Dynamic properties of question words

Jakub Dotlačil (joint work with Floris Roelofsen)
Paper

www.jakubdotlacil.com

Publications → Dynamics of questions
Dynamic and inquisitive semantics

Montagovian tradition – sentences $\mapsto$ propositions

Complicating the picture:

- dynamic semantics: sentences $\mapsto$ relations between information states
- inquisitive semantics: sentences $\mapsto$ sets of propositions
Main domain of inquiry

Dynamic semantics
- How context affects interpretation
  (e.g., context-sensitivity of pronominal anaphora)

Inquisitive semantics
- Interpretation of questions
- Resolution conditions
Dynamic and inquisitive semantics

- Questions update context
  (e.g., wh-words license pronominal anaphora)
  Groenendijk (1998); van Rooij (1998); Haida (2007, 2008)

(1)  
  a. Who\textsubscript{1} went to the party? And what did he/they\textsubscript{1} bring as a present? 
  b. A: Who\textsubscript{1} won the competition? B: You don’t know him\textsubscript{1}. He\textsubscript{1} was an outsider.
Dynamic properties of questions

Combine

■ inquisitive semantics (interpretation of questions)
■ with dynamic semantics (context update)

Result

■ dynamics of questions
  alternatives – Groenendijk (1998); van Rooij (1998); Haida (2007)
Compositional inquisitive semantics

Inquisitive compositional DRT

Dynamic properties of questions

Conclusion
Compositional inquisitive semantics

Inquisitive compositional DRT

Dynamic properties of questions

Conclusion
Sentences in inquisitive semantics

- sentence – a set of propositions
  - informative content
  - inquisitive content
Sentences in inquisitive semantics

(2) John walks.

\[ \text{INFO}(2) = |W_j| \]
Sentences in inquisitive semantics

(3) Does John walk or dance?

\[ \text{INFO}(3) = |W_j| \cup |D_j| \]

\[ \text{INQ}(3) = \{p | p \subseteq |W_j| \text{ or } p \subseteq |D_j|\} \]
Sentences in inquisitive semantics

(4) Who walks?

\[ \text{INFO}(4) = |\exists x(Wx)| \]

\[ \text{INQ}(4) = \{ p | \exists x(p \subseteq |Wx|) \} \]
Sentences in inquisitive semantics

(5) John walks and dances.

\[
\text{INFO(5)} = |W_j| \cap |D_j|
\]

\[
\text{INQ(5)} = \{ p | p \subseteq |W_j| \text{ and } p \subseteq |D_j| \}
\]
Sentences in inquisitive semantics

(6)  
   a. John walks or dances.  
   b. Does J. walk or dance?  
   c. Somebody walks.  
   d. Who walks?

- lexical meaning of *or* in (6-a) & (6-b), and of *somebody* and *who* in (6-c) & (6-d) the same, composition differs
Info and inq in inquisitive semantics

set of propositions, $q$

- **inquisitive content**
  - issue(s) that the sentence raises;
  - modeled as a set of propositions that resolve the issue(s)
  - persistent (downward-closed)

- **informative content**
  - information that the sentence provides
  - modeled as a set of worlds
  - $INFO(q) = \bigcup(q)$
Compositional inq semantics

Ciardelli et al. (2017)

Type abbreviation: \( T := \langle \langle \text{it} \rangle t \rangle \)
Sentence-abbreviation: \( /\varphi/ := \lambda p^{\langle \text{it} \rangle} . p \subseteq |\varphi| \)
Compositional inq semantics

Ciardelli et al. (2017)

Type abbreviation: \( T := \langle \langle \text{it} \rangle t \rangle \)

Sentence-abbreviation: \( \langle \varphi \rangle := \lambda p \langle \text{it} \rangle . p \subseteq |\varphi| \)

\((7)\)

\(a. \) \[\text{walk} \] = \( \lambda x. /Wx/ \)
\(b. \) \[\text{see} \] = \( \lambda Q \lambda x. Q(\lambda y. /S(x, y)/) \)
Compositional inq semantics

Ciardelli et al. (2017)

