Questions Under Discussion

Chris Potts, Ling 236: Seminar in Lexical & Constructional Pragmatics, Fall 2009

Oct 7

1 Overview

i. **Three theories of interrogative denotations**

The theories are alike in assuming that questions are sets of propositions, in some sense or another. In this sense, these theories contrast with, e.g., those of Ginzburg and Sag (2001); Ginzburg (1996), who deny this fundamental premise.

ii. **Two theories of discourse**

The look at interrogative denotations sets the stage for a close look at two theories of discourse that are built around questions: Groenendijk (1999) and Roberts (1996).

iii. **One ongoing research project in this area**

Probing QUD structures via over-answers to questions.

iv. **One appendix discussing another related ongoing project**

Using the QUD to resolve underspecification in collaborative search dialogues.

2 Interrogative denotations

2.1 Translation examples

(1) a. *Is Sam tired?* $\rightsquigarrow$?**sam tired**

b. *Who is tired?* $\rightsquigarrow$ $?x(x$ **tired**$)$

c. *Who ate what?* $\rightsquigarrow$ $?\langle x, y\rangle(x$ **eat** $y)$

2.2 Hamblin semantics

Definition 1 (Hamblin declaratives).

$$[\![\varphi]\!]^g = \big\{\{w \mid [\![\varphi]\!]^g(w) = \texttt{True}\}\big\}$$

Definition 2 (Hamblin polar interrogatives).

$$[\![?\varphi]\!]^g = \big\{[\![\varphi]\!]^g, W - [\![\varphi]\!]^g\big\}$$

Definition 3 (Hamblin constituent interrogatives). For $n > 0$, $\vec{x}^n$ abbreviates $\langle x_1 \dots x_n\rangle$:

$$[\![?\vec{x}^n\varphi]\!]^g = \big\{p \mid \exists d \in D^n : p = [\![\varphi]\!]^{g[\vec{x}^n \mapsto d]}\big\}$$

2.3 Karttunen semantics

Definition 4 (Karttunen polar interrogatives).

$$\llbracket ?\varphi \rrbracket^{g} = \left\{ \langle w, p \rangle \mid \llbracket \varphi \rrbracket^{g} = p \wedge p(w) = \texttt{True} \right\}$$

Definition 5 (Karttunen constituent interrogatives).

$$\llbracket ?\vec{x}^{n}\varphi \rrbracket^{g} = \left\{ \langle w, p \rangle \mid \exists d \in D^{n} : p = \llbracket \varphi \rrbracket^{g[\vec{x}^{n} \mapsto d]}(w) \wedge p(w) = \texttt{True} \right\}$$

2.4 Partition semantics

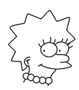
Definition 6 (G&S declaratives).

$$\llbracket \varphi \rrbracket^{g} = \{ \langle w, w' \rangle \mid \forall d \in D^{n} : \llbracket \varphi \rrbracket^{g[\vec{x}^{n} \mapsto d]}(w) = \llbracket \varphi \rrbracket^{g[\vec{x}^{n} \mapsto d]}(w') = \texttt{True} \}$$

Definition 7 (G&S interrogatives). For $n \geqslant 0$, $\vec{x}^{n}$ abbreviates $\langle x_1 \ldots x_n \rangle$:

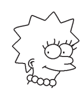
$$\llbracket ?\vec{x}^{n}\varphi \rrbracket^{g} = \{ \langle w, w' \rangle \mid \forall d \in D^{n} : \llbracket \varphi \rrbracket^{g[\vec{x}^{n} \mapsto d]}(w) = \llbracket \varphi \rrbracket^{g[\vec{x}^{n} \mapsto d]}(w') \}$$

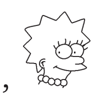
2.5 Comparison

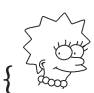
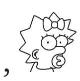
$D = \{$  ,  ,  $\}$

$W = \{w_1, w_2, w_3, w_4\}$

$\llbracket \textbf{tired} \rrbracket^{w_1} = \{\ \}$

$\llbracket \textbf{tired} \rrbracket^{w_2} = \{$  ,  $\}$

$\llbracket \textbf{tired} \rrbracket^{w_3} = \{$  ,  $\}$

$\llbracket \textbf{tired} \rrbracket^{w_4} = \{$  ,  $\}$

(2) $?x(x\ \textbf{tired})$

a. Hamblin:

$$\left\{ \begin{array}{c} \{w_2, w_3\} \\ \{w_2, w_3, w_4\} \\ \{w_4\} \end{array} \right\}$$

b. Karttunen:

$$\left\{ \begin{array}{cccc} \langle & w_2 & , & \left\{ \begin{array}{c} \{w_2, w_3\}, \\ \{w_2, w_3, w_4\} \end{array} \right\} \rangle \\ \langle & w_3 & , & \left\{ \begin{array}{c} \{w_2, w_3\}, \\ \{w_2, w_3, w_4\} \end{array} \right\} \rangle \\ \langle & w_4 & , & \left\{ \begin{array}{c} \{w_2, w_3, w_4\} \\ \{w_4\} \end{array} \right\} \rangle \end{array} \right\}$$

