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# How Questions and Answer Cohere

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## 1. The basic problem, and some simple but (I think) unsatisfactory solutions

In the context of a question, a declarative utterance may express "more" content than we would expect it to by compositional semantics.

(1) Q: What did Clara draw with her new pencil?
A: She drew a dragon.
*Content expressed*: Clara drew a dragon with her new pencil.

(2) Q: Where is John going on Wednesday?
A: He's going to Chicago.
*Content expressed*: John is going to Chicago on Wednesday.

(3) Q: How is John getting to Chicago?
A: He's taking the train.
*Content expressed*: John is getting to Chicago by taking the train.

(4) Q: Why is John going to Chicago by [$_F$ train]?
A: He's afraid to fly.
*Content expressed*: John is going to Chicago by train because he's afraid to fly.

• Speaker is fully committed to the enriched content *as long as they are considered to intend to answer*.

*Simple solution #1: Gricean reasoning about Relevance to modify the content*

• what I have previously assumed; major challenge of this project is to establish that we need anything else.

*Simple solution #2: Ellipsis* (on analogy to one account of fragment answers)

(5) Q: Who ate the bagel?
$A_1$: Anna.
$A_2$: Anna did.

(6) Q: Where's Brian going next week?
A: (To) Columbus.

• Straightforward for examples like (1) and (2).

• Example (3): paraphrase given does not contain the linguistic string *he's taking the train*, so this cannot be derived from that paraphrase by ellipsis. But perhaps this is the correct paraphrase:
(3)alt He's taking the train to get to Chicago.

But does it matter? Ellipsis provides a mechanism but not an explanation; the explanation comes from pragmatics; so positing ellipsis is really just a matter of adopting the pragmatic account of how questions and answers cohere, and reduces to solution 1.

*Simple solution (??) #3: The partition does the work*

(2) Q: Where is John going on Wednesday?
A: He's going to Chicago.
*Content expressed*: John is going to Chicago on Wednesday.

• Assume 1: the question partitions W, or the current context set, in the standard way:
{{w: John is going to Aberdeen on Weds}, {w: John is going to Birmingham on Weds}, {w: John is going to Chicago on Weds}....}

• Assume 2: a felicitous answer must pick out some cell of the partition.

• Problem: which one? If (2) A picks out, by virtue of its semantics, those worlds in which John is going to Chicago currently or at some future time, this overlaps with all of the cells of the partition (modulo practical constraints)
– So, we go back to treating Assumption 2 as a pragmatic constraint which leads to inferences about what the speaker intends; the partition doesn't really do any work.

• Another attempt: (2)A picks out a set of worlds which *includes* one and only one cell of the partition i.e. the cell {w: John is going to Chicago on Weds}. So we can say that an answer (pragmatically? conventionally?) expresses the proposition corresponding to that cell which is included in the proposition semantically expressed.
– But what about the answer *He isn't going to Chicago*.
– Does not include any cell, yet is still understood as being about John's Wednesday trip.

Conclusion (possibly hasty)
We can't express the coherence between questions and answers at the semantic level i.e. at the level of propositions, partitions & worlds. We need to do it at the level of representations.

*Some observations towards a different kind of solution*
• Some obvious anaphoric connections: nominal anaphora, temporal anaphora

## 2. The proposal in overview

(i) An utterance interpreted as a direct answer is subject to special rules of interpretation.
   a. Questions introduce a special discourse referent ("forward looking anaphor") about which more information is required. A discourse move counts as a direct answer only if it provides such information.
   b. If an utterance is taken to be a direct answer, discourse referents in the universe of its provisional representation are preferably treated as anaphoric on the question.

• Developments of the thesis

(ii) Where subordinate clauses (such as disjuncts in a disjunction or the antecedent of a conditional) are understood to stand in something like a question-answer relation to an explicit question, the content of those clauses depends, in a similar way, on the content of the question. This gives rise to enrichment of the content of subordinate clauses.

(iii) [Not for this talk] Where utterances are understood as answers to *implicit* questions, the content expressed may be dependent on the content of the implicit question.

• Plan for this talk:

A: Develop a formal treatment (utilizing SDRT-lite) of answers that allows me to express the view
B: Look at application to embedded clauses
C: Conclude, thinking a bit about what has and hasn't been accomplished.

