Polynomial Event Semantics

Negation

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Outline

Summary

An interpretation of Neo-Davidsonian semantics in which the event quantification problem does not even arise

- Denotations are constructed strictly compositionally, following the structure of the sentence
- Quantifiers are analyzed in situ

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- Analysis of Quantifier/Negation ambiguities

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Neo-Davidsonian Semantics

- Brutus stabbed Caesar
- Brutus stabbed Caesar violently

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$$\exists e.\ \mathsf{stabbed}(e) \wedge \mathsf{th}(e) = \mathsf{caesar} \wedge \mathsf{ag}(e) = \mathsf{brutus}$$

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$$\exists e.\ \mathsf{stabbed}(e) \wedge \mathsf{th}(e) = \mathsf{caesar} \wedge \mathsf{ag}(e) = \mathsf{brutus} \wedge \mathsf{violent}(e)$$

Quantification Problem

- Brutus stabbed every senator

Quantification Problem

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$$\exists e.\ \forall x.\ \mathsf{senator}(x) \Rightarrow \mathsf{stabbed}(e) \wedge \mathsf{th}(e) = x \wedge \mathsf{ag}(e) = \mathsf{brutus}$$

Quantification Problem

- Brutus stabbed every senator

$$\exists e.\ \forall x.\ \mathsf{senator}(x) \Rightarrow \mathsf{stabbed}(e) \wedge \mathsf{th}(e) = x \wedge \mathsf{ag}(e) = \mathsf{brutus}$$

'Collective' reading only

Negation/Negative Quantification Problem

- Brutus stabbed Caesar

$$\exists e.\ \mathsf{stabbed}(e) \wedge \mathsf{th}(e) = \mathsf{caesar} \wedge \mathsf{ag}(e) = \mathsf{brutus}$$

- Brutus stabbed nobody

Negation/Negative Quantification Problem

- Brutus stabbed Caesar

$$\exists e.\ \mathsf{stabbed}(e) \wedge \mathsf{th}(e) = \mathsf{caesar} \wedge \mathsf{ag}(e) = \mathsf{brutus}$$

- Brutus stabbed nobody

$$\exists e.\ \neg\exists x.\ \mathsf{human}(x) \wedge \mathsf{stabbed}(e) \wedge \mathsf{th}(e) = x \wedge \mathsf{ag}(e) = \mathsf{brutus}$$

Negation/Negative Quantification Problem

- Brutus stabbed Caesar

$$\exists e.\ \mathsf{stabbed}(e) \wedge \mathsf{th}(e){=}\ \mathsf{caesar} \wedge \mathsf{ag}(e){=}\ \mathsf{brutus}$$

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$$\exists e.\ \neg\exists x.\ \mathsf{human}(x) \wedge \mathsf{stabbed}(e) \wedge \mathsf{th}(e){=}x \wedge \mathsf{ag}(e){=}\ \mathsf{brutus}$$

Sentences are contradictory, but denotations aren't

Event Quantification Problem

The problem of scoping of the existential closure with respect to other quantificational phrases

Resolutions so far

Scope Domain Principle

The existential quantifier for the event variable obligatory takes the lowest scope

Implementation: Movement of the QP

(Syntactic) QR: movement because we say so

(ACG) Assigning types in the creative way, so the movement happens when computing surface form

(Semantic) Type raising in the creative way, so the movement happens when normalizing the (Montagovian) denotation

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What to do when existential closure doesn't take the lowest scope?

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Polynomial Event Semantics

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- Brutus stabbed Caesar violently

Polynomial Event Semantics

- Brutus stabbed Caesar

$$\mathsf{subj}'/\mathsf{brutus} \sqcap \mathsf{Stabbed} \sqcap \mathsf{ob1}'/\mathsf{caesar}$$

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Entailment just from the properties of $\sqcap$

Polynomial Event Semantics

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$$\mathsf{subj}'/\mathsf{brutus} \sqcap \mathsf{Stabbed} \sqcap \mathsf{ob1}'/\mathsf{caesar}$$

Observations

- The truth value of a sentence is the set of evidence for it (the support set)
- The query is denotation
- No existential closure (and no variables either)
- Structure of denotation matches the structure of the sentence

