distinction by means of intonation—the pitch accent in a sentence must be borne by word contained in an informationally new constituent.⁴

- A **congruent answer** is one in which question-answer congruence is respected. (20b) is an example: the pitch accent is placed on *protons and neutrons*

(20) Which elementary particles make up a typical atomic nucleus?

- b. PROTONS AND NEUTRONS make up the nucleus.

- An **incongruent answer** is one in which question-answer congruence is not respected. An example is in (21), where the pitch accent is placed on *nucleus*—a piece of old information.

- Incongruent answers are *semantically well-formed*—they express a proposition which is a (complete or partial) answer to the question. However, they are *pragmatically infelicitous* due to the use of an inappropriate formal expression.⁵

(21) Which elementary particles make up a typical atomic nucleus?

- l. Protons and neutrons make up the NUCLEUS.

⁴This is a big simplification and perhaps it’s even wrong.

⁵This is a simplification. The source of the unacceptability is an open issue and has been subject to long ongoing discussion. There are also accounts which attribute the unacceptability to a syntactic anomaly or to a semantic one.

3.1.4 Summary

We introduced a fine-grained structure into the set of reactions to questions and showed how these can be modeled by a theory of question semantics (and pragmatics), mostly by the partition approach of Groenendijk and Stokhof (1984b,a).

- I introduced the following taxonomy, which is a simplification (as all taxonomies are):
 - Formal classification
 - * Short vs. full answers
 - * Direct vs. indirect answers
 - Semantic classification
 - * Complete vs. partial answers
 - * True vs. false answers
 - * Over-informative vs. under-informative answers
 - Pragmatic classification
 - * Replies vs. inappropriate reactions
 - * Congruent vs. incongruent answers
- It should be obvious that one reaction can be assigned to more classes. Roughly, the following relations hold:
 - $\text{reactions} = \text{answers} \cup \text{replies} \cup \text{inappropriate reactions}$; $\{\text{answers, replies, inappropriate reactions}\}$ *is a partition of* reactions
 - $\text{answers} = \text{short answers} \cup \text{full answers}$; $\{\text{short answers, full answers}\}$ *is a partition of* answers
 - $\text{answers} = \text{direct answers} \cup \text{indirect answers}$; $\{\text{direct answers, indirect answers}\}$ *is a partition of* answers (though the border between them may be fuzzy)
 - $\text{answers} = \text{complete answers} \cup \text{partial answers}$; $\{\text{complete answers, partial answers}\}$ *is a partition of* answers
 - $\text{answers} = \text{true answers} \cup \text{false answers}$; $\{\text{true answers, false answers}\}$ *is a partition of* answers
 - $\text{over-informative answers} \subset \text{answers}$
 - $\text{under-informative answers} \subset \text{replies}$
 - $\text{congruent answers} \subset \text{answers}$
 - $\text{incongruent answers} \subset \text{full answers}$

3.2 A typology of questions

What I'm not going to discuss:

- Questions with a declarative form.
- Question tags.

3.2.1 What is the syntactic status of a question?

Root vs. embedded questions⁶

3.2.2 Where in the question is the information gap and how is it represented?

Yes-no, wh-, and alternative questions⁷

- Asking questions is in some sense “triggered” by information gaps. These information gaps are of different types and are represented in different ways within the sentence structure. The two basic types are represented by *yes-no questions*, where the gap corresponds to the truth-value, and *wh-questions*, where the gap corresponds to some substantial piece of information—corresponding to some syntactic constituent. The third type we’ll have a look at are *alternative questions*, which lie somewhere between the previous two.
- We are already familiar with **yes-no questions** and **wh-questions**. Examples along with the three major analyses are given below:

(22) Did Mary sleep?

- Propositional set analysis: $\lambda p[p = \text{slept}'(m) \vee p = \neg \text{slept}'(m)]$
- Partition analysis: $\lambda w \lambda w'[\text{slept}'(w)(m) = \text{slept}'(w')(m)]$
- Categorial analysis: $\lambda f[f(\text{slept}'(m))]$

(23) Where did Mary sleep?

- Propositional set analysis: $\lambda p \exists x[\text{place}'(x) \wedge p = \text{slept}'(m)(x)]$
- Partition analysis: $\lambda w \lambda w'[\lambda x[\text{place}'(x) \wedge \text{slept}'(w)(m)(x)]$
 $= \lambda x[\text{place}'(x) \wedge \text{slept}'(w')(m)(x)]$
- Categorial analysis: $\lambda x[\text{place}'(x) \wedge \text{slept}'(m)(x)]$

- **Alternative questions** look superficially like yes-no questions, however, they disallow yes-no answers, in which respect they resemble wh-questions. They also resemble wh-questions semantically, as we will see, and by the fact that they ask about a substantial piece of information rather than just about a truth-value.
- Consider the contrast between the yes-no question in (24), the alternative question in (25), and wh-questions in (26). Notice that while yes-no questions and alternative questions share formal properties, alternative questions and wh-questions share answerhood conditions (first discussed by Bäuerle 1979).⁸

(24) Did Mary eat tomatoes or BEAN SPROUTS/?

- Yes. / No. *complete answers*
- She ate tomatoes. / She ate both. *over-informative answers*

(25) Did Mary eat /TOMATOES or BEEN SPROUTS\?