c. G&S

$$\left\{ \begin{array}{ccccc} \langle & w_1 & , & \{w_1\} & \rangle \\ \langle & w_2 & , & \{w_2, w_3\} & \rangle \\ \langle & w_3 & , & \{w_2, w_3\} & \rangle \\ \langle & w_4 & , & \{w_4\} & \rangle \end{array} \right\} \Longleftrightarrow \left\{ \begin{array}{cccc} \langle w_1, w_1 \rangle & & & \\ & \langle w_2, w_2 \rangle & \langle w_2, w_3 \rangle & \\ & \langle w_3, w_2 \rangle & \langle w_3, w_3 \rangle & \\ & & & \langle w_4, w_4 \rangle \end{array} \right\}$$

2.6 Relations

Definition 8 (Ans values)**.** For propositions p and question Q:

$$\text{Ans}(p, Q) = \{q \in Q \mid p \cap q \neq \emptyset\}$$

i. p partially resolves Q iff $\text{Ans}(p, Q) \neq \emptyset$ and $\text{Ans}(p, Q) \subset Q$

ii. p (completely) resolves Q iff $\text{Ans}(p, Q)$ is a singleton.

Definition 9 (Entailment)**.**

$$Q \text{ entails } Q' \text{ iff } Q \subseteq Q'$$

Definition 10 (Granularity)**.**

$$Q \sqsubseteq Q' \text{ iff } \forall q \in Q\ \exists q' \in Q'\ q \subseteq q'$$

Note The Hamblin and G&S semantics can include declarative meanings in these orderings.

3 Discourse structure

Let's now look at the technical details of tworr theories of discourse that are built around questions.

3.1 Groenendijk 1999

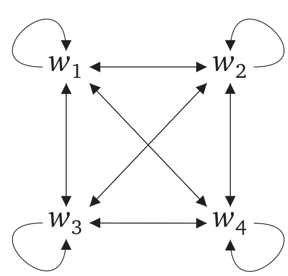
Groenendijk's (1999) Logic of Interrogation (LOI) is a dynamic statement of the partition semantics for questions, with a pragmatic theory layered atop it. The formulation is game-theoretic in the intuitive, but not in the technical, sense.

3.1.1 Contexts

Definition 11 (Contexts)**.** Let W be the set of worlds. A context is an equivalence relation on W.

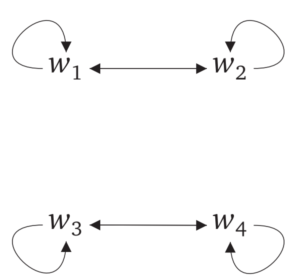
(3)

$$\left\{ \begin{array}{cccc} \langle w_1, w_1 \rangle & \langle w_1, w_2 \rangle & \langle w_1, w_3 \rangle & \langle w_1, w_4 \rangle \\ \langle w_2, w_1 \rangle & \langle w_2, w_2 \rangle & \langle w_2, w_3 \rangle & \langle w_2, w_4 \rangle \\ \langle w_3, w_1 \rangle & \langle w_3, w_2 \rangle & \langle w_3, w_3 \rangle & \langle w_3, w_4 \rangle \\ \langle w_4, w_1 \rangle & \langle w_4, w_2 \rangle & \langle w_4, w_3 \rangle & \langle w_4, w_4 \rangle \end{array} \right\}$$



(4)

$$\left\{ \begin{array}{cccc} \langle w_1, w_1 \rangle & \langle w_1, w_2 \rangle & & \\ \langle w_2, w_1 \rangle & \langle w_2, w_2 \rangle & & \\ & & \langle w_3, w_3 \rangle & \langle w_3, w_4 \rangle \\ & & \langle w_4, w_3 \rangle & \langle w_4, w_4 \rangle \end{array} \right\}$$



3.1.2 Updates

Definition 12 (Context change potentials)**.** Let C be an equivalence relation on $W \times W$.

i. $C[\varphi!] = \{\langle w, w' \rangle \in C \mid [\![\varphi]\!]^{g,w} = [\![\varphi]\!]^{g,w'} = \texttt{True}\}$ (declaratives)

ii. $C[\varphi?] = \{\langle w, w' \rangle \in C \mid [\![\varphi]\!]^{g,w} = [\![\varphi]\!]^{g,w'}\}$ (interrogatives)

iii. Let $\tau = \varphi_1 \ldots \varphi_n$. Then $C[\tau] = C[\varphi_1] \ldots C[\varphi_n]$.

