A bilateral dynamic semantics for questions and propositions

MLC Seminar, ILLC

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2022-10-07

Outline

Today:

- A bit of background: yes/no (a)symmetry in polar questions
- The proposal: questions as dynamic propositions
- What is it good for?

The first part draws mostly from an article I published, and the rest is novel.

Émile Enguehard (2021). "Explaining presupposition projection in (coordinations of) polar questions". *Natural Language Semantics*

Yes/no asymmetry in polar questions (1)

In answer set semantics, questions are identified to sets of propositions (their answers).
Polar questions can be resolved in two ways, "yes", or "no", hence they are analysed as a 2-element set:

(1) a. Is Ann married? (p?)
 b. $\{$Ann is married, Ann is unmarried$\}$ ($\{p, \neg p\}$)

Note: this representation is invariant to $p/\neg p$ substitution.

(2) a. Is Ann unmarried? ($\neg p$?)
 b. Is Ann married or not? (p or $\neg p$?)
 Natural analysis: $\{p, \neg p\}$.

(Same can be said of partition semantics or inquisitive semantics.)

Yes/no asymmetry in polar questions (2)

Problem: these are not the same.

(3) a. Is Ann married?
    b. Is Ann unmarried?
    c. Is Ann married or not?

- Simple polar questions have asymmetric epistemic biases (Büring and Gunlogson 2000; Sudo 2013, a.o.).
- *or not* questions license specific pragmatic inferences (Biezma and Rawlins 2012, a.o.).
- Today: presupposition projection in coordinated polar questions exhibits asymmetric patterns.

Presupposition projection

(4) Ann's spouse is unemployed.
$\rightsquigarrow$ Ann is married.

(5) Ann's spouse is not unemployed.
$\rightsquigarrow$ Ann is not married.

(6) Is Ann's spouse an unemployed?
$\rightsquigarrow$ Ann is married.

A look at coordinated questions

(7) a. Is Ann married, and is Ann's spouse unemployed?
b. Is Ann unmarried, or is Ann's spouse unemployed?
$\not\rightsquigarrow$ Ann is married.

(8) a. #Is Ann unmarried, and is Ann's spouse unemployed?
b. #Is Ann married, or is Ann's spouse unemployed?

These are the same projection patterns as those Karttunen (1973) identifies for declaratives: *and* $\rightarrow$ grant that yes, *or* $\rightarrow$ grant that no.

Theoretical significance (1)

We know how to model presupposition projection in declaratives.

- Dynamic semantics (Heim 1983, a.o.)
- Trivalent semantics (Beaver and Krahmer 2001, a.o.)
- Deriving the above systematically from classical truth-conditional semantics (Schlenker 2009; Rothschild 2011; George 2014)

Ideally, we combine an existing account of presupposition projection with a theory of what questions denote and how they can be coordinated, and the presupposition projection facts follow.

Theoretical significance (2)

We want a representation of questions and a theory of question connectives that can model the projection facts.

- This requires a parallel treatment of conjunction and disjunction, as we have for declaratives.
- It also requires yes/no-asymmetry : the "yes" and "no" answers need to be formally distinguished.

Problem: existing theories do not fit these requirements, e.g. in answer set theory:

(9) a. "whether p" $\approx \{p, \neg p\}$
b. $Q_1 \wedge Q_2 = \{p_1 \wedge p_2 \mid p_1 \in Q_1, p_2 \in Q_2\}$
$Q_1 \vee Q_2 = Q_1 \cup Q_2$

For a lot more detail on this point, see the paper.

Towards an analysis

- Polar questions, like declaratives, should distinguish positive and negative possibilities.
- The connectives should be sensitive to that in the same way they are for declaratives.

In the paper, I propose a trivalent semantics for questions that incorporates these ideas.

Today, I will do it with dynamic semantics instead.

Dynamic semantics and bilateralism

Just as with declaratives, presupposition projection and anaphoric binding follow parallel patterns in coordinations of questions.

(10) a. Do you have a car$_i$, and is it$_i$ electric?
(A similar example is noted by Groenendijk (1998).)
b. Do you have no car$_i$, and is it$_{*i/j}$ electric?

(11) a. Is there no bathroom$_i$, or is it$_i$ hidden?
b. Is there a bathroom$_i$, or is it$_{*i/j}$ hidden?

For declaratives, there are established dynamic analyses of (10) such as DPL (Groenendijk and Stokhof 1991). Sentences are assumed to relate inputs and outputs.