- #Yes. / No. *inappropriate reaction*

⁶Root questions are also called matrix/direct questions. Embedded questions are also called indirect questions. Some traditional grammars incorrectly categorize embedded questions as relative clauses (consider the superficial similarity: *John found out what Mary presented* vs. *John enjoyed what Mary presented*).

⁷Yes-no questions are also called polar/polarity questions. Wh-questions are also called constituent questions.

⁸The forward slash / marks rising intonation and the backward slash \ marks falling intonation.

b. She ate tomatoes. *complete answer*

(26) What did Mary eat, /TOMATOES or BEEN SPROUTS\?

a. #Yes. / No. *inappropriate reaction*

b. She ate tomatoes. *complete answer*

- The representations below show how different approaches capture the difference between yes-no and alternative questions:

(27) Propositional set analysis (see e.g. von Stechow 1991, 1993)⁹

a. Yes-no: $\lambda p[p = [\text{ate}'(t)(m) \vee \text{ate}'(bs)(m)] \vee p = \neg[\text{ate}'(t)(m) \vee \text{ate}'(bs)(m)]]$

b. Alternative: $\lambda p[p = \text{ate}'(t)(m) \vee p = \text{ate}'(bs)(m)]$

c. Wh-: $\lambda p\exists x[x \in \{t, bs\} \wedge p = \text{ate}'(x)(m)]$
 $\equiv \lambda p[p = \text{ate}'(t)(m) \vee p = \text{ate}'(bs)(m)]$

(28) Partition analysis (see Groenendijk and Stokhof 1984b)

a. Yes-no: $\lambda w\lambda w'[[\text{ate}'(w)(t)(m) \vee \text{ate}'(w)(bs)(m)]$
 $= [\text{ate}'(w')(t)(m) \vee \text{ate}'(w')(bs)(m)]]$

b. Alternative: $\lambda w\lambda w'[[\text{ate}'(w)(t)(m) = \text{ate}'(w')(t)(m)]$
 $\wedge [\text{ate}'(w)(bs)(m) = \text{ate}'(w')(bs)(m)]]$

c. Wh-: $\lambda w\lambda w'[\lambda x[x \in \{t, bs\} \wedge \text{ate}'(w)(x)(m)]$
 $= \lambda x[x \in \{t, bs\} \wedge \text{ate}'(w')(x)(m)]]$

(29) Structured meaning analysis (Krifka 2001a)¹⁰

a. Yes-no: $\langle \lambda f[f(\text{ate}'(t)(m) \vee \text{ate}'(bs)(m))], \{\lambda p[p], \lambda p[\neg p]\} \rangle$

b. Alternative: $\langle \lambda x[\text{ate}'(x)(m)], \{t, bs\} \rangle$

c. Wh-: $\langle \lambda x[\text{ate}'(x)(m)], \{t, bs\} \rangle$

- **Multiple wh-questions** are wh-questions with two (discontinuous) information gaps at once. I devote extra space to these later on.

(30) Who ate what?

3.2.3 Does a question seek information?

Information-seeking questions vs. rhetorical questions¹¹

- Not all sentences which have an interrogative form are information-seeking questions. The interrogative form can also be used for declarative-like purposes.
- **Information-seeking questions** have no truth-value due to the information gap they contain. The presence of the gap is modeled in different ways, depending on the approach, as discussed above.

⁹Karttunen (1977) considers yes-no questions to be a subclass of polarity questions. See Bolinger (1978) for counterarguments.

¹⁰Krifka (2001a) doesn't attempt to derive the equivalence of the alternative and wh-questions, he takes it for granted and designs the meaning of the alternative question as such.

¹¹There is no conventionalized terminology for either of the terms. I assign the term "rhetorical questions" a rather broad meaning—encompassing anything that looks like a question but has no question pragmatics. Rhetorical questions were called *queclaratives* by Sadock (1971).

- **Rhetorical questions** correspond to assertions in that they can be judged true or false. These statements are typically *universal*, but can also be *definite*.
- Consider the following examples. (31a) is an example of a **negative bias question**, which corresponds to a negative universal. (32a) is an example of an **exclamative**, which corresponds to a statement about some salient individual. The reactions in (b) support the view that the interrogatives in (a) are assertions rather than questions.

(31) Who would ever eat there? (\approx Nobody would ever eat there.)

- It's actually not such a bad restaurant.
- Yeah, you're right.

(32) [Looking at a list of invited people...]

Oh my god, who did you invite!?

- Well, you know they've/he's been sponsoring us.
- No, I actually didn't invite them/him in the end.

- How can the semantics of rhetorical questions be modeled? There are various ways to do this; below are some examples. In the propositional set analysis and the categorial analysis, wh-words are simply turned to negative quantifiers (for negative-bias questions) or definite descriptions (for definite exclamatives). In the partition approach, the same effect can be achieved by introducing a presupposition (see Guerzoni 2003 for an account along these lines).