3.1.3 Discourse game

In Groenendijk's (1999) simple game of interrogation, there are two players: interrogator and witness. The interrogator asks questions and the witness answers them. The paper is not explicit about the informational asymmetry between witness and interrogator, but the following seems in keeping with the descriptions and examples:

(5) a. The witness and and interrogator each have their own contexts, C_w and C_i

b. The witness's context does not change. The interrogator's does: he asks questions, the witness answers them, and the interrogator faithfully updates C_i with the answer.

c. The game finishes when $C_w = C_i$.

Definition 13 ("Groengrice maxims")**.** Groenendijk's (1999) definition of pertinence: φ is pertinent after τ iff φ consistent, informative, and licensed wrt τ:

i. φ is consistent with τ iff there is a C such that $C[\tau][\varphi] \neq \emptyset$ (quality)

ii. φ is informative with respect to τ there is a C such that $C[\tau] \neq C[\tau][\varphi]$ (quantity)

iii. τ licenses φ iff $\forall C, w, w'$ if $\langle w, w' \rangle \in C[\psi]$ and $\langle w, w \rangle \notin C[\tau][\varphi]$, then $\langle w', w' \rangle \notin C[\tau][\varphi]$ (relevance)

> The notions of consistency and entailment are standard logical notions. New is at most that they indiscriminately apply to statements and questions, and that we focus on the use of these notions in the formulation of Quality and Quantity requirements for the cooperative exchange of information, instead of as criteria for the soundness and validity of reasoning. Groenendijk (1999:115)

Play the Game of Interrogation online!
http://christopherpotts.net/ling/implementations/loi/

Over answers Licensing punishes answers that don't exactly match a single cell in the partition (though there is one circumstance in which over-answers are permitted: in case of conjunctions in which each conjunct counts as an answer (Fact 12).)

(6) $[\![a\ \mathbf{red}]\!]^g = \{w_1, w_2, w_3\}$; $[\![b\ \mathbf{red}]\!]^g = \{w_1, w_4, w_5\}$

$$\Big(W \times W\Big)[?(a\ \mathbf{red})]\left\{\begin{array}{cccc} \langle w_1, w_1\rangle & \langle w_1, w_2\rangle & \langle w_1, w_3\rangle & \\ \langle w_2, w_1\rangle & \langle w_2, w_2\rangle & \langle w_2, w_3\rangle & \\ \langle w_3, w_1\rangle & \langle w_3, w_2\rangle & \langle w_3, w_3\rangle & \\ & & \langle w_4, w_4\rangle & \langle w_4, w_5\rangle \\ & & \langle w_5, w_4\rangle & \langle w_5, w_5\rangle \end{array}\right\}$$

$$[(a\ \mathbf{red}) \wedge (b\ \mathbf{red})]\left\{\begin{array}{l} \langle w_1, w_1\rangle \\ \\ \\ \\ \end{array}\right\}$$

Violates licensing (fails to address a single contextual alternative):

i. $\langle w_1, w_2\rangle \in C[?(a\ \mathbf{red})]$ and

ii. $\langle w_2, w_2\rangle \notin C[?\mathbf{red}(a)][(a\ \mathbf{red}) \wedge (b\ \mathbf{red})]$, but

iii. $\langle w_1, w_1\rangle \in C[?(a\ \mathbf{red})][(a\ \mathbf{red}) \wedge (b\ \mathbf{red})]$.

Unlicensed partial answer

(7) $[\![\mathbf{red}(a)]\!]^g = \{w_1, w_2, w_3\}$; $[\![\mathbf{red}(b)]\!]^g = \{w_1, w_3, w_5\}$

$$\Big(W \times W\Big)[?(a\ \mathbf{red})]\left\{\begin{array}{ccccc} \langle w_1, w_1\rangle & & & & \langle w_1, w_5\rangle \\ & \langle w_2, w_2\rangle & \langle w_2, w_3\rangle & \langle w_2, w_4\rangle & \\ & \langle w_3, w_2\rangle & \langle w_3, w_3\rangle & \langle w_3, w_4\rangle & \\ & \langle w_4, w_2\rangle & \langle w_4, w_3\rangle & \langle w_4, w_4\rangle & \\ \langle w_5, w_1\rangle & & & & \langle w_5, w_5\rangle \end{array}\right\}$$

$$[(a\ \mathbf{red}) \vee (b\ \mathbf{red})]\left\{\begin{array}{cccc} \langle w_1, w_1\rangle & & & \\ & \langle w_2, w_2\rangle & \langle w_2, w_3\rangle & \langle w_2, w_4\rangle \\ & \langle w_3, w_2\rangle & \langle w_3, w_3\rangle & \langle w_3, w_4\rangle \\ & \langle w_4, w_2\rangle & \langle w_4, w_3\rangle & \langle w_4, w_4\rangle \\ & & & \end{array}\right\}$$

Licensed partial answer Groenendijk (1999) observes that this is a retreat from the requirement of strongly exhaustive answers, though not one that demands a change to the semantics.

