Towards a Theory of Anaphoric Binding in Event Semantics

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LENLS
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Outline

- **Introduction**
- Polynomial Event Semantics
- Relative Denotations
- Nominal Pronouns and Referents
- Conclusions

Motivation

Give compositional denotations and
Decide entailments (in FraCaS, etc.)
with Neo-Davidsonian event semantics

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- Quantification: some, all, every
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- Negative quantification and Negation
- Copula clauses
- Relative clauses
- Anaphora: pronouns, crossover, ellipsis, ...

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3 Copula clauses

2 Relative clauses

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Rank in importance

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4 Copula clauses
5 Relative clauses
6 Anaphora: pronouns, crossover, ellipsis, ...

Rank in attention received in event semantics research

Polynomial Event Semantics

A *variable-free* dialect of Neo-Davidsonian event semantics specifically designed to address the problems

- Quantification: some, all, every
  LENLS 2018
- Complex quantification: many, most, few, at least 5, ...
  LENLS 2021
- Negative quantification and Negation
  LENLS 2020
- Copula clauses
  LENLS 2021
- Relative clauses
  LENLS 2022
- Anaphora: pronouns, crossover, ellipsis, ...
  Beginning now

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Anaphoric binding becomes oddly symmetric

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Basics of Polynomial Event Semantics

$$[\![\text{John traveled to Paris.}]\!]$$
$$= (\mathsf{subj}'/\ \mathsf{john}) \ \cap \ \mathsf{Travel} \ \cap \ (\mathsf{toloc}'/\ \mathsf{paris})$$

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The meaning of the whole sentence is the intersection of the meaning of its constituents

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The denotation of a sentence

- a set of events that witness it
- a formula that represents the set
- a query of the record of world events

The sentence is true in a world if the result of the query is non-empty

Poly-Denotations

$$[\![\text{Bill and John traveled to Paris.}]\!]$$
$$= \mathsf{subj}'/\,(\mathsf{john} \otimes \mathsf{bill}) \;\sqcap\; \mathsf{Travel} \;\sqcap\; \mathsf{TP}$$

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&\qquad (\mathsf{subj}'/\ \mathsf{bill}\ \cap\ \mathsf{Travel}\ \cap\ \mathsf{TP})
\end{aligned}
$$

Poly-Denotations: Further Choices

$$
\begin{aligned}
&[\![\text{Bill or John}]\!] \\
&\quad = \begin{cases} \mathsf{bill} \;\oplus\; \mathsf{john} & \text{if external} \\ \mathsf{bill} \;\sqcup\; \mathsf{john} & \text{if internal} \end{cases}
\end{aligned}
$$

Poly-Denotations: Quantification

$$[\![\text{Everyone}]\!] = \bigotimes_{i \in \mathsf{Person}} i = \mathcal{A}\ \mathsf{Person}$$

$$[\![\text{A}_W\ \text{person}]\!] = \bigoplus_{i \in \mathsf{Person}} i = \mathcal{I}\ \mathsf{Person}$$

wide-scope; indefinite

$$[\![\text{A}_N\ \text{person}]\!] = \bigsqcup_{i \in \mathsf{Person}} i = \mathcal{E}\ \mathsf{Person}$$

narrow-scope; some

Outline

Traces

$$[\![\text{city John traveled to } \texttt{T}]\!]$$
$$= \mathsf{City} \cap \{i \mid [\![\text{John traveled to } i]\!] \neq \bot\}$$

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the denotation was *compositionally derived*

$$[\![\texttt{T}]\!] = ?$$

Generalization to other anaphora

Relative *things*

Things d

individuals, sets (concepts), poly-concepts, already relitivized individuals and concepts, etc.

Relative things

relations between individuals and things, or
sets of pairs (i, d)

$$\{(i, d) \mid i \in C\}$$

where C is some set

$$\equiv d|i{:}C$$

Relativitizing

$$d \underset{\rho}{\overset{\iota}{\rightleftarrows}} d|i{:}C$$

where

$$\iota_C\, d = d|i{:}C$$

inclusion (or, embedding)

$$\rho\,(d|i{:}C) = d \qquad \text{provided } d \text{ is independent of } i$$

retract (or, projection)

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ι and ρ are inverses, but not a bijection:
not all relations are constant

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When C is singleton, ι and ρ are a bijection:
A singleton context may *always* be disposed of

Algebras

Denotations so far

individual	j
concept (event set)	d
constant	$\perp$
Operations	$\oplus$, $\otimes$, $\sqcap$, $\sqcup$

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Algebra of poly-concepts (poly-individuals)

$$(d_1|i{:}C) \sqcap (d_2|i{:}C) = (d_1 \sqcap d_2)|i{:}C$$

Relative denotations

individual	$j|i{:}C$
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&[\![\text{city John traveled to } \mathtt{T}]\!] \\
&= \mathsf{City} \cap \{ i \mid [\![\text{John traveled to } i]\!] \neq \bot \}
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the denotation was *compositionally derived*

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the denotation was *compositionally derived*

$$[\![\mathtt{T}]\!] = i | i{:}\mathcal{I}$$
$$(\mathcal{I} : \text{set of all individuals})$$

It

⟦It is famous.⟧

It

$$[\![\text{It is famous.}]\!]$$

$$[\![\text{it}]\!] = ?$$

It

$$[\![\text{It is famous.}]\!]$$

$$[\![\text{it}]\!] = i | i \colon \mathsf{Thing}$$

It

$$[\![\text{It is famous.}]\!] \\ = (\mathsf{subj}'/\ i \ \cap \ \mathsf{Famous})|i\text{: }\mathsf{Thing}$$

(Embeddings are applied as necessary, silently)

It

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- Grammatical and meaningful, even by itself:

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- a listener is free to imagine a suitable referent for "it", not constrained by any prior discourse