(33) Propositional set analysis

- Information-seeking question: $\lambda p \exists x [p = P(x)]$
- Negative-bias question: $\lambda p \neg \exists x [p = P(x)]$
- Definite-exclamative question: $\lambda p \exists ! x [p = P(x)]$

(34) Partition analysis

- Information-seeking question: $\lambda w \lambda w' [\lambda x [P(w)(x)] = \lambda x [P(w')(x)]]$
- Negative-bias question: $\lambda w \lambda w' : \neg \exists x [P(w)(x)]$
 $[\lambda x [P(w)(x)] = \lambda x [P(w')(x)]]$
- Definite-exclamative question: $\lambda w \lambda w' : \exists ! x [P(w)(x)]$
 $[\lambda x [P(w)(x)] = \lambda x [P(w')(x)]]$

(35) Categorial analysis

- Information-seeking question: $\lambda x [p = P(x)]$
- Negative-bias question: $\neg \exists x [p = P(x)]$
- Definite-exclamative question: $\exists ! x [p = P(x)]$

- Besides exclamatives that are formally indistinguishable from interrogatives, like the one above, there is a class of exclamatives which are clearly related to interrogatives, though they are not the same. They display word-order differences, additional morphemes, etc. Compare the exclamative in (36) with the ungrammatical interrogative in (37).

(36) What a beautiful house you have!

(37) *What a beautiful house do you have?

3.2.4 What kind of information does a question seek?

Ordinary questions vs. echo-questions

- **Ordinary questions**, i.e. the majority of the questions discussed so far, are questions that query the **properties of the world** (propositions).

- (38) a. Did John show up?
b. Is the world such that John showed up or such that he did not show up?

- **Echo question** are different. They query the **properties of the discourse** (utterances).

- (39) a. JOHN showed up?
b. Is the discourse such that you said that it was John (rather than anybody else) that showed up?

- How to model these? It seems that we can easily extend the world/proposition/question ontology (40) to a discourse/utterance/echo-question ontology (41).

- (40) a. A *world* $w \approx$ the set of propositions which are true in w .
b. A *proposition* $p =$ the set of worlds in which p is true.
c. A *question about the world* $q =$ the set of propositions which are possible (complete) answers of q , i.e. candidates of what the actual world w_0 is like.

- (41) a. A *discourse* $\delta =$ a set of utterances which have been made in δ .
b. An *utterance* $v =$ a set of discourses in which v has been made.
c. A *question about the discourse* $\kappa =$ a set of utterances which are possible (complete) answers to κ , i.e. candidates of what the actual discourse δ_0 is like.

- A partition representation of an echo-question can thus be as follows. A **yes-no echo-question** is in (42) and a **wh-echo-question** is in (43).

- (42) *Yes-no echo-question*
a. JOHN showed up?
b. $\lambda\delta\lambda\delta'[\text{Assert}(\delta)(\text{showed.up}'(j))(you) = \text{Assert}(\delta')(\text{showed.up}'(j))(you)]$
c. An equivalence relation between two discourses in which you asserted that John showed up. It divides the set of possible discourses into two cells: those where you asserted that John showed up and those where you didn't assert that John showed up.

- (43) *Wh-echo-question*
a. WHO showed up?
b. $\lambda\delta\lambda\delta'[\lambda x[\text{Assert}(\delta)(\text{showed.up}'(x))(you)] = \lambda x[\text{Assert}(\delta')(\text{showed.up}'(x))(you)]$
c. An equivalence relation between two discourses in which you asserted some x showed up. It divides the set of possible discourses into 2^n cells (where n is the cardinality of the range of x), such that each cell contains equivalent from the perspective which x you asserted that they showed up.

- This higher-order treatment of echo-questions is supported by the fact that echo-questions can be formed out of all sorts of utterances—not only **assertions**, but also **questions** or

imperatives. Cf. (44) and (45). (The representation of the question embedded is very simplified.)

(44) *Echo-question about a question*

- a. Who showed up WHERE?
- b. $\lambda\delta\lambda\delta'[\lambda x[\text{Quest}(\delta)(?y.\text{showed.up}'(y)(x))(you)]$
 $= \lambda x[\text{Quest}(\delta')(?y.\text{showed.up}'(y)(x))(you)]$
- c. \approx The partition consisting of the set questions 'Who showed up at x ' for every (relevant) place x .

(45) *Echo-question about an imperative*

- a. Open WHAT?
- b. $\lambda\delta\lambda\delta'[\lambda x[\text{Order}(\delta)(\text{open}'(x)(I))(you)] = \lambda x[\text{Order}(\delta')(\text{open}'(x)(I))(you)]$
- c. \approx The partition consisting of the set of orders 'Open x ' for every (relevant) x .

- Echo-questions resemble ordinary questions in that they come in two variants: **information echo-questions** and **rhetorical echo-questions**. Examples are below (they're only suggestive, both questions could be interpreted in both ways).

(46) *Information echo-questions*

- A We're going to Barcelona on vacation.
- B You're going WHERE on vacation? [I really didn't understand where you said you were going]
- A To Barcelona.

(47) *Rhetorical echo-questions*

- A We're going to Afghanistan on vacation.
- B You're going WHERE on vacation? [I can't believe you're going to Afghanistan]
- A You heard well. There's beautiful nature there.