(8) $[\![(a\ \textbf{red})]\!]^g = \{w_1, w_2\}$; $[\![(b\ \textbf{red})]\!] = [\![(c\ \textbf{red})]\!]^g = \{w_4, w_5\}$

$$\Big(W \times W\Big)[?x(x\ \textbf{red})] \left\{ \begin{array}{cccccc} \langle w_1,w_1\rangle & \langle w_1,w_2\rangle & & & & \\ \langle w_2,w_1\rangle & \langle w_2,w_2\rangle & & & & \\ & & \langle w_3,w_3\rangle & & & \\ & & & \langle w_4,w_4\rangle & \langle w_4,w_5\rangle & \\ & & & \langle w_5,w_4\rangle & \langle w_5,w_5\rangle & \end{array} \right\}$$

$$[\exists x(x\ \textbf{red})] \left\{ \begin{array}{cccc} \langle w_1,w_1\rangle & \langle w_1,w_2\rangle & & \\ \langle w_2,w_1\rangle & \langle w_2,w_2\rangle & & \\ & & & \\ & & \langle w_4,w_4\rangle & \langle w_4,w_5\rangle \\ & & \langle w_5,w_4\rangle & \langle w_5,w_5\rangle \end{array} \right\}$$

3.1.4 A few observations

Declaratives and their associated questions Fact 4 (The ‘Relatedness test’) says that a declarative is licensed iff its corresponding yes/no question is non-inquisitive. This is just to say that you can’t assert φ unless the question of whether φ is really an issue. Groenendijk (1999:117) calls this a particular kind of presupposition, but I think that we need not use that terminology or theoretical conception.

No hybrids In the terms Inquisitive Semantics, there are no hybrids — no expressions that can simultaneously delink worlds and eliminate world pairs. An interrogative with nontrivial presuppositions would have to do that, though. And there may well be other motivations.

Exhaustivity is best We’ve seen situations in which non-exhaustive answers are licensed. However, even there, an exhaustive answer is considered to be the best sort of answer.

Constraining the interrogator The felicity conditions on asking questions are weak. The requirement is simply that some world-pairs get disconected. The article reads, “licensing only puts constraints on the statements of the witness, but reckons any statement from the interrogator to be relevant” (p. 116), and the associated footnote 9 says, “This is a feature particular to the present set-up. One could add requirements of relatedness for the questions of the interrogator as well.” Questions can clearly be relevant or irrelevant.

3.2 Roberts 1996

Roberts (1996) construes the game of discourse in a manner that is fundamentally the same as that of Groenendijk (1999): the goal of discourse is to reduce the context set (qua set of worlds) to a singleton containing the actual world, and our talk exchanges take us monotonically towards this end. Roberts' interrogative semantics is Hamblin-style, as in section 2.2 above, but this seems to be a minor difference. More important is the fact that Roberts' discourse model is much more articulated than Groenendijk's, with explicit definitions for how participants accept/reject discourse moves, and how they deal with multiple issues simultaneously. It is also more lenient wrt to partial answering and over-answering.

3.2.1 QUDs

Roberts' definition is given on page 11 of the paper. Here is a slightly simplified and reworked version of it:

Definition 14 (QUD stacks)**.** Suppose we are at the ith stage of discourse. Then $q \in \text{QUD}_i$ iff

i. q was raised prior to i;

ii. q is not resolved by the common ground at i; and

iii. q been determined at i to be unresolvable.

In addition, the members of QUD_i are totally ordered by temporal precedence, according to when they were asked, and if $q, q' \in \text{QUD}_i$ and q was raised before q', then fully resolving q' entails partially resolving q.

Definition 15 (Immediate question under discussion)**.** If QUD_i is a QUD stack, then the immediate question under discussion at i is the most recent member of QUD_i.

I think figure 1 gives an intuitive picture of what these QUD structures are supposed to achieve.

3.2.2 Questioning and asserting

i. The *strategy of inquiry* for a question q is a subtree of questions rooted at q, organized by the partial-resolution relation (p. 14, (12)).

ii. If an assertion is accepted by the interlocutors, then its content is added to the common ground (p. 16).

iii. If a question is accepted by the interlocutors, then it is added to the stack of questions under discussion (p. 17).

iv. Assertions and questions are related by relevance (p. 16):

   a. An assertion is relevant iff it partially resolves the immediate QUD.

   b. A question is relevant if it is part of a strategy for resolving the immediate question under discussion.