## 3. The representational framework: SDRT-lite

• SDRT (segmented DRT; Asher 1993, Lascarides & Asher 2003; etc.): an extension of DRT developed specifically to allow for the expression of discourse relations ( *rhetorical relations, coherence relations*) between discourse segments. The theory makes full use of the mechanisms in DRT for representing anaphoric relations between utterances, while adding constraints on anaphora stemming from discourse relations.
• Crucial features for current purposes:
   (i) representations keep track of which content "belongs with" which discourse segment and
   (ii) explicit representations of discourse relations.
• I am using only a very minimal extension of DRT, SDRT-lite

**Definition 1: SDRS**

An SDRS is an ordered pair ⟨A, F⟩, where A is a set of labels (for discourse segments), and F is a function mapping each label to a formula of the SDRS language, which for our purposes will be one of the following two things:

(i) a DRS
(ii) an expression of a discourse relation

**SDRS update: Informally & procedurally**

Asher 1993, Asher & Lascarides 2003 provide formal and fully general definition of SDRS update. I'll be using only a small part of the whole system, so I describe that part of the update procedure that I need, informally.

Update of an SDRS with a new sentence[1]

1. Construct a preliminary DRS for the sentence in accord with standard construction rules. Anaphoric elements marked as such.[2] Introduce a label corresponding to that discourse segment.

2. Identify an attachment point for this new discourse segment i.e. determine to which existing discourse segment(s) this will be attached, and with which discourse relation(s). Introduce a new label for the discourse segment corresponding to the new structure.
   – I'll be focusing entirely on question/answer sequences, where the presence of the question is presumed to highly constrain the construction of the discourse relation. So this part will be uninteresting.

3. Resolve anaphora as consistent with the coherence relation & dominance relations.
   – We should not think of steps 2. and 3. as being strictly sequential. As is well known, resolution of anaphora and assignment of discourse relations are deeply intertwined, as illustrated in:
   (7) John yelled at Bill. He was upset. [*he*=John <=> explanation; *he*=Bill <=> narration]
   But again, for the cases under consideration, we'll be utilizing the strong assumption that a response to a question is intended as an answer, so it is plausible that this discourse relation is presumed, and anaphoric relations constructed accordingly. (Failure leads to revision.)

4. Revision of constituents after update: Revise any constituents of the resulting SDRS to guarantee that any well-formedness conditions (coherence requirements on discourse relations) are satisfied.

Example

(8) John yelled at Bill. = $\pi_1$

(9) $[x_1, x_2, e_1 : x_1=\text{john}, x_2=\text{bill}, \text{yell}(e_1), \text{ag}(e_1, x_1), \text{pat}(e_1, x_2)]$

(10) He was upset. = $\pi_2$

(11) Provisional DRS: $[y_1, e_2 : y_1=?, \text{be-upset}(e_2)]$

(12) Assume: Narration( $\pi_1$, $\pi_2$)

(13) Establish anaphoric & temporal relations:
Final DRS for $\pi_2$: $[y_1, e_2 : y_1=x_2, \text{be-upset}(e_2), e_1 > e_2]$

[1] Strictly, this should be "discourse segment," itself possibly a problematic notion. For current purposes, we can think about update just going one sentence at a time.

[2] We could build preliminary DRSs with a van der Sandtian A-structure, but I will avoid that extra complication here.

• Next: use this framework to build representations of question/answer sequences & to account for the enriched content of declaratives serving as answers.

## 4. Representing the content of questions

*Syntactic assumption: wh-questions*
All *wh*-questions have the following logical form: [$wh_1$ ...[ $wh_n$ [$_S$ ...$x_1$ ... $x_n$... ]]
• *wh*-questions: *wh*-expressions taking scope over a sentence which contains a variable co-indexed with and grammatically linked to the *wh*-expressions.
• Semantic type information(e.g. person, for *who*, non-person for *what*, location for *where* etc.) is "left behind" as a feature on the variable.

**DRS construction for wh-questions:**
Follow standard DRS construction procedures for the embedded S. The variables corresponding to *wh*-traces are treated as follows:

**Construction rule for *wh*-traces:**
Given the configuration: [$_{XP}$ $x_i$: $\varphi_1$...$\varphi_n$ ], ( $\varphi_1$...$\varphi_n$ being the features derived from the *wh*-expression itself), where $x_i$ is bound by a *wh*-expression, introduce a new discourse referent $x_i$ into the universe of the DRS under construction, and conditions $\varphi_1(x_1)$...$\varphi_n(x_1)$ into the set of conditions of that DRS.
Then, add a condition of the form , ?$x_1$ to the set of conditions of the DRS.