3.2.5 Summary

We introduced some structure into the set of questions and showed how the various types of questions be modeled by (some) of the theories of question semantics. The taxonomy is summarized below:

- What is the syntactic status of a question?
 - Matrix questions
 - Embedded questions
- Where in the question is the information gap and how is it represented?
 - Yes-no questions
 - Wh-questions (single or multiple)
 - Alternative questions
- Does the question seek information?
 - Information questions

- Rhetorical questions (negative bias, exclamatives)
- What kind of information does the question seek?
 - Ordinary questions
 - Echo-questions

Again, one question can be assigned to more classes:

- questions = matrix questions \cup embedded questions; {matrix questions, embedded questions} *is a partition* of questions
- questions = yes-no questions \cup wh-questions \cup alternative questions; {yes-no questions, wh-questions, alternative questions} *is a partition* of questions
- questions = information questions \cup rhetorical questions; {information questions, rhetorical questions} *is a partition* of questions
- echo-questions \subset matrix questions

3.3 Multiple wh-questions

3.3.1 Baseline

- Consider the following **multiple wh-question**. What does the question mean? I.e. what are its answerhood conditions?¹²

(48) Which boy danced with which girl?

- Basic prediction of the three main approaches.

(49) *Propositional set approaches*
 $\lambda p \exists x \exists y [\text{boy}'(x) \wedge \text{girl}'(y) \wedge p = \text{danced.with}'(y)(x)]$

(50) *Categorial approaches*
 $\lambda \langle x, y \rangle [\text{boy}'(x) \wedge \text{girl}'(y) \wedge \text{danced.with}'(y)(x)]$

(51) *Partition approaches*
 $\lambda w \lambda w' [\lambda x \lambda y [\text{boy}'(w)(x) \wedge \text{girl}'(w)(y) \wedge \text{danced.with}'(w)(y)(x)]$
 $= \lambda x \lambda y [\text{boy}'(w')(x) \wedge \text{girl}'(w')(y) \wedge \text{danced.with}'(w')(y)(x)]$

- In order to see the answerhood conditions more clearly, consider the scenario in (52) and the partition representation of the question in 3.5 (there are four ways of (not-)liking, which gives us $2^4 = 16$ cells).

(52) *There are two boys—Adam (a) and Ben (b), and two girls—Karen (k) and Laura (l)*

¹²I limit the discussion to double wh-questions. Wh-questions with three or more words are not particularly well-studied, though apparently some of their properties differ from double questions.

Table 3.5: The partition (51) under the scenario (52)

1	$D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge D(b,k)$
2	$\neg D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge D(b,k)$
3	$D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge D(b,k)$
4	$D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
5	$D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
6	$\neg D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge D(b,k)$
7	$\neg D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
8	$\neg D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
9	$D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
10	$D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
11	$D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
12	$\neg D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
13	$\neg D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
14	$\neg D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
15	$D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
16	$\neg D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$

- Now, pick any of the cells in 3.5 and you get a complete answer to our question. (53) give examples of such answers:

- (53) Which boy danced with which girl?
- Adam danced with Laura. (15)
 - Ben danced with Karen and Laura. (6)
 - Adam and Ben danced with Karen. (7)
 - Adam danced with Karen and Ben danced with Laura. (8)
 - Adam danced with Laura and Karen and Ben danced with Karen. (4)
 - ...

- **But are all the answers above really felicitous?**

- The majority of linguists have argued that the answerhood conditions above are too weak and that these should be grammatically constrained (cf. Wachowicz 1974; Higginbotham and May 1981; Dayal 1996). Typically, multiple wh-questions are argued to allow either only so called **pair-list readings** (section ??) or only so called **single-pair readings** (section ??)—ruling out some proper subset of the cells of 3.5.
- Yet, I showed that in some contexts these weak answerhood conditions are in fact appropriate in Czech (Šimík 2010); in (54), all kinds of answers are felicitous; notice, however, that the English translation doesn't seem ok in the very same context, suggesting that there's something genuinely linguistic (syntactic or semantic) which distinguishes Czech multiple interrogatives from English ones.

- (54) *I meet a friend about whom I know that he recently decided to be polite, do good deeds, and help people as much as possible. I can start the conversation by asking*

Tak co, komu jsi dnes s čím pomohl?
 so whom AUX:PST.2SG today with what help:PST.PTCP
 ‘So, who did you help with what today?’

- This fact suggests that the basic prediction of the theories is essentially correct. However, there are additional aspects of multiple wh-questions which make this “default” reading so rare, both in Czech and cross-linguistically.¹³

3.3.2 Pair-list readings

Types of pair-list readings¹⁴

- **“Weak” pair list readings** Many assume that (the majority of) English multiple wh-questions presuppose that the non-wh-part of the question holds of at least two pairs of individuals. Thus, the answer in (55a) is felicitous, while (55b) is infelicitous. In general, given such a “list presupposition”, the partition that our question denotes is the one in 3.6 (gray cells are not part of the partition—technically speaking, they are in contradiction with the list-presupposition).¹⁵

- (55) Which boy danced with which girl?
- Adam danced with Karen and Ben danced with Laura.
 - Adam and Ben danced with Laura. / Adam danced with Laura and Ben (also) danced with Laura.
 - #Adam danced with Karen.

Table 3.6: The “weak” pair list reading

1	$D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge D(b,k)$
2	$\neg D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge D(b,k)$
3	$D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge D(b,k)$
4	$D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
5	$D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
6	$\neg D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge D(b,k)$
7	$\neg D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
8	$\neg D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
9	$D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
10	$D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
11	$D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
12	$\neg D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
13	$\neg D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
14	$\neg D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
15	$D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
16	$\neg D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$

¹³See Hagstrom (1998); Bošković (2001); Grebenyova (2004) for a discussion of cross-linguistic variation.