Type abbreviation: $T := \langle\langle it \rangle t \rangle$
Sentence-abbreviation: $/\varphi/ := \lambda p_{\langle it \rangle}. p \subseteq |\varphi|$

(7) a. $[\text{walk}] = \lambda x./Wx/$
   b. $[\text{see}] = \lambda Q \lambda x. Q(\lambda y./S(x, y)/)$

(8) a. $q \sqcup q' := \lambda p. q(p) \lor q'(p)$
   b. $q \sqcap q' := \lambda p. q(p) \land q'(p)$
Compositional inq semantics

Ciardelli et al. (2017)

Type abbreviation: \( T := \langle\langle it\rangle t \rangle \)

Sentence-abbreviation: \( /\varphi/ := \lambda p_{\langle it \rangle}. p \subseteq |\varphi| \)

(7)  
a.  \([\text{walk}] = \lambda x./Wx/\)

b.  \([\text{see}] = \lambda Q\lambda x. Q(\lambda y./S(x, y)/)\)

(8)  
a.  \( q \sqcup q' := \lambda p. q(p) \lor q'(p) \)

b.  \( q \sqcap q' := \lambda p. q(p) \land q'(p) \)

(9)  
a.  \( \exists x q := \lambda p. \exists x[q(p)] \)

b.  \( \forall x q := \lambda p. \forall x[q(p)] \)
Compositional inq semantics

Ciardelli et al. (2017)

Type abbreviation: $T := \langle \langle it \rangle t \rangle$
Sentence-abbreviation: $/\varphi/ := \lambda p_{\langle it \rangle}. p \subseteq |\varphi|$

(10)  
a. $[\text{walk}] = \lambda x./Wx/$  
b. $[\text{see}] = \lambda Q\lambda x.Q(\lambda y./S(x, y)/)$

(11)  
a. $[\text{or}] = \sqcup$  
b. $[\text{and}] = \sqcap$

(12)  
a. $[\text{somebody}] = [\text{who}] = \lambda P_{eT}.\exists x(Px)$  
b. $[\text{everyone}] = \lambda P_{eT}.\forall x(Px)$
Example 1

(13) John walks or John dances.

\[ /Wj/ \sqcup /Dj/ \]

\[ \begin{array}{c}
\text{John} \\
\lambda x. /Wx/
\end{array} \quad \text{or} \quad \begin{array}{c}
\text{John} \\
\lambda x. /Dx/
\end{array} \]

walks \\
dances

(14) \[ \lambda p. p \subseteq |Wj| \lor p \subseteq |Dj| \]
Example 1

(13)  John walks or John dances.

\[
\lambda x. (Wj \sqcup Dx)
\]

(14)  \(\lambda p. p \subseteq |Wj| \lor p \subseteq |Dj|\)
Example 2

(15) Some man sleeps.

\[ \exists x(\forall x' \in Mx \land x' \in Sx) \]

\[ \lambda Q_e T. \exists x(\forall x' \in Mx \land Qx) \]

\[ \lambda P_e T. \lambda Q_e T. \exists x(Px \land Qx) \]

\[ \lambda x. \forall x' \in Mx \]

some \hspace{2cm} man

(16) \[ \lambda p. \exists x(p \subseteq \mid Mx \mid \land p \subseteq \mid Sx \mid ) \]
Compositional inquisitive semantics

Inquisitive compositional DRT

Dynamic properties of questions

Conclusion
Context sensitivity

(17) He walks.

(18) $\lambda p. p \subseteq |W_{x_1}|$
Context sensitivity

Interpretation is sensitive to assignment
Two steps:

1. We will explicitly signal this by propositions – sets of possibilities; possibilities are world-assignment pairs
2. Assignments become object-language objects (see Muskens, 1996, for axioms they have to satisfy)
3. We will re-interpret existential quantifier as an update on assignment
Context sensitivity

- A **possibility** is a pair \( \langle w, g \rangle \), where \( w \) is a world and \( g \) an assignment.
- An **information state** is a set of possibilities.
- What information state conveys:
  -  \( s_w := \{ w \mid \langle w, g \rangle \in s \text{ for some } g \} \)
  -  \( s_g := \{ g \mid \langle w, g \rangle \in s \text{ for some } w \} \)
  -  possible correlations between the two.
Context sensitivity