Handling the declarative equivalent of (11) requires us to add a *bilateral* component: sentences have both positive and negative outputs (Krahmer and Muskens 1995; see also Charlow 2020 for an unrelated motivation for bilateralism).

The system

- In DPL, the type of sentences can be written as $s \to i \to \{i\}$.
- For our purposes, we need to add a truth value, which we will call a *tag*. Thus the type of sentences will be $s \to i \to \{(i;t)\}$. There are two types of outputs now, *active* (tag 1) and *passive* (tag 0) outputs.

(Here s is worlds, i is assignments, $\{\cdot\}$ is a type constructor for sets of things, and $(\cdot;\cdot)$ is a type constructor for pairs.)

(Remark: declaratives will be true when they have active outputs. Thus they may be false and still have outputs, unlike in DPL. This allows for double negation elimination.)

Conventions

We always assume variables introduced by indefinites to be novel in discourse: in the starting context, assignments map these variables to the empty value $\perp$.

(12) **Storage.**
For $g : i$ an assignment, x a variable, a a value, $g[x \mapsto a]$ is the assignment g' that coincides with g other than on x and such that $g'(x) = a$.

(13) **Active and passive extension.**
For $p : i \to \{(i; t)\}$ a propositional extension:

$$[p]_+ = \lambda g.\, \{g' \mid (g'; 1) \in p(g)\}$$
$$[p]_- = \lambda g.\, \{g' \mid (g'; 0) \in p(g)\}$$

(14) **Active and passive denotation.**
For φ a sentence:

$$[\![\varphi]\!]^w_+ = [[\![\varphi]\!]^w]_+$$
$$[\![\varphi]\!]^w_- = [[\![\varphi]\!]^w]_-$$

Dynamic declaratives

A static declarative:

(15) $[\![\text{John came}]\!]^w = \lambda g.\,\{(g; \mathbf{came}^w(\mathbf{j}))\}$

A dynamic declarative:

(16) $[\![\text{there is a}^x \text{ bathroom in this building}]\!]^w =$

$$\lambda g.\,\begin{cases}\{(g[x \mapsto a]; 1) \mid \mathbf{bathroom}^w(a) \wedge \mathbf{itb}^w(a)\} & \text{if non-empty}\\ \{(g; 0)\} & \text{otherwise}\end{cases}$$

Dynamic constituent questions

wh-words are known to be related to indefinites through morphology (Haspelmath 1997, a.o.).

We will take this fact very literally, and make *who came* exactly the same proposition as *someone came* (for now):

(17) $[\![\text{who}^x \text{ came}]\!]^w =$
$$\lambda g.\begin{cases}\{(g[x \mapsto a];1) \mid \mathbf{came}^w(a)\} & \text{if non-empty}\\ \{(g;0)\} & \text{otherwise}\end{cases}$$

This is similar to the treatment of *wh*-indefinites in Aloni and van Rooy (2002), but for bilateralism.

Note that multiple-*wh* questions are possible in this framework:

(18) $[\![\text{who}^x \text{ danced with who}^y]\!]^w =$
$$\lambda g.\begin{cases}\left\{\left(g\begin{bmatrix}x \mapsto a\\ y \mapsto b\end{bmatrix};1\right) \mid \mathbf{danced\text{-}with}^w(a,b)\right\} & \text{if non-empty}\\ \{(g;0)\} & \text{otherwise}\end{cases}$$

Dynamic polar questions

We take polar questions to feature a silent *wh*-word. The difference with constituent questions is only that the *wh*-word has a singleton domain. We store a dummy value α in the *wh*-variable.

(19) Did John come? $\approx$ ~~whether~~^{u} John came

(20) $[\![\text{whether}^u \text{ John came}]\!]^w =$

$$\lambda g.\begin{cases}\{(g[u \mapsto \alpha];1)\} & \text{if } \mathbf{came}^w(\mathbf{j}) = 1\\ \{(g;0)\} & \text{otherwise}\end{cases}$$

(What we store in the variable does not matter; it could also be a propositional referent. The syntax of polar questions in Turkish, where the question particle occurs close to the element bearing focus (Kamali and Büring 2011), suggests that perhaps it should be the value of the focussed element.)