¹⁴Also referred to as simply list readings, matching readings, or, correspondingly, matching questions (cf. Wachowicz 1974).

¹⁵Actually, I’m not aware of anybody proposing that multiple wh-questions have these “weak” list readings.

- **Exhaustive readings** Most linguists take even 3.6 to be too weak (Comorovski 1989; Dayal 1996; Hagstrom 1998; Willis 2008). While (56a) and (56b) are fine, (56c) is supposed to be out. In general, the non-wh-part of the question is supposed to be true of every individual in the domain of the subject (or more generally *topic*) of the question. This gives us the denotation in 3.7. Those cells colored with lighter gray are ruled out if an additional (injective) presupposition is added—a condition that each of the boys danced with a *different* girl.

- (56) Which boy danced with which girl?
- Adam danced with Karen and Ben danced with Laura.
 - Adam danced with Karen and Ben (also) danced with Karen.
 - #Adam danced with Karen and Laura. / Adam danced with Karen and Adam also danced with Laura.

Table 3.7: The exhaustive (plus injective) reading

1	$D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge D(b,k)$
2	$\neg D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge D(b,k)$
3	$D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge D(b,k)$
4	$D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
5	$D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
6	$\neg D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge D(b,k)$
7	$\neg D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
8	$\neg D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
9	$D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
10	$D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
11	$D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
12	$\neg D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
13	$\neg D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
14	$\neg D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
15	$D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
16	$\neg D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$

- Now consider the slightly modified scenario in (57). Given the exhaustive presupposition in conjunction with the injective presupposition, (58a) is supposed to be a well-formed question, while (58b) should simply be unacceptable, as there will always be one girl with no partner.

(57) *There are 2 boys and 3 girls.*

- (58) a. Which boy danced with which girl.
 b. #Which girl danced with which boy?

- **Doubly exhaustive readings** Finally, for some even 3.7 is too weak (Higginbotham and May 1981; Dayal 1996). For them, the non-wh-part has to be true not only of every element in the domain of the subject, but also of every element in the domain of the object. See 3.8. Again, the light-gray parts are ruled out if the injective presupposition is added (injection going both ways is bijection).

(59) Which boy danced with which girl?

- a. Adam danced with Karen and Ben danced Laura.
 b. #Adam danced with Karen and Ben (also) danced with Karen.

Table 3.8: The doubly exhaustive (plus bijective) reading

1	$D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge D(b,k)$
2	$\neg D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge D(b,k)$
3	$D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge D(b,k)$
4	$D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
5	$D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
6	$\neg D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge D(b,k)$
7	$\neg D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
8	$\neg D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
9	$D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
10	$D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
11	$D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
12	$\neg D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
13	$\neg D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
14	$\neg D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
15	$D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
16	$\neg D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$

- Compare the partitions 3.7 and 3.8. The stronger reading of the former seems to be identical to the stronger reading of the latter. However, this is only an illusion. Consider once more the scenario in (57), repeated below; under the bijective reading, both (61a) and (61b) are bad.

(60) *There are 2 boys and 3 girls.*

- (61) a. #Which boy danced with which girl.
 b. #Which girl danced with which boy?

Two types of accounts of the exhaustive list readings (¹⁶

- **Skolem functions** (Engdahl 1986; Comorovski 1996)¹⁷
- Skolem functions are functions from individuals to individuals (type $\langle e, e \rangle$). One example of a Skolem function is the possessive DP, which map possessors to their possessees: e.g. in [Mary [’s [boyfriend]]] [’s boyfriend] takes [[Mary]] (type e) as its argument and returns Mary’s boyfriend (type e).
- In a multiple wh-question, the “higher” wh-word (the subject or the topic) is represented simply as an ordinary variable x (existentially quantified, given the Hamblin-Karttunen account), while the “lower” wh-word is represented as a Skolem function f (also existentially quantified) which takes x as its argument. The values of x and $f(x)$ are restricted in the usual way.

¹⁶I abstract away from a lot of (potentially important) details. I also don’t show discuss bijective readings are accounted for (see Higginbotham and May 1981).

¹⁷See Dayal (1996) for some critical comments and amendments of this basic Skolem function account.

- (62) a. Which boy danced with which girl?
 b. $\lambda p \exists x \exists f [\text{boy}'(x) \wedge \text{girl}'(f(x)) \wedge \forall p \wedge p = \text{danced.with}'(f(x), x)]$

- The *exhaustive interpretation* follows from the very definition of a **function**, which maps *every* element in its domain to some element in its range. If there are two boys, there will be at least two (true, given Karttunen) propositions—one about each boy.
- The answer can either be provided by listing, for every boy x , a corresponding girl $f(x)$ such that x danced with $f(x)$, as in (63a). Another option is to provide a description of the function f (provided that the domain of boys is known to the participants of the discourse), as in (63b):

- (63) Which boy danced with which girl?
 a. Adam danced with Karen and Ben danced with Laura. $f = \{\langle a, k \rangle, \langle b, l \rangle\}$
 b. Every boy danced with his sister. $f = \text{sister of}'$

- **Sets of questions** (Roberts 1996; Hagstrom 1998; Krifka 2001b; Büring 2003; Willis 2008)¹⁸
- The basic idea is that a multiple question with the exhaustive pair-list reading does not denote a question, but rather a *set* of questions.¹⁹ Thus, (64a) is in fact (64b).