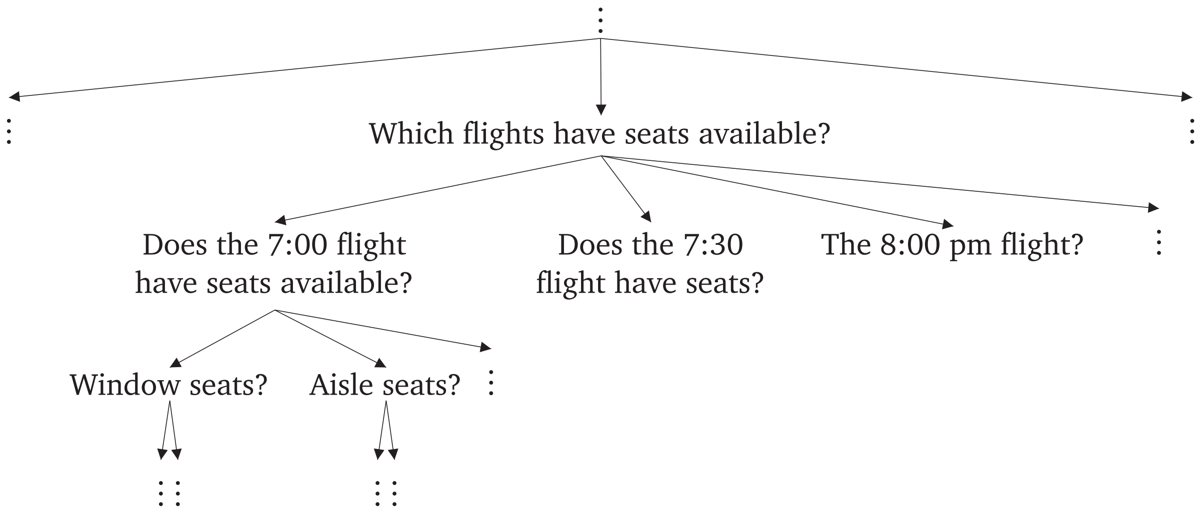


Figure 1: Part of the QUD structure for a discourse about airplane bookings, with the arrows connecting super-questions to sub-questions.

3.2.3 Question–answer alignment

If we assume that relevance is not binary, but rather organized by the size of the Ans sets defined in definition 8, then we get a more articulated view of relevance.

Definition 16 (Relevance; G&S, van Rooy 2003)**.**

$$p \succ_Q q \quad \text{iff} \quad \begin{array}{l} \text{Ans}(p,Q) \subset \text{Ans}(q,Q) \text{ or} \\ \text{Ans}(p,Q) = \text{Ans}(q,Q) \text{ and } q \subset p \end{array}$$

(9) Here, relevance is maximized in the above set-theoretic sense, by resolving *she* to Lisa and filling out the ellipsis with (the meaning of) *tired*.

A Is Lisa tired?

B Yes, she is.

(10) A Where are you from?

B Palo Alto/California/The U.S./Earth . . .

	$\text{Where}_{\text{city}}$	$\sqsubseteq$	$\text{Where}_{\text{state}}$	$\sqsubseteq$	$\text{Where}_{\text{country}}$	. . .
Palo Alto	$\succ$					
California			$\succ$			
U.S.					$\succ$	

In general, if the Ans set is not a singleton, then something interesting happens — the original question is partly rejected and/or an epistemic/relevance/politeness implicature is generated by the answer and/or . . .

3.2.4 Intonational focus

Definition 17 (Ordinary and focus denotations)**.** For any syntactic phrase α with semantic type σ,

$$\begin{aligned} [\![\alpha]\!] &\in D_\sigma \\ [\![\alpha]\!]^{f} &= \{[\![\alpha]\!]\} \\ [\![\alpha_{\mathbf{F}}]\!]^{f} &\subseteq D_\sigma \end{aligned}$$

(11) a. Wittgenstein: Would that mean that behind every claim lies a question?

b. Groenendijk & Stokhof: Ja!

(12)

Did Bart pass?	Who passed?	What did Bart do?	Who wore what?
↑	↑	↑	↑
Bart passed	$\text{BART}_{\mathbf{F}}$ passed.	Bart $\text{PASSED}_{\mathbf{F}}$	The ROCKSTARS wore LEATHER.

Definition 18 (Congruence)**.** Declarative φ is congruent to interrogative $?\psi$ iff $[\![\varphi]\!]^{f} = [\![?\psi]\!]$.

4 Polar questions corpus

We collected a small corpus of question–answer pairs, where the majority of the questions are polar questions and the answerers were encouraged to over-answer. The assumption was that the ways in which they over-answered would provide windows into the QUD structure. We basically assumed that the following observation from Zeevat (1994) would hold for over-answers as well:

> A proper partial answer is then one where the answerer indicates that she is not giving a full answer to the question that was asked, but a standard answer to a weaker question. It is then the task of the person interpreting the answer to work out the weaker question on the basis of the formal properties of the answer and the original question.
>
> (Zeevat 1994)

4.1 Corpus details

4.1.1 Numbers

i. one exceedingly simple context (figure 2)

ii. 26 simple polar questions (+20 using a different picture/context)

iii. 2600 answers (+2000 using picture 2)

iv. with shallow semantic representations.