Abstract formation

In general, dynamic theories are very expressive.
We can recover the question abstracts of categorial theories from our dynamic questions, using the operation of *existential disclosure* which turns dynamic propositions into predicates (Dekker 1993):

(21) **Abstract formation.**
For p with type $s \to i \to \{(i; t)\}$, g an assignment:

$$\{p\}^x_g = \lambda a.\, \lambda w.\, \exists v \in \{0, 1\}.\\ \exists g'.\, (g'; v) \in p(w)(g) \wedge g'(x) = a$$

Abstract formation: examples

(22) $$\{p\}^x_g = \lambda a.\, \lambda w.\, \exists v \in \{0, 1\}.\ \exists g'.\, (g'; v) \in p(w)(g) \wedge g'(x) = a$$

With $p_0 = [\![\text{who}^x \text{ came}]\!]$:

(23) $$\{p_0\}^x_g = \lambda a.\, \lambda w.\, \begin{cases} \textbf{came}^w(a) & \text{if } a \neq \bot \\ \neg \exists b.\, \textbf{came}^w(b) & \text{if } a = \bot \end{cases}$$

With $p_1 = [\![\text{whether}^u \text{ John came}]\!]$:

(24) $$\{p_1\}^u_g = \lambda a.\, \lambda w.\, \begin{cases} \textbf{came}^w(\textbf{j}) & \text{if } a = \alpha \\ \neg \textbf{came}^w(\textbf{j}) & \text{if } a = \bot \end{cases}$$

Answer sets

We can also extract sets of true answers in the sense of Karttunen (1977) by collecting the propositional values in the range of the abstracts:

(25) **Answer set.**
For p with type $s \to i \to \{(i; t)\}$:

$$alt_g^x(p) = \lambda w.\, \big\{ \{p\}_g^x(a) \,|\, \{p\}_g^x(a)(w) \big\}$$

Whence:

(26) $alt_g^x\,([\![\text{who}^x \text{ came}]\!]) =$

$$\lambda w.\, \begin{cases} \left\{ \lambda w'.\, \textbf{came}^{w'}(a) \,|\, \textbf{came}^{w}(a) \right\} & \text{if someone came in } w \\ \left\{ \lambda w'.\, \neg\exists a.\, \textbf{came}^{w'}(a) \right\} & \text{otherwise} \end{cases}$$

(27) $alt_g^u\,([\![\text{whether}^u \text{ John came}]\!]) =$

$$\lambda w.\, \begin{cases} \left\{ \lambda w'.\, \textbf{came}^{w'}(\textbf{j}) \right\} & \text{if John came in } w \\ \left\{ \lambda w'.\, \neg\textbf{came}^{w'}(\textbf{j}) \right\} & \text{if John did not come in } w \end{cases}$$

Pragmatics

Recall that we are not distinguishing *wh*-indefinites and regular indefinites at this point.

If we want to add a discourse model, we need to.

Sketch of a proposal:

- Contexts include a list of distinguished *topic variables.*
- Variables introduced by *wh*-words are added to the distinguished list.
- Pragmatic rule: the identity of topic variables must be resolved for conversation to proceed.

Dynamic effects in answers

Earlier dynamic approaches to questions (like Haida 2008 or Dotlačil and Roelofsen 2022) point to examples like (28).

(28) Q: Who came?
A: I don't know but they didn't stay long.

Unlike Haida (2008) (but like Dotlačil and Roelofsen (2022)) we do not need the existence of the witness to be presupposed, and the following example is not problematic:

(29) Q: Did someone come?
A: Yes, but they didn't stay long.

Short-circuiting connectives

Usual definition of dynamic conjunction or sequencing:

(30) $$p \oplus q = \lambda w.\, \lambda g.\, \{g'' \mid \exists g'.\, g' \in p(w)(g) \wedge g'' \in q(w)(g')\}$$

Our dynamic connectives are sensitive to the active/passive distinction:

(31) $$[p \wedge q]_+ = [p]_+ \oplus [q]_+$$
$$[p \wedge q]_- = [p]_- \cup ([p]_+ \oplus [q]_-)$$

(32) $$[p \vee q]_+ = [p]_+ \cup ([p]_- \oplus [q]_+)$$
$$[p \vee q]_- = [p]_- \oplus [q]_-$$

Notice the *short-circuiting* property: some outputs will not have "gone through" the second operand.

Short-circuiting connectives: dynamicity

Conjunction and disjunction are completely symmetric and therefore both internally and externally dynamic, unlike in DPL.

(33) *Disjunctive reference:*
Sometimes a student or a visitor comes and they ask how to open the side door.

(34) *Bathroom sentences:*
Is there no bathroom, or is it hidden?

(35) *Conjunctive questions:*

a. Who wants dessert, and what do they want?
b. Do you have a car and is it electric?

Note: (35a) need not presuppose that someone wants dessert, thanks to the bilateral approach.