- (64) a. Which boy danced with which girl?
 b. Which girl did Adam dance with? Which girl did Ben dance with?

- (64b) are familiar objects and require no more comment. There are more ways of making the step from (64a) to (64b). One of them is the combination of two different ways of set-formation (Hamblin-style and Karttunen-style; see e.g. Hagstrom 1998; Šimík 2010, and section 2.2). The other one is explicit conjunction of question speech acts (Krifka 2001b; Willis 2008).²⁰ Disregarding the details of the semantic derivation, the resulting semantic object of (65a) (Hamblin-Karttunen-style) is in (65b) (in lambda notation) and in (65c) (in set-notation).

- (65) a. Which boy danced with which girl?
 b. $\lambda Q \exists x [\text{boy}'(x) \wedge Q = \lambda p \exists y [\text{girl}'(y) \wedge p = \text{danced.with}'(y, x)]]$
 where Q is a question (a set of propositions)
 c. $\{\{p : \text{danced.with}'(y, a) \mid y \in \text{girl}'\}, \{p : \text{danced.with}'(y, b) \mid y \in \text{girl}'\}\}$

3.3.3 Single-pair readings

Ref-questions, quiz questions, reciprocal questions, conjoined questions

- In general, **single-pair** readings arise if the context rules out multiple pairs. If we stick to our example, under a single-pair reading, the question in (66) will allow for an answer like (66a), but not (66b). See the partition in 3.9.

- (66) Which boy danced with which girl?
 a. Adam danced with Laura.

¹⁸Also called *families of questions* (Dayal 1996) or *superquestions*.

¹⁹We can speak about *superquestions* (sets of questions) and *subquestions* (ordinary questions).

²⁰The last option I am aware of is a recursive application of a generalized question operator, à la Wagner's (2009) analysis of contrastive topics, cf. also Šimík (2009).

- b. #Adam danced with Laura and Ben danced with Karen.

Table 3.9: The single-pair reading

1	$D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge D(b,k)$
2	$\neg D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge D(b,k)$
3	$D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge D(b,k)$
4	$D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
5	$D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
6	$\neg D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge D(b,k)$
7	$\neg D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
8	$\neg D(a,l) \wedge D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
9	$D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
10	$D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
11	$D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
12	$\neg D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge D(b,k)$
13	$\neg D(a,l) \wedge \neg D(a,k) \wedge D(b,l) \wedge \neg D(b,k)$
14	$\neg D(a,l) \wedge D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
15	$D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$
16	$\neg D(a,l) \wedge \neg D(a,k) \wedge \neg D(b,l) \wedge \neg D(b,k)$

- **Ref-questions** (Wachowicz 1974) resemble echo-questions (though are not the same, cf. Pope 1976). They ask for a clarification of (pronominal) reference, i.e. they are essentially reactions to a presupposition failure (comparable to (68)).

(67) A I met him there.
B Wait a minute, who did you meet where?

(68) A John was there, too.
B Wait a minute, who else was there?

- **Quiz questions** (Åqvist 1965; Wachowicz 1974) are questions about unique events involving a unique pair. They were called quiz questions because they typically (though not necessarily, cf. Krifka 2001a) appear in quizzes.

(69) a. Who killed John Kennedy when?
b. Which maestro is conducting which symphony at tonight's concert?

- **Reciprocal questions** typically involve two individuals such that it is presupposed that both are participants in a certain event, but it is not clear which roles these individual play in that event.

(70) a. *I know that John and Mary are going to marry, but...*
Who proposed to whom?
b. *I know that criminality and low social status often co-occur, but...*
What causes what?

(71) **Conjoined questions** are either genuine multiple questions or simply two conjoined full questions with ellipsis. If the latter is the case, SP readings follow automatically.

If the former is the case, some other mechanism might be needed (see e.g. Gribanova 2009).²¹

- (72) a. When and where did you last drink caipirinha?
 b. When did you last drink caipirinha, and where?

3.4 Exercises

1. In section 3.1.3 we saw that some answers (in the technical sense of the word) can be pragmatically infelicitous. Can you think of other kinds of pragmatically infelicitous answers, i.e. other than incongruent answers?
2. In section 3.1.2 we represented complete and partial answers graphically—by so-called Venn diagrams. What would a Venn-diagram representation of over-informative and under-informative answers look like?
3. In section 3.2.2 we saw that alternative questions are answerhood-conditionally equivalent to corresponding wh-questions. Can you prove that this equivalence holds in the partition approach, i.e. that (28b) is equivalent to (28c)?

²¹Which strategy, or rather strategies, for constructing conjoined question are the correct ones is a matter of ongoing discussion; for recent discussion, see e.g. Gribanova (2009) (wh-words conjoined directly), Tomaszewicz (2011) (conjunction of wh-clauses plus ellipsis), Haida and Repp (to appear) (both types are needed).