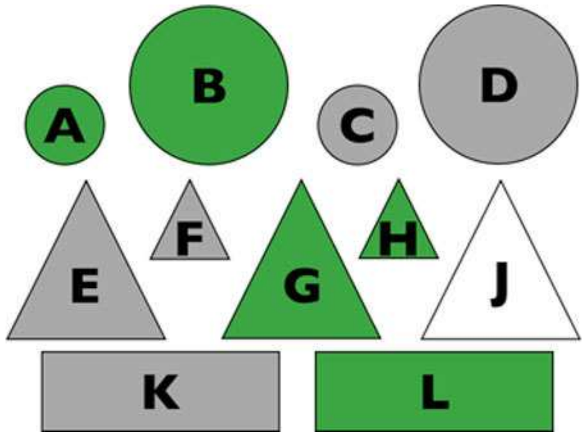


Figure 2: Participants answered simple polar questions about shapes in this diagram.

4.1.2 Sample questions

i. Is shape A a gray triangle?

ii. If shape B is a gray circle, is it large?

iii. Is shape C large or green?

iv. Is shape B green?

v. Are there four green triangles?

vi. Is shape F a green triangle?

4.1.3 Question types

i. 26 questions: 10 plain polar, 3 disjunctive, 7 conditional, 6 fillers

ii. 100 answers to each question

iii. About two dozen removed for various reasons.

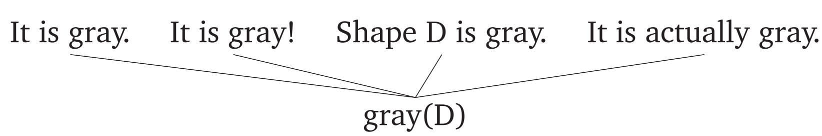
iv. Annotated so far: 1,592 (10 plain polar, 3 disjunctive, 4 conditional)

4.1.4 Collection method

Amazon's Mechanical Turk: Figure 2 was displayed, along with

> Imagine that you're in conversation with someone, and they ask you the following question about the above image, which they can't see:
>
> ${question}
>
> Please choose 'yes', 'no', or 'well' and also provide some additional information that is relevant to the question.

4.1.5 Semantic annotations



4.2 Conceptual alternatives

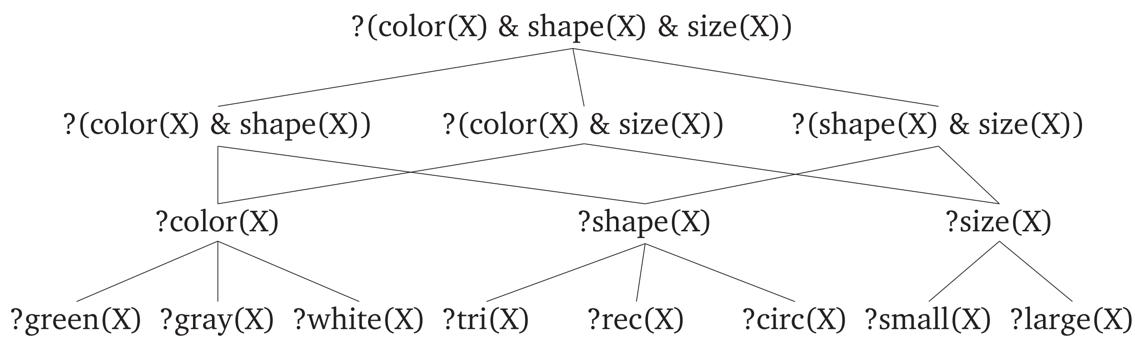


Figure 3: The hierarchy of questions revealed by the corpus of answers. Each entity in the domain determines such a hierarchy. Hierarchies for multiple shapes are easily obtained from these through boolean operations.

4.3 Generalizations

4.3.1 Up the hierarchy

If the answer to a polar question is 'no', then the follow-up resolves a dominating Wh-question.

(13) Q Is shape D green?
A It's gray
A It's a gray circle.
A It's a large gray circle.
A #It's a circle.
A #It's large.

4.3.2 Ignored predicates

If a question predication P(X) is ignored in a reply, then P(X) is implicated to be true.

(14) Q Is shape G a small green triangle?
A (No|Well), it's large. ($+\!\!>$ It's small and gray.)

4.3.3 Well and but

The 'well' prefix is disfavored in general but becomes the favored prefix where the follow-up contains *but*.

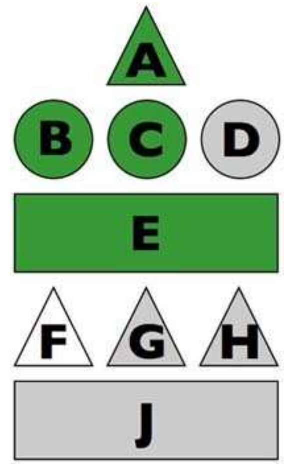
Distribution over answers :

No	56%
Yes	30%
Well	14%

Distribution over answers containing *but*:

No	33%
Yes	7%
Well	60%

4.3.4 Domain restriction



(15) Are the triangles green?