Existential Quantification: Motivation

The truth value of a sentence is the set of witnesses for it

- Brutus stabbed Caesar

$$\mathsf{subj}'/\mathsf{brutus} \sqcap \mathsf{Stabbed} \sqcap \mathsf{ob1}'/\mathsf{caesar}$$

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$$\mathsf{subj}'/\mathsf{brutus} \sqcap \mathsf{Stabbed} \sqcap \mathsf{ob1}'/\mathsf{caesar}$$

- Brutus stabbed somebody

Existential Quantification: Motivation

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$$\mathsf{subj}'/\mathsf{brutus} \sqcap \mathsf{Stabbed} \sqcap \mathsf{ob1}'/\mathsf{caesar}$$

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1. $\mathsf{subj}'/\mathsf{brutus} \sqcap \mathsf{Stabbed} \sqcap$
   $(\mathsf{ob1}'/\mathsf{Caesar} \sqcup \mathsf{ob1}'/\mathsf{Antonius} \sqcup \ldots)$

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   $(\mathsf{ob1}'/\mathsf{Caesar} \sqcup \mathsf{ob1}'/\mathsf{Antonius} \sqcup \ldots)$

2. $(\mathsf{subj}'/\mathsf{brutus} \sqcap \mathsf{Stabbed} \sqcap \mathsf{ob1}'/\mathsf{Caesar}) \sqcup$
   $(\mathsf{subj}'/\mathsf{brutus} \sqcap \mathsf{Stabbed} \sqcap \mathsf{ob1}'/\mathsf{Antonius}) \sqcup \ldots$

Factors

Factor

A collection of events grouped according to some criterion (e.g., by the common theme)

- Grouping of events into sets of alternatives
- The truth value of a sentence is a set *of factors* of witnessing events

Notation

c	concept: a set of events
x, y	polyconcept: a set of factors
$\mathcal{P}c$	$= \{c\}$
$x \sqcup y$	$= x \cup y$
$x \sqcap y$	$= \{c_x \cap c_y \mid c_x \in x, c_y \in y\}$

Polynomial Semantics

Brutus stabbed Caesar

$$\begin{aligned} & \mathcal{P}\,\mathsf{subj}'/\mathsf{brutus} \sqcap \mathcal{P}\,\mathsf{Stabbed} \sqcap \mathcal{P}\,\mathsf{ob1}'/\mathsf{caesar} \\ = \quad & \mathcal{P}(\mathsf{subj}'/\mathsf{brutus} \cap \mathsf{Stabbed} \cap \mathsf{ob1}'/\mathsf{caesar}) \end{aligned}$$

$\mathsf{ob1}'/\mathsf{caesar}$	concept: events with Caesar as a theme	
$\mathcal{P}\,\mathsf{ob1}'/\mathsf{caesar}$	$= \{\mathsf{ob1}'/\mathsf{caesar}\}$	singleton polyconcept

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$\mathsf{ob1}'/\mathsf{Human}$	$= ???$	

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$\mathsf{ob1}'/\mathsf{Human}$	$= \{\mathsf{ob1}'/i \mid i \in \mathsf{Human}\}$ a factor per human

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$\mathsf{ob1}'/\mathsf{Human}$	$= \{\mathsf{ob1}'/i \mid i \in \mathsf{Human}\}$ a factor per human
$\mathcal{N}x$	$= \mathcal{P} \bigcup x$
$\mathcal{N}\,\mathsf{ob1}'/\mathsf{Human}$	$= \mathcal{P}\{i' \mid \mathsf{ob1}'\,(i', i), i \in \mathsf{Human}\}$ singleton

Polynomial Semantics

Brutus stabbed somebody

1. $\mathcal{P}\,\mathsf{subj}'/\mathsf{brutus} \sqcap \mathcal{P}\,\mathsf{Stabbed} \sqcap \mathcal{N}\,\mathsf{ob1}'/\mathsf{Human}$

$$= \mathsf{subj}'/\mathsf{brutus} \cap \mathsf{Stabbed} \cap (\mathsf{ob1}'/\mathsf{Caesar} \cup \mathsf{ob1}'/\mathsf{Antonius} \cup \ldots)$$