Short-circuiting connectives: resolution conditions

We predict unusual resolution conditions for conjunctive and disjunctive polar questions:

(36) $alt(?p \wedge ?q) = \{\neg p, p \wedge \neg q, p \wedge q\}$
Standard: $alt(?p \wedge ?q) = \{\neg p \wedge \neg q, \neg p \wedge q, p \wedge \neg q, p \wedge q\}$

(37) $alt(?p \vee ?q) = \{p, \neg p \wedge q, \neg p \wedge \neg q\}$
Standard: $alt(?p \vee ?q) = \{p, q, \neg p \wedge \neg q\}$

The predictions extend to constituent questions:

(38) alt("who came and what did they do") $=$
$\{$"nobody came"$\} \cup \{$"x came and did y" $| \, x, y\}$
$\cup \, \{$"x came and did nothing" $| \, x\}$

(39) alt("who came or what happened") $=$
$\{$"x came" $| \, x\} \cup \{$"nobody came and x happened" $| \, x\}$
$\cup \, \{$"nobody came and nothing happened$\}$

(The analysis in Enguehard 2021 has the same properties.)

Short-circuiting connectives: resolution conditions (2)

(40) Q: Is it sunny outside and is there some charcoal left? $(?p \wedge ?q)$

a. A: It is raining. $(\neg p)$

b. A: It is sunny but there is no charcoal left. $(p \wedge \neg q)$

c. A: It is sunny and there is some charcoal left. $(p \wedge q)$

(41) Q: Did Ann arrive, or Bill?$\nearrow$ $(?p \vee ?q)$

a. A: Ann arrived. $(p;\ \rightsquigarrow \varnothing)$

b. A: Bill arrived. $(q;\ \rightsquigarrow \neg p)$

(42) Who wants dessert, and what do they want?

(43) ?Who went to the seminar, or where did everyone go?

Short answers: the problem

In answer set semantics or inquisitive semantics, the short answers to questions are not represented. Thus the answer in (44) is analysed as an elliptical proposition. The relation between the answer and the question is a pragmatic one (congruence).

(44) Who came? Ann ~~came~~.

Problem: short answers do not behave like long answers (Jacobson 2016). Only (45a) presupposes that Ann is a professor.

(45) Which professors came?

a. Only Ann.

b. Only Ann came.

Important: the answer is congruent either way! If Ann is not a professor, (46b) entails that no professor came.

Dynamic approaches to short answers

Jacobson (2016) uses a categorial theory, and assumes that questions (which are functors) and short answers combine at the syntactic level.

Since dynamic theories are even more expressive, we can also represent short answers. For us it is more natural to assume that the question-answer relation is one of binding:

(46) $[\![short^x]\!]^w = \lambda a.\, \lambda g.\, \{(g; g(x) = a)\}$

(47) Who^x came? *short*^{x} Ann.

"Yes" and "no" can be taken to be arguments to *short*:

(48) a. $[\![\text{yes}]\!] = \alpha$
b. $[\![\text{no}]\!] = \bot$

(Some related ideas are found in Li 2019 and Aloni and van Rooy 2002.)

Dynamic approach to short answers (2)

Multiple-*wh* is not problematic:

(49) Who^x danced with who^y? *short*^{x,y} Ann, with Bill.

We in fact allow for "extra" answers:

(50) ~~whether~~^{u} Did you see someone^x?
short^{u,x} Yes, John.

To account for all cases of quantified short answers as in (51), we would need to introduce plural states.

(51) Who came? Everyone.

Other potential benefits

- Number distinctions that do not affect truth/resolution conditions (see also Dotlačil and Roelofsen 2022 for a dynamic approach to number on *wh*-words):

(52) a. Do you have a pet? (And is it / *are they cute?)
b. Do you have pets? (And *is it / are they cute?)

(53) a. A: There is no bathroom.
B: Yes there is, it is / *they are upstairs.
b. There are no bathrooms.
B: Yes there are. *It is / they are upstairs.

- There is some redundancy between the *wh*-variable and the tag in the analysis of polar questions. Could we leverage this to distinguish inner and outer negative polar questions?

(54) a. Aren't there chairs?
b. Aren't there any chairs?

Conclusion

Bilateral dynamic semantics allows us to:

- Build a complete theory of questions with the established elements (answer sets, short answers, abstracts).
- Model polar and constituent questions in a parallel way.
- Model declarative and questions as being the same type.
- Account for declarative-like behaviour in question coordination.

See also Dotlačil and Roelofsen 2022 for a much more complete theory focussed on constituent questions, and Enguehard 2021 for a static approach to some of the issues raised here.

Thank you!

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