"Yes":	10%
"No":	16%
Other:	24%

(16) I am curious about the things above shape C. Are the triangles green?

"Yes":	36%
"No":	4%
Other:	9%

For discussion, Malamud (2006a,b).

4.4 More natural solicitation of answer types

How might we naturally solicit truly partial, indirect, and over- answers like the following in controlled contexts?

(17) **Over-answer**

Q Is Ali in Room 413?

A (No,) Room 211

A (No,) She checked out.

A #No.

(18) **Intended as partial answer**

From the detective show *Monk* (approximate from 'Mr. Monk goes to the Carnival'). The subject is whether Mr. Monk, who earlier had a nervous breakdown, is ready to be put back on the police force. Stottlemeyer is Monk's friend and former captain.

Commission member	Is Mr. Monk ready to be put back on the force?
Stottlemeyer	Mr. Monk has *excellent* instincts.
Commission member	Yes, but is he ready to be reinstated?
Stottlemeyer	He is an *excellent* investigator.
Commission member	Captain, please. . .

(19) **Intended as partial answer**

John and Mary have recently started going together. Valentino is Mary's ex-boyfriend. One evening, John asks Mary, "Have you seen Valentino this week?" Mary answers, "Valentino's been sick with mononucleosis for the past two weeks." Valentino has in fact been sick with mononucleosis for the past two weeks, but it is also the case that Mary had a date with Valentino the night before.

5 Additional directions

i. Inquisitive semantics, which allows for hybrids — clauses that are both assertive and inquisitive — and which relaxes the partition assumptions.

ii. Büring's (2003) builds a discourse model that is even more attuned to intonational contours in general.

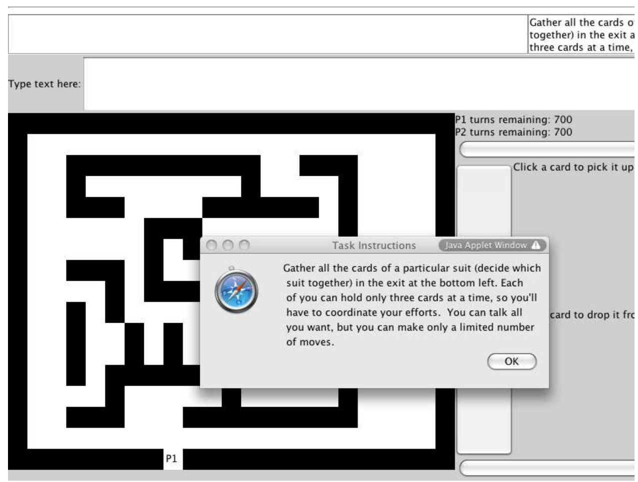
iii. Roberts (1996:6) connects with planning, but only briefly, and the generality of her notion of strategy suggests that we need to add a planning module, as it were.

A Underspecification in a collaborative search task

This section, highly relevant, is taken from a brief presentation I have in the semantics research seminar. I'm including it because it is so obviously related to the QUD-based frameworks.

A.1 The game

The basic scenario was a two-person collaborative search task. The game-world consisted of a maze-like environment in which a deck of cards had been randomly distributed. Each player could always see his own location, but the location of the cards and the other player were limited by distance and line of sight. The general approach is inspired and guided by the efforts of Thompson et al. (1993), Allen et al. (1996), and Stoia et al. (2008).



A.2 The task

9 10 J Q K A 2 3 4 5 6 7 8

{H,D,S,C}

The players were assigned the underspecified task 'Find six consecutive cards of the same suit'. They then explored the world, manipulating cards and communicating via an instant-messaging function. They had to settle on a specific version of the task and then solve it.

A.3 Transcripts as data structures

The transcripts record not only what the players said to each other, but also the full history of their movements, their actions regarding the cards and each other, the timing of all their actions, and the initial state of play. Using the transcripts, one can automatically re-run the entire game exactly as it was played.

```
Player 1, 566650: PLAYER_MOVE7,11
Player 2, 567771: CHAT_MESSAGE_PREFIXwhich c's do you
                  have again?
Player 1, 576500: CHAT_MESSAGE_PREFIXi have a 5c and
                  an 8c
Player 2, 577907: CHAT_MESSAGE_PREFIXi jsut found a 4
                  of clubs
Player 1, 581474: PLAYER_PICKUP_CARD7,11:8C
Player 1, 586098: PLAYER_MOVE7,10
```

```
Server, 56: MAX_LINEOFSIGHT3
Server, 118: CREATE_ENVIRONMENT
-----------------------;
-                     -;
-  ----------  ---    -;
-  -        -    -    -;
-  ---    ------ -    -;
-      ---       -    -;
-  b   - -       -    -;
-  --- -       ---    -;
-    - ---       -    -;
-  - -  b      ---    -;
-  -  - -      -      -;
-  -  - -      -      -;
-  - ----- -   - -    -;
-    -     -     -    -;
-  ---  b---------    -;
-                     -;
-------- --------------;
```

A.4 States

- The players' locations.
- The players' current card holdings.
- The players' remaining move counts.
- Action:
  - player move;
  - player card pick-up;
  - player card drop; or
  - player utterance (a player–text pair)

A.5 Underspecification

(20) **Context** The players are collecively holding 4H and KH.