Type abbreviation: $s := \langle i \langle at \rangle \rangle$, $T := \langle s, t \rangle$
$e := \langle ae \rangle$

Condition abbreviation:
$R\{x_1, \ldots, x_n\} := \lambda s.s \subseteq \{ \langle w, g \rangle \mid [R]^w(x_1g, \ldots, x_ng) \}$
Context sensitivity

Type abbreviation: \( s := \langle i \langle at \rangle \rangle \), \( T := \langle s, t \rangle \)
\( e := \langle ae \rangle \)
Condition abbreviation:
\( R\{x_1, \ldots, x_n\} := \lambda s.s \subseteq \{ \langle w, g \rangle \mid [R]^w(x_1g, \ldots, x_ng) \} \)

(19)  \[ \begin{align*}
a. \quad [\text{walk}] &= \lambda x_e.W\{x\} \\
b. \quad [\text{see}] &= \lambda Q\lambda x_e.Q(\lambda y_e.S\{x, y\})
\end{align*} \]
Example

\[ W\{x_1\} \]

\[ \lambda P. P(x_1) \quad \lambda x. W\{x\} \]

He_1 \quad \text{walks}

\[ \lambda s.s \subseteq \{\langle w, g \rangle \mid [W]^w(x_1g)\} \]

(20)
Context sensitivity

\[(21) \quad \exists x_1 q := \lambda s. \exists s'(s[x_1]s' \land q(s'))\]

Update abbreviation: \(s[x_1, \ldots, x_n]s' := \) assignments in \(s\) differ from assignments in \(s'\) at most wrt \(x_1 \ldots x_n\); all assignments in \(s'\) assign the same entity to \(x_1\), the same entity to \(\ldots x_n\)

\[
s[x_1, \ldots, x_n]s' := \forall v_e(v \neq x_1 \land \ldots \land v \neq x_n \rightarrow \\
\forall w \forall g \forall g'(s(w)(g) \land s'(w)(g') \rightarrow v(g) = v(g'))) \land \forall v_e(v = x_1 \lor \ldots \lor v = x_n \rightarrow \forall w \forall g \forall w' \forall g'(s'(w)(g) \land s'(w')(g') \rightarrow v(g) = v(g'))\]

Example

(22) Some man sleeps.

\[ \exists x_1(M\{x_1\} \cap S\{x_1\}) \]

\[ \lambda Q_eT. \exists x_1(M\{x_1\} \cap Q(x_1)) \]

\[ \lambda x. M\{x\} \]

\text{sleeps}

\[ \lambda P_eT \lambda Q_eT. \exists x_1(P(x_1) \cap Q(x_1)) \]

\[ \lambda x. S\{x\} \]

\text{some}

\text{man}

(23) \[ \lambda s. \exists s'(s[x_1]s' \land s') \subseteq \{\langle w, g \rangle | [M]^w(x_1g) \land s' \subseteq \{\langle w, g \rangle | [S]^w(x_1g)\}\} \]
Example

(24)  a. Some man sleeps.

b. \( \lambda s. \exists s' (s[x_1]s' \land s' \subseteq \{ \langle w, g \rangle \mid [M]^w(x_1 g) \} \land s' \subseteq \{ \langle w, g \rangle \mid [S]^w(x_1 g) \}) \)
Example

(24) a. Some man sleeps.
   b. \( \lambda s. \exists s'(s[x_1]s' \land s' \subseteq \{ \langle w, g \rangle \mid [M]^w(x_1g) \} \land s' \subseteq \{ \langle w, g \rangle \mid [S]^w(x_1g) \} \} \)

(24-b)_w

\begin{array}{cc}
11 & 10 \\
01 & 00 \\
\end{array}
Quick summary

- A compositional inquisitive semantics
- The role of assignment explicit
- The resulting system static:
  Some man sleeps and he was tired. – unexplained
ICDRT