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$$[\![\text{It is famous.}]\!] \sim [\![\text{Who is famous?}]\!]$$

Paris

$$[\![\text{John traveled to Paris}^{\triangleright}.]\!]$$

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$$\begin{aligned}&[\![\text{Paris}^{\triangleright}]\!]\\ &= \iota_{\{\mathsf{paris}\}}\ \ \mathsf{paris}\\ &= \mathsf{paris}\ |i{:}\ \{\mathsf{paris}\}\end{aligned}$$

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$[\![$John traveled to Paris$^{\triangleright}$.$]\!]$

$$[\![\text{Paris}^{\triangleright}]\!]$$
$$= \iota_{\{\mathsf{paris}\}}\ \mathsf{paris}$$
$$= \mathsf{paris}\ |i{:}\ \{\mathsf{paris}\}$$
$$= i|i{:}\ \{\mathsf{paris}\}$$

Paris

$$[\![\text{John traveled to Paris}^{\triangleright}.]\!]$$

$$\begin{aligned} [\![\text{Paris}^{\triangleright}]\!] &= i|i\colon \{\mathsf{paris}\} \\ [\![\text{it}]\!] &= i|i\colon \mathsf{Thing} \end{aligned}$$

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$$[\![\text{John traveled to Paris}^{\triangleright}.]\!]$$
$$= [\![\text{John traveled to } i]\!] | i\colon \{\mathsf{paris}\}\ .$$

$$[\![\text{Paris}^{\triangleright}]\!] = i | i\colon \{\mathsf{paris}\}$$
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- The denotation is not inherently relative (ρ does apply): contains no unresolved anaphoric references

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- The denotation is not inherently relative (ρ does apply): contains no unresolved anaphoric references
- Referent and reference: odd symmetry

Discourse and Resolution

John traveled to Paris$^{\triangleright}$. It is famous.

Operations on Disparate context

$$(d_1|i{:}C) \sqcap (d_2|i{:}C) = (d_1 \sqcap d_2)|i{:}C$$

$$(d_1|i{:}C_1) \sqcap (d_2|i{:}C_2) = ? \qquad (C_1 \neq C_2)$$

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$$\iota_{C_2}(d_1|i_1{:}C_1) \quad \sqcap \quad \iota_{C_1}(d_2|i_2{:}C_2)$$

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$$= (d_1|i_1{:}C_1)|i_2{:}C_2 \;\sqcap\; (d_2|i_2{:}C_2)|i_1{:}C_1$$

Operations on Disparate context

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&\iota_{C_2}(d_1|i_1{:}C_1) \;\sqcap\; \iota_{C_1}(d_2|i_2{:}C_2) \\
&= (d_1|i_1{:}C_1)|i_2{:}C_2 \;\sqcap\; (d_2|i_2{:}C_2)|i_1{:}C_1 \\
&= (d_1|(i_1{:}C_1 \times i_2{:}C_2)) \sqcap (d_2|(i_1{:}C_1 \times i_2{:}C_2))
\end{aligned}$$

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&= (d_1|(i_1{:}C_1 \times i_2{:}C_2)) \sqcap (d_2|(i_1{:}C_1 \times i_2{:}C_2))\\
&= (d_1 \sqcap d_2)|(i_1{:}C_1 \times i_2{:}C_2)
\end{aligned}
$$

Discourse and Resolution

$$[\![\text{John traveled to Paris}^{\triangleright}\text{. It is famous.}]\!]$$
$$= ([\![\text{John traveled to } i_1]\!] \otimes [\![i_2 \text{ is famous}]\!]) | (i_1\colon \{\mathsf{paris}\} \times i_2\colon \mathsf{Thing})$$

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{Imposing an equality constraint via pragmatics.}

$\Rightarrow ([\![\text{John traveled to } i]\!] \otimes [\![i \text{ is famous}]\!]) | i : \{\mathsf{paris}\}$

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{Imposing an equality constraint via pragmatics.}

$\Rightarrow ([\![\text{John traveled to } i]\!] \otimes [\![i \text{ is famous}]\!]) | i : \{\mathsf{paris}\}$

$\xrightarrow{\rho} [\![\text{John traveled to Paris.}]\!] \otimes [\![\text{Paris is famous.}]\!]$

The result after resolution is ‘context-free’

Time Arrow

Are things too symmetric?

John travel to it. Paris is famous.

Anaphora vs. Cataphora

Operations on Disparate context

$$
\begin{aligned}
&\iota_{C_2}(d_1|i_1{:}C_1) \;\sqcap\; \iota_{C_1}(d_2|i_2{:}C_2) \\
&= (d_1|i_1{:}C_1)|i_2{:}C_2 \;\sqcap\; (d_2|i_2{:}C_2)|i_1{:}C_1 \\
&= (d_1|(i_1{:}C_1 \times i_2{:}C_2)) \sqcap (d_2|(i_1{:}C_1 \times i_2{:}C_2)) \\
&= (d_1 \sqcap d_2)|(i_1{:}C_1 \times i_2{:}C_2)
\end{aligned}
$$

Context as an Imagination Restriction

Discourse/Context is a constraint on listeners' imagination

- The more narrow is the context, the tighter is the constraint
- In the limit, a proper noun is the anaphoric reference in the singleton context, which constrains it unambiguously

The close similarity of $[\![\text{Paris}^{\triangleright}]\!]$ and $[\![\text{it}]\!]$ should not be so surprising

Outline

Conclusions

Anaphoric dependencies can, after all, be expressed in a variable-free event semantics

in a surprisingly symmetric way:
Both the referent and the reference denoted by a polyconcept relative to a context

Context as an Imagination Restriction

The development of the theory of anaphoric binding in event semantics has just began

Many, many more examples to analyze