Player 2:	Look for 2.	
Player 1:	and the 3?	

Literal	103	(37%)
Requiring enrichment	172	(63%)
Total	275	

(21) **Context** Player 2 is looking for JH, QH, KH

Player 2: Did you find anything?
Player 1: yep, h at the top exit

(22) **Context** The players are trying to get six consecutive hearts, but they are still in the process of deciding which six.

Player 2: i got 2H
Player 1: I found a 3H
Player 2: sweet.
[. . .]
Player 1: Have you found anything?
Player 2: no, just 2H.

A.6 Annotations

```
[_FEATURES text ]_{DENOTATION}
```

We annotated 10 transcripts with information about the basic propositional content of the players' utterances and the intended illocutionary force of those utterances.

- `I have [_3H 3H ]_{3H}`
- `Need [_8 8 ]_{8H}`
- `I'll drop [_9|DEF|SG the 9 ]_{9H}`
- `try [_H|INDEF|PL h ]_{2H, 3H, 4H, 5H, 6H, 7H, 8H, 9H, 10H, JH, QH, KH}`
- `got [_X|PRO|SG it ]_{9H}`

A.7 Modeling the central Question Under Discussion

We model the central Question Under Discussion — the task — as a probability distribution over subsets of cards, with the values representing the likelihood of that subset being the particular one sought by the players.

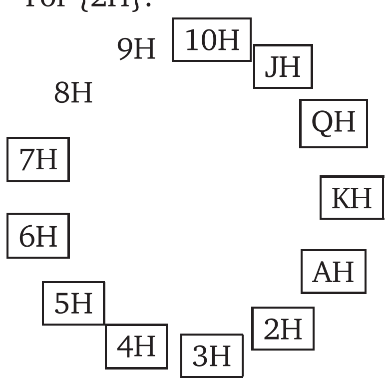
$$T(A) = \begin{cases} \frac{1}{6,868} & \text{if } A \text{ is a set of six like-suited cards} \\ 0 & \text{otherwise} \end{cases}$$

Initialization $(4\binom{13}{6} = 6,868)$:

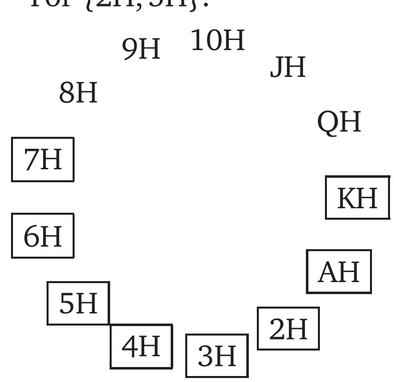
A.8 Relevance spheres

The central pragmatic concept for this experiment is that of a *relevance sphere*. The relevance sphere for a set of like-suited cards c is the smallest set of at least six consecutive like-suited cards containing all the members of c. For sets of cards with differing suits, we take the union of the relevance spheres for the subsets with the same suit.

For {2H}:



For {2H, 5H}:



A.9 Hypothesis

Speakers leverage their understanding of the (evolving) task to resolve underspecified expressions. More specifically:

(23) At stage S, with the players holding cards C, and the task distribution T:

For each underspecified card-nominal N, select the denotation D such that $C \cup \{D\}$ maximizes probability with regard to T.

A.10 Results

Experiment conducted using custom Python classes.

Correct inference	164	(95%)
Incorrect inference	8	(5%)
Total	172	

A.11 Discussion

- Performance is good for singular definite nominals.
- Perfomance is very poor for nominals with the PRO feature, since these require reference tracking.
- For many plural indefinites, the inferences look reasonable, but evaluation is harder, since their domains are less clearly specified.

Conclusion The general task-like QUD is an important guide, but it is far from being the only influence (of course).

A.12 Immediate future plans

i. Collect and annotate more data.

ii. Improve and use speech-act annotations to harness the power of more immediate QUDs.

iii. Seek to resolve pronominal anaphora by leveraging both the overarching task QUD and more immediate ones.

iv. Infer predicates (e.g., *found*, *seek*, *picked-up*) for fragment utterances like like *4H!*.

v. Take more advantage of the players' language to get a picture of the QUDs.

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