Bibliography

- Ajdukiewicz, Kazimierz. 1928. *Logiczne podstawy nauczania [the logical foundations of teaching]*.
- Alonso-Ovalle, Luis. 2006. Disjunction in alternative semantics. Doctoral Dissertation, University of Massachusetts, Amherst.
- Åqvist, Lennart. 1965. *A new approach to the logical theory of interrogatives*. Uppsala: Filosofiska Föreningen.
- Bäuerle, Rainer. 1979. *Temporale Deixis – Temporale Frage*. Tübingen: Narr.
- Beck, Sigrid, and Hotze Rullmann. 1999. A flexible approach to exhaustivity in questions. *Natural Language Semantics* 7:249–298.
- Belnap, Nuel D. 1982. Questions and answers in Montague grammar. In *Processes, beliefs, and questions*, ed. Stanley Peters and Esa Saarinen, 165–198. Dordrecht: Reidel.
- Bennett, Michael. 1979. *Questions in Montague grammar*. Bloomington, IN: Indiana University Linguistics Club.
- Berman, Stephen. 1991. On the semantics and logical form of wh-clauses. Doctoral Dissertation, University of Massachusetts, Amherst.
- Boër, Steven. 1978. *Who and whether: Towards a theory of indirect questions clauses*. *Linguistics and Philosophy* 2:307–345.
- Bolinger, Dwight. 1978. Yes/no questions are not alternative questions. In *Questions*, ed. Henry Hiz, 87–105. Dordrecht: Reidel.
- Bošković, Željko. 2001. On the interpretation of multiple questions. *Linguistic Variation Yearbook* 1:1–15.
- Büring, Daniel. 2003. On D-trees, beans, and B-accent. *Linguistics and Philosophy* 26:511–545.
- Comorovski, Ileana. 1989. Discourse and the syntax of multiple constituent questions. Doctoral Dissertation, Cornell University.
- Comorovski, Ileana. 1996. *Interrogative phrases and the syntax-semantics interface*. Dordrecht: Kluwer.
- Dayal, Veneeta. 1996. *Locality in wh-quantification: Questions and relative clauses in Hindi*. Dordrecht: Kluwer.
- Engdahl, Elisabet. 1986. *Constituent questions*. Dordrecht: Kluwer.

- Grebenyova, Lydia. 2004. Interpretation of Slavic multiple wh-questions. In *Formal Approaches to Slavic Linguistics 12: The Ottawa Meeting 2003*, ed. Olga Arnaudova, Wayles Browne, Maria Luisa Rivero, and Danijela Stojanović, 169–186. Ann Arbor, MI: Michigan Slavic Publications.
- Gribanova, Vera. 2009. Structural adjacency and the typology of interrogative interpretations. *Linguistic Inquiry* 40:133–154.
- Groenendijk, Jeroen, and Martin Stokhof. 1982. Semantic analysis of wh-complements. *Linguistics and Philosophy* 5:175–233.
- Groenendijk, Jeroen, and Martin Stokhof. 1984a. On the semantics of questions and the pragmatics of answers. In *Varieties of formal semantics*, ed. Fred Landman and Frank Veltman, 143–170. Dordrecht: Foris.
- Groenendijk, Jeroen, and Martin Stokhof. 1984b. Studies on the semantics of questions and the pragmatics of answers. Doctoral Dissertation, University of Amsterdam.
- Guerzoni, Elena. 2003. Why even ask? On the pragmatics of questions and the semantics of answers. Doctoral Dissertation, MIT, Cambridge, MA.
- Hagstrom, Paul. 1998. Decomposing questions. Doctoral Dissertation, MIT, Cambridge, MA.
- Haida, Andreas, and Sophie Repp. to appear. Monoclausal question word coordinations across languages. In *Proceedings of NELS 39*.
- Hamblin, Charles L. 1958. Questions. *The Australasian Journal of Philosophy* 36:159–168.
- Hamblin, Charles L. 1973. Questions in Montague English. *Foundations of Language* 10:41–53.
- Hausser, Roland R., and Dietmar Zäfferer. 1979. Questions and answers in a context-dependent montague grammar. In *Formal semantics and pragmatics for natural languages*, ed. F. Gnthner and S. J. Schmidt. Dordrecht: Reidel.
- Heim, Irene. 1994. Interrogative semantics and Karttunen semantics for *know*. In *Proceedings of IATL 1*, volume 1, 128–144.
- Heim, Irene, and Angelika Kratzer. 1998. *Semantics in generative grammar*. Oxford: Blackwell.
- Higginbotham, James. 1996. The semantics of questions. In *The handbook of contemporary semantic theory*, ed. Shalom Lappin, 361–383. Oxford: Blackwell.
- Higginbotham, James, and Robert May. 1981. Questions, quantifiers, and crossing. *The Linguistic Review* 1:41–79.
- Hintikka, Jaakko. 1974. Questions about questions. In *Semantics and philosophy*, ed. Milton Munitz and Peter Unger. New York: New York University Press.
- Hintikka, Jaakko. 1976. *The semantics of questions and the questions of semantics*. Amsterdam: North Holland.
- Hintikka, Jaakko. 1983. New foundations for a theory of questions and answers. In *Questions and answers*, ed. Ferenc Kiefer, 159–190. Dordrecht: Reidel.