**Example**:
(14) Who did Jane see?
(15) [ x, y, $e_1$ : x=Jane, SEE($e_1$), Ag($e_1$, x), Pat($e_1$, y), person(y), ?y ]

**Discussion**

1. <u>The condition ?$x_1$ and the Question/Answer Relation</u>
• Condition has no effect on embeddings in a model, but rather imposes coherence constraints on what comes next.
• Think of this as a *forward looking anaphor*: it indicates that some information-carrying predication involving this variable is expected in the discourse.

2. <u>Content or presupposition?</u>
• I treat the content of questions as ordinary content, not presupposition i.e. there is no distinction in my representations between:
(16) *Who did John see?*
(17) *John saw someone. Who (was it)?*

• No strong commitments intended here: It *is* important that we allow that content introduced by a *wh*-question need not be new (i.e. need not add new information), to allow for the felicity of sequences like the following:

(18) A: Jane saw someone at the park. B: Oh yeah? Who did she see?

3. Interpretation of the representation

It's not my goal here to say anything new about the semantics of *wh*-questions. I am making the assumption that the representations I am giving can be interpreted in some standard way i.e. as sets of propositions. (Cf: DRT treatment of questions in Asher & Lascarides 1998 (Questions in Dialogue, *L&P* 21(3).)

4. Preferably, responses are interpreted as answers

I make here the assumption that in a discourse, if a question is asked and then the next discourse move is an utterance of a declarative with assertoric intonation by the addressee of the question, then that utterance is assumed to be intended as an answer, unless that assumption leads to incoherence. As a first pass, assume that the response is intended as a Direct Answer i.e. establish the discourse relation *DirAns*.

## 4. Answers as anaphors

### 4.1. Two coherence constraints on DirAns

**Answerhood Constraint**

Suppose $F(\pi_i) = K$, where $?x_1 \in Con(K)$.

If $DirAns(\pi_i, \pi_j)$, then the result of update with $F(\pi_j)$ will contain or entail some new predication involving $x_i$

i.e. If $\pi_j$ is to count as a direct answer to a question expressed by $\pi_i$, then the DRS corresponding to $\pi_j$ must introduce new information about the dr corresponding to the *wh*-variable.

**Assumption of Anaphoricity**:

If $DirAns(\pi_1, \pi_2)$, then preferably interpret dr's in $U(F(\pi_2))$ as anaphoric on dr's in $U(F(\pi_1))$

i.e. For each dr $x \in U(F(\pi_2))$, introduce a condition $x$=? in $Con(F(\pi_2))$, and attempt to solve it with some dr in $U(F(\pi_1)$

• *preferably interpret as anaphoric*: assume anaphoricity unless the assumption leads to incoherence and/or no suitable antecedent can be found in the question.

### 4.2. Examples: *who, what, where, when*

**Examples**

EXAMPLE 1:

(19) Q: Who did Jane see? A: Jane saw a man.

(20) a. $K_Q$: [ x, y, $e_1$ : x=Jane, SEE($e_1$), Ag($e_1$, x), Th($e_1$, y), person(y), ?y ]

b. Prelim $K_A$: [w, z, $e_2$: w=Jane, man(z), SEE($e_2$), Ag($e_2$, w), Th($e_2$, z) ]

(21) SDRS: $\langle\{\pi_1, \pi_2, \pi_3\}, F\rangle$, where:
$F(\pi_1)=K_Q$,
$F(\pi_2)=K_A$,
$F(\pi_3)=DirAns(\pi_1, \pi_2)$

(22) Add anaphoric conditions as required by Assumption of Anaphoricity:
[w, z, $e_2$: w=Jane, man(z), SEE($e_2$), Ag($e_2$, w), Th($e_2$, z), w=?, z=?, $e_2$=? ]

(23) Resolve anaphora maximizing consistency. Identification of the two events forces us to treat the Themes of the two events as identical, and thus to satisfy the requirement introduced by ?y.
Final $K_A$: [w, z, $e_2$: w=Jane, man(z), SEE($e_2$), Ag($e_2$, w), Th($e_2$, z), $e_2$=$e_1$, w=x, z=y ]

– This is a completely simple example, where the answer does not "gain" any extra content by virtue of being an answer, other than any temporal constraints introduced by identifying the events.