2. $\mathcal{P}\,\mathsf{subj}'/\mathsf{brutus} \sqcap \mathcal{P}\,\mathsf{Stabbed} \sqcap \mathsf{ob1}'/\mathsf{Human}$

$$= (\mathsf{subj}'/\mathsf{brutus} \cap \mathsf{Stabbed} \cap \mathsf{ob1}'/\mathsf{Caesar}) \cup (\mathsf{subj}'/\mathsf{brutus} \cap \mathsf{Stabbed} \cap \mathsf{ob1}'/\mathsf{Antonius}) \cup \ldots$$

Both denotations are built compositionally

Entailments

- Brutus stabbed somebody
  1a. $\mathcal{P}\ \mathsf{subj}'/\mathsf{brutus} \sqcap \mathcal{P}\ \mathsf{Stabbed} \sqcap \mathcal{N}\ \mathsf{ob1}'/\mathsf{Human}$
  1b. $\mathcal{P}\ \mathsf{subj}'/\mathsf{brutus} \sqcap \mathcal{P}\ \mathsf{Stabbed} \sqcap \mathsf{ob1}'/\mathsf{Human}$

- Brutus stabbed somebody violently
  2a. $\mathcal{P}\ \mathsf{subj}'/\mathsf{brutus} \sqcap \mathcal{P}\ \mathsf{Stabbed} \sqcap \mathcal{N}\ \mathsf{ob1}'/\mathsf{Human} \sqcap \mathcal{P}\ \mathsf{Violently}$
  2b. $\mathcal{P}\ \mathsf{subj}'/\mathsf{brutus} \sqcap \mathcal{P}\ \mathsf{Stabbed} \sqcap \mathsf{ob1}'/\mathsf{Human} \sqcap \mathcal{P}\ \mathsf{Violently}$

$$2a \Rightarrow 1a$$
$$2b \Rightarrow 1b$$

$$1b \Rightarrow 1a$$
$$2b \Rightarrow 2a$$

Outline

How to Witness Non-existence

- Brutus stabbed nobody
- Brutus stabbed nobody violently

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Refutation

- Technically, a negative factor
- The truth value is a set of witnesses and a set of refutations

How to Witness Non-existence

- Brutus stabbed nobody

$$
\begin{aligned}
1. \quad & \mathcal{P}\,\mathsf{subj}'/\mathsf{brutus} \sqcap \mathcal{P}\,\mathsf{Stabbed} \sqcap \neg\mathcal{N}\,\mathsf{ob1}'/\mathsf{Human} \\
= \quad & \neg\mathcal{P}(\mathsf{subj}'/\mathsf{brutus} \cap \mathsf{Stabbed} \cap \bigcup \mathsf{ob1}'/\mathsf{Human})
\end{aligned}
$$

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2. \quad & \mathcal{P}\,\mathsf{subj}'/\mathsf{brutus} \sqcap \mathcal{P}\,\mathsf{Stabbed} \sqcap \neg\mathcal{N}\,\mathsf{ob1}'/\mathsf{Human} \sqcap \mathcal{P}\,\mathsf{Violently} \\
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$$
\begin{aligned}
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\end{aligned}
$$

$$1 \Rightarrow 2$$

Refutation

- Technically, a negative factor
- The truth value is a set of witnesses and a set of refutations

Negation

- Brutus did not stab Caesar

$$
\begin{aligned}
& \mathcal{P}\ \mathsf{subj}'/\mathsf{brutus} \sqcap \neg\mathcal{P}\ \mathsf{Stabbed} \sqcap \mathcal{P}\ \mathsf{ob1}'/\mathsf{caesar} \\
= \quad & \neg\mathcal{P}(\mathsf{subj}'/\mathsf{brutus} \cap \mathsf{Stabbed} \cap \mathsf{ob1}'/\mathsf{caesar})
\end{aligned}
$$

Negation and Ambiguities

- A soldier did not stab everyone
- Brutus did not accuse Caesar for one hour

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