- Hiž, Henry. 1978. Introduction. In *Questions*, ed. Henry Hiž, ix–xvii. Dordrecht: Reidel.
- Jacobson, Pauline. 2009. The answer (in short). Manuscript, Brown University.
- Karttunen, Lauri. 1977. The syntax and semantics of questions. *Linguistics and Philosophy* 1:3–44.
- Kratzer, Angelika, and Junko Shimoyama. 2002. Indeterminate pronouns: The view from Japanese. In *Proceedings of the Third Tokyo Conference on Psycholinguistics*, ed. Yukio Otsu, 1–25. Tokyo: Hituzi Syobo.
- Krifka, Manfred. 2001a. For a structured meaning account of questions and answers. In *Audiatur Vox Sapientia: A festschrift for Arnim von Stechow*, ed. Caroline Féry and Wolfgang Sternefeld, 287–319. Berlin: Akademie-Verlag.
- Krifka, Manfred. 2001b. Quantifying into question acts. *Natural Language Semantics* 9:1–40.
- Levi, Isaac. 1967. *Gambling with truth*. New York: Alfred A. Knopf.
- Lewis, David. 1970. General semantics. *Synthese* 22:18–67.
- Menéndez-Benito, Paula. 2005. The grammar of choice. Doctoral Dissertation, University of Massachusetts, Amherst.
- Pope, Emily. 1976. *Questions and answers in English*. The Hague: Mouton.
- Ramchand, Gillian. 1996. Questions, polarity, and alternative semantics. Manuscript, Oxford University.
- Ramchand, Gillian. 1997. Questions, polarity, and alternative semantics. In *NELS 27: Proceedings of the 27th Annual Meeting of the North East Linguistic Society*, 383–396. Amherst, MA: GLSA Publications.
- Roberts, Craige. 1996. Information structure in discourse: Towards an integrated formal theory of pragmatics. In *OSU Working Papers in Linguistics 49: Papers in Semantics*, ed. J. H. Yoon and Andreas Kathol, 91–136.
- Rooth, Mats. 1985. Association with focus. Doctoral Dissertation, University of Massachusetts, Amherst.
- Rooth, Mats. 1992. A theory of focus interpretation. *Natural Language Semantics* 1:75–116.
- Sadock, Jerry. 1971. Queclaratives. In *CLS 7: Papers from the Seventh Regional Meeting of the Chicago Linguistic Society*, 223–331. Chicago, IL.
- Sag, Ivan A., Gerald Gazdar, Thomas Wasow, and Steven Weisler. 1985. Coordination and how to distinguish categories. *Natural Language & Linguistic Theory* 3:117–171.
- Scha, Remko. 1983. Logical foundations for question answering. Doctoral Dissertation, University of Groningen.
- Sharvit, Yael. 2002. Embedded questions and de dicto readings. *Natural Language Semantics* 10:97–123.
- Šimík, Radek. 2009. Generating subquestions in syntax. Presented at the Southern New England Workshop on Semantics (SNEWS), University of Massachusetts, Amherst.

- Šimík, Radek. 2010. Interpretation of multiple interrogatives: An information structure sensitive account. In *Formal Approaches to Slavic Linguistics 18: The Second Cornell Meeting 2009*, ed. Wayles Browne, Adam Cooper, Alison Fisher, Esra Kesici, Nikola Predolac, and Draga Zec, 486–501. Ann Arbor, MI: Michigan Slavic Publications.
- Stahl, Gerold. 1956. La lógica de las preguntas. In *Anales de la Universidad de Chile*, 102. Santiago de Chile.
- von Stechow, Arnim. 1982. Structured propositions. In *Arbeitspapiere des SFB 99*. University of Konstanz.
- von Stechow, Arnim. 1991. Focusing and backgrounding operators. In *Discourse particles: Descriptive and theoretical investigations on the logical, syntactic, and pragmatic properties of discourse particles in German*, ed. Werner Abraham, 37–84. University Konstanz: John Benjamins. Arbeitspapier 6, Fachgruppe Sprachwissenschaft.
- von Stechow, Arnim. 1993. Die Aufgaben der Syntax. In *Syntax: Ein internationales Handbuch zeitgenössischer Forschung*, ed. Joachim Jacobs, Arnim von Stechow, Wolfgang Sternefeld, and Theo Vennemann, 1–88. Berlin: de Gruyter.
- von Stechow, Arnim, and Thomas Ede Zimmermann. 1984. Term answers and contextual change. *Linguistics* 22:3–40.
- Tarski, Alfred. 1944. The semantic conception of truth and the foundations of semantics. *Philosophy and Phenomenological Research* 4.
- Tichy, Pavel. 1978. Questions, answers, and logic. *American Philosophical Quarterly* 15:275–284.
- Tomaszewicz, Barbara. 2011. Against spurious coordination in multiple wh-questions. In *WCCFL 28: Proceedings of the 28th West Coast Conference on Formal Linguistics*, ed. Mary Byram Washburn, Katherine McKinney-Bock, Erika Varis, Ann Sawyer, and Barbara Tomaszewicz, 186–195. Somerville, MA: Cascadilla Proceedings Project.
- Wachowicz, Krystyna. 1974. On the syntax and semantics of multiple questions. Doctoral Dissertation, University of Texas, Austin.
- Wagner, Michael. 2009. A compositional analysis of contrastive topics. In *NELS 38: Proceedings of the 38th Annual Meeting of the North East Linguistic Society*, ed. Muhammad Abdurrahman, Anisa Schardl, and Martin Walkow, volume 2, 455–468. Amherst, MA: GLSA Publications.
- Willis, Paul M. 2008. The role of topic-hood in multiple-wh question semantics. Manuscript, University of California, Santa Cruz.