EXAMPLE 2:

(24) Q: What did Clara draw with her new pencil? A: She drew a dragon.

(25) $K_Q$: [$e_1$, $x_1$, $x_2$, $x_3$ : $x_1$=Clara, her-new-pencil($x_2$), DRAW($e_1$), Ag($e_1$, $x_1$), Instr($e_1$, $x_2$), Th($e_1$, $x_3$), non-person($x_3$), ?$x_3$ ]

(26) Prelim $K_A$: [$e_2$, $y_1$, $y_2$: female($y_1$), $y_1$=?, DRAW($e_2$), Ag($e_2$, $y_1$), Th($e_2$, $y_2$), dragon($y_2$) ]

(27) Assume: DirAns($\pi_Q$, $\pi_A$)

(28) Final $K_A$:
[$e_2$, $y_1$, $y_2$: female($y_1$), **$y_1$=$x_1$,** DRAW($e_2$), Ag($e_2$, $y_1$), Th($e_2$, $y_2$), dragon($y_2$), **$e_2$=$e_3$, $y_2$=$x_3$** ]

• As the drawing of the dragon is identical to the drawing with the new pencil, it follows that Clara drew a dragon with her new pencil. So, although the content conventionally derivable for the sentence *she drew a dragon* in isolation does not entail anything about an instrument, the content of the question+answer is richer.

EXAMPLE 3, in brief

(29) Q: Where is John going on Wednesday? A: He's going to Chicago.

• The DRS for Q will include a dr *x* for the GOAL of the going event, and a condition ?*x*.
• The preliminary DRS for A identifies a going event whose goal is Chicago, with anaphoric agent.
• Identifying the subject pronoun of A with (the dr corresponding to) *John* in Q does not by itself guarantee that the two going events are identical, hence does not entail any new predication on *x*.
• We could satisfy that requirement by simply identifying *x* with (the dr corresponding to) *Chicago* in $K_A$: then we have a new predication on *x* but not necessarily identity of the events. The need to satisfy the anaphoricity requirement leads us to also identify the events.

### 4.3. *why* – a very naive approach

(30) Q: Why did Jane sneeze?
A: She has a cold.
*Content expressed*: Jane sneezed because she has a cold.

• Content/presupposition of the *why*-sentence:
  (i) That Jane sneezed.
  (ii) That this event has a cause.

• I will make the naive assumption that the answer to a *why* question provides an event which is a cause; so, I represent the content of the *why* question as in (31). The DRS for the answer is as in (32)

(31) $[x, e_1, e_2 : x=Jane, sneeze(e_1), Th(e_1,x), cause(e_1, e_2), \ ?e_2 ]$

(32) $[y, e_3 : y=?, has\text{-}cold(e_3), Exp(e_3, y)]$

• It'll be obvious by now how I expect things to work: we treat $e_3$ as anaphoric. We have in this case two potential antecedents, $e_1$ (the sneezing), and $e_2$ (the cause of the sneeze, type unspecified). Suppose we posit that the having-a-cold event is identical to the sneezing event; this might be coherent, but leaves us without any new predication on the mystery variable $e_2$. So identifying the having-a-cold event with the cause is a better solution.

## 5. Embedding

• Observation: The same enrichment of content occurs in non-asserted embedded clauses which form part of the response to a question.

*Question*
(33) What did Clara draw with her new pencil?

*Some appropriate responses*
(34) She drew a dragon or she drew a snake.
(35) Bill said that she drew a dragon.
(36) If she drew a dragon, we should hang it up on the refrigerator.
(37) If she's been reading *My Father's Dragon*, she probably drew a dragon.

• Difference between (34) and the rest: (34) is a direct answer; none of the others are. Yet we easily construe all of these responses as relevant to the question (with some caveats concerning (36)). However, the difference suggests we should approach the two cases differently.

### 5.1. Disjunction

• Observation: $S_1$ *or .... or* $S_n$ can answer Q only if all of its disjuncts potentially answer it.
• Call the disjuncts in this case *Proposed Answers*: none are asserted, but they are "put forward" as possible answers. Proposed Answers should be intended to cohere with the question in the same way as actually asserted answers, i.e. the Assumption of Anaphoricity applies to them individually. Putting this in pretty notation:

**Rule governing disjunctive answers:**
$DirAns(\pi_i, \pi_j) \ \& \ Disj(\pi_j, \pi_1 \ ... \ \pi_n) \rightarrow PropAns(\pi_i, \pi_1) \ \& \ ... \ \& \ PropAns(\pi_i, \pi_n)$

**Assumption of Anaphoricity, extended**:
If DirAns($\pi_1$, $\pi_2$) or PropAns($\pi_1$, $\pi_2$), then interpret dr's in F($\pi_2$) as anaphoric (all else being equal).