Type abbreviation: \( s := \langle i \langle at \rangle \rangle, \ C := \langle s, t \rangle \)
Type abbreviation for sentences: \( T := \langle CC \rangle \)

(25) Sentence abbreviation – DRS:
\[
[x_1, \ldots x_n|C_1, \ldots, C_m] := \lambda K_C \lambda s_{\langle i, at \rangle}. \exists s^K(K(s^K) \land s_w = s^K \land K^K[x_1, \ldots x_n]s \land C_1(s) \land \ldots \land C_m(s))
\]

(26) Merging
\[
\mathcal{D}_1; \mathcal{D}_2 := \lambda K_C. \mathcal{D}_2(\mathcal{D}_1(K))
\]

(27) \( \exists x_n(\mathcal{D}) := [x_n|]; \mathcal{D} = \lambda K_C. \mathcal{D}([x_n|](K)) \)
ICDRT

(28) Verbs and nouns
a. \( [\text{walk}] = \lambda v_e. [ W \{ v \} ] \)
b. \( [\text{see}] = \lambda Q_{eTT} \lambda v_e. Q(\lambda v'_e. [ S \{ v, v' \} ]) \)

(29) Pronouns
a. \( [\text{he}_n] = \lambda P_{eT} . P(x_n) \)

(30) Connectives
a. \( [\text{and}] = \lambda q \lambda q'. q; q' \)

(31) 1-place quantifiers
a. \( [\text{somebody}^n] = [\text{who}^n] = \lambda P_{eT}. \exists x_n(P(x_n)) \)
Example

(32) Some\(^1\) man walks.
Example

(33) Some\(^1\) man walks.

\[ \lambda K \lambda s. \exists s^K (K (s^K)) \land s_w = s^K_w \land s^K [x_1] s \land s \subseteq \{ \langle w, g \rangle \mid [M]^w (x_1 g) \} \land s \subseteq \{ \langle w, g \rangle \mid [S]^w (x_1 g) \} \]

Input contexts:
OK:
\[
\begin{array}{ll}
11 & 10 \\
01 & 00 \\
\end{array}
\]

Not OK:
\[
\begin{array}{ll}
11 & 10 \\
01 & 00 \\
\end{array}
\]
Example

(34) Some\(^1\) man walks. He\(_1\) sings.
Observations

- ICDRT – inquisitive CDRT
- CDRT in which conditions – inquisitive sentences (in CDRT, conditions – extensional sentences)
- Other operators (;, ∃, □) as in CDRT
Compositional inquisitive semantics

Inquisitive compositional DRT

Dynamic properties of questions

Conclusion
Wh-words & cross-sentential anaphora

(35) A: Who\(^1\) is walking? B: You know him\(^1\).

(36) \(A; B = [x_1 | W\{x_1\}] ; [[K\{y, x_1\}] =
[\[x_1 | W\{x_1\}, K\{y, x_1\}] \) (Merging Lemma, Muskens, 1996)

(37) \(\lambda K \lambda s. \exists s^K (K(s^K) \land s_w = s^K \land s^K[x_1]s \land s \subseteq
\{s, \{s, [W]^w(x_1g)\} \land s \subseteq \{s, [K]^w(y_1, x_1g)\}\))
Observation

- wh-words treated as indefinites:
  - $[\text{who}] = [\text{sombody}]$
  - $[\text{which}] = [\text{some}]$

- we expect that they update context as indefinites do
Wh-words & cross-sentential anaphora

A quick comparison Haida (2007)

(38) A: Who¹ is walking? B: You know him₁.

- wh-words analyzed as indefinites, but question are bi-conditionals (due to partition semantics)
- (Bi-)conditionals are externally static
- (38) not accounted in partition dynamic semantics
  (Haida, 2007, ch. 4)
Wh-words & cross-sentential anaphora

A quick comparison van Rooij (1998)

(39) A: Who¹ is walking? B: You know him¹.