- Consequence: we straightforwardly get "enrichment" under the scope of *or* without any fancy pragmatic moves.
- This will also provide a new disjunctive predication on the *wh*-variable, hence confirming that the disjunction is a DirAns.

### 5.2. Evidential and conditional answers

Some further evidential examples:

(38) Q: What did Clara draw with her new pencil?

(39) Bill said/thinks/hinted/let slip that she drew a dragon.
(40) Bill dreamed/hopes that she drew a dragon.
(41) Bill predicted that she would draw a dragon.
(42) Bill denies that she drew a dragon.

(43) If she's been reading *My Father's Dragon*, she drew a dragon.

Problem? Some of the embedded clauses here are not plausibly proposed answers; yet all are interpreted anaphorically.

<u>Some possible treatments</u>

1. Brute force: Posit that there is a *Discourse Schema* (something like Question-Evidential Answer) corresponding to this sequence, and propose a specific interpretation rule for the schema, according to which the Assumption of Anaphoricity applies to the embedded clauses.

2. Weaken the conditions under which the Assumption of Anaphoricity applies: So far I've suggested that this assumption is made once a particular discourse relation has been established: DirAns or PropAns. But maybe Anaphoricity is a default for any response to a question: Without trying to decide whether the response is an answer at all, first try to build anaphoric links between it (some constituent of it) and the question.

3. Invoke heavy duty pragmatic inference: Even where the evidential predicate is not adequate to support the proposing of an answer (e.g. as with *dreamed*), interpreter (the questioner) determines that the utterance as a whole will be more relevant to her interests if in fact the embedded clause can be made anaphoric on the question, than if it cannot. So, she makes the embedded clause anaphoric. (But then wouldn't we expect more variability?)

### 5.3. Antecedent answers

(44) What did Clara draw with her new pencil?
(45) If she drew a dragon, we should hang it on the refrigerator.

- The antecedent is the PropAns, hence anaphoricity assumption applies.
- This is an odd way to propose an answer, for independent reasons.

### 5.4. Embedding, summary

• Does embedding provide an argument in favor of the proposed approach?
  – For those opposed to allowing fully pragmatic enrichment at the embedded level, yes.
  – For me, not so much.
  – However, it reinforces the claim that this anaphoric dependency between questions and what follows them is pervasive.

• Embedding suggests that the Anaphoricity requirement applies more broadly than I originally suggested. Preference for anaphoricity is triggered not only by DirAns relation but also by my newly invented PropAns. Or perhaps triggered just by *being the utterance that follows a question*.

## 6. Wrap Up

• What I haven't done:
  – Given an argument that the dependency between questions & answers *must* be accounted for by a mechanism such as I've proposed, or that it can't adequately be accounted for by a fully extra-linguistic inferential mechanism. (Given that we have no theories of what the limits might be on such a mechanism, it's hard to see how such a claim could be supported.)
  – Explained more elaborate kinds of enrichment such as this:

(46) Q: How is Jenn getting to Boston?
A: She's renting a car.
A': Either she's renting a car or she's going by train.
==> She is getting to Boston by renting a car and subsequently driving it to Boston.

– My account gets: "Jenn is getting to Boston by renting a car," for both the unembedded & embedded cases. But surely we need world knowledge for the rest.

• What I have done:
  – Articulated the systematic dependency of the content of answers on the content of questions. This dependency is unsurprising, but I think has not been articulated in this way before.
  – Proposed a very simple mechanism whereby this dependency may be accomplished, namely anaphoricity. In the process of anaphora resolution, there is heavy dependency on the black box inside of which anaphora is resolved; but there is reason to believe that whatever progress is made on elucidating what goes on inside that box for e.g. pronominal anaphora will also help with this case too.
  – By suggesting that the dependency is linguistically mediated, I have committed to the claim that the "enriched" interpretation of answers is not "merely pragmatic," but conventional, in the sense that the determination of this content is a consequence of following the linguistic rule for interpreting answers.