- Not compositional at sub-clausal level
- Works with sets of sets of assignments (van den Berg, 1996)
Wh-words and quantificational subordination

(40)  a. Every player chooses a pawn. He puts it on square one.  
      (Roberts, 1989)
  b. Who brought what cake and how much did he eat of it?  
      (van Rooij, 1998)

(41)  Who\(^1\) owns what\(^2\) and whom\(^3\) will he\(_1\) give it\(_2\)?
  a. \([x_1, x_2|O\{x_1, x_2\}]; [x_3|G\{x_1, x_2, x_3\}] =
     [x_1, x_2|O\{x_1, x_2\}, G\{x_1, x_2, x_3\}]\)
Wh-words and quantificational subordination

(42)  Who\(^1\) owns what\(^2\) and whom\(^3\) will he\(_1\) give it\(_2\)?
Wh-words and donkey-style anaphora

(43) a. Every farmer who owns a donkey beats it.
    b. Wer kaufte was und verschenkte es sofort?

    who bought what and gave-away it immediately

    literally: ‘Who bought what and gave it away immediately?’ (Haida, 2008)

(44) a. Who¹ owns what² and likes it²?
    b. \([x_1, x_2 | O\{x_1, x_2\}] ; [\langle L\{x_1, x_2\}]\)
    c. \([x_1, x_2 | O\{x_1, x_2\}, L\{x_1, x_2\}]\)
Existentials

(45) Some man walks. ≠ Who walks?
Existentials

(45) Some man walks. ≠ Who walks?

(46) !(Some man walks).

Standardly, ! := ¬¬. But this is not possible in ICDRT.

(47) *¬¬(Some¹ man walks). He₁ is tired.
Assignments

Partial assignments:

- \( D_e = E \cup \{*\} \)
- \(*\) – universal falsifier
- \( R \subseteq (D_e \setminus \{*\})^n \)
- ‘Enough states’ – for each state, assignment and entity different from universal falsifier, there must be a second state which is like the first one but the entity is assigned
  \[ \forall g \forall v \forall x (v \neq * \rightarrow \exists j (i[v]j \land vj = x)) \]
- Default discourse-initial context - assignments in states only assign to universal falsifier
Extension

- For any $r \subseteq V$: an $r$-possibility as a pair $\langle w, g \rangle$, where $w$ is a world and $g$ an assignment function, mapping all variables in $r$ to individuals in $D_e \setminus \{*\}$.

- An $r'$-possibility $\langle w', g' \rangle$ is an extension of an $r$-possibility $\langle w, g \rangle$ iff $r' \supseteq r$, $w' = w$, and $g'|_r = g|_r$. Notation: $\langle w', g' \rangle \geq \langle w, g \rangle$.

- An information state $s'$ is an extension of another information state $s$ iff every possibility in $s'$ is an extension of a possibility in $s$. Notation: $s' \geq s$. 
\[ \begin{align*}
!D &:= \lambda K \lambda s. \exists s^K (K(s^K) \land s \geq s^K \land s \in \{\bigcup(D(K))\})^\downarrow \\
\text{The output of } !D \text{ has to include the discourse referents introduced by } D. \\
\text{The issues of } D \text{ are removed.} \\
\text{The output still has to resolve the issues that were present in the old context.}
\end{align*} \]
Existentials

(48) Some man walks. \(\neq\) Who walks?

(49) Who saw something? \(\neq\) Who saw what?
Existentials

(50) 1-place quantifiers
a. \([\text{who}^n] = \lambda P_{eT}. [x_n]; D\]
b. \([\text{somebody}^n] = \lambda P_{eT}. !([x_n]); D\]

(51) Some\(^1\) man walks. He\(_1\) is tired.

*some* introduces a new dref that can be picked up later, but *some* itself does not introduce inquisitiveness
Conclusion

- A glimpse of a system to account for dynamic properties of questions
- Inquisitive semantics + Compositional DRT
- Captures cross-sentential anaphora for questions, donkey-style anaphora and quantificational subordination
- Existentials and wh-words have the same basic meaning ($\exists_3$), but existentials add non-inquisitiveness on top

Haida, Andreas. 2007. The indefiniteness and focusing of wh-words. Doctoral Dissertation, Humboldt University, Berlin.

