Joint work with David Beaver, Stanford University

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Cleo Condoravdi

Syntax-semantics interface

An event free neo-Neo-Davidsonian
Motivations for this work

Overlapping concerns

- interface between syntax and semantics: glue logic

Concentrate here on inferential properties of modification

- lexical semantics and linking

- nature of modification
deriving logical forms from syntactic structures

Overlapping concerns

- for individual-denoting and quantificational arguments

Interface with a uniform mode of composition
and a relatively simple model of syntax-semantics

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Overview

The problem

- Linking semantics
- Composition in event semantics
- Davidsonian solution
- Meaning vs. valence
- Logic of modifiers: diamond entailments
- Arity expansion by modifiers
- The problem

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Arity expansion effected by modifiers

- How arity expansion of a basic predicate relation is brought about by modifiers?

- If types are part of the meaning is it possible to separate meaning and valence?

- What is the incremental contribution of modifiers such as stabbed Caesar with a knife?

- Caesar, is expanded to a ternary relation in Brutus stabbed with a knife to the city, from every candidate?

- E.g. basic binary relation stab, as in Brutus stabbed Caesar, is expanded to a ternary relation in Brutus gave John the book, be given the same meaning as I gave the book to John?
Diamond entailments

Of the sentences below, (1) is the least informative (entailed by all others), (4) is the most informative (entailing all others), and (2), (3) are incomparable (neither entails the other). (2) (3)

(1) Felix miaowed.

(2) Felix miaowed loudly.

(3) Felix miaowed in the kitchen.

(4) Felix miaowed loudly in the kitchen.

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The Davidsonian solution

verbs have an implicit argument

that implicit argument denotes an event

modifiers apply to this argument

and is existentially closed off

so modifiers are conjunctively added to the verbal predication

they are co-predicates on the event variable
logic of modifiers reduced to conjunctive elimination

miaow corresponds to a binary predicate throughout

\[
((\exists e) \text{loud} \land (\forall x) \text{loc}(e, \text{elix, kitchen}) \lor (\exists e) \text{miaow}(e, \text{elix, kitchen}))
\]

(5)

\[
(\exists e) \text{miaow}(e, \text{elix, kitchen}) \land (\forall e) \text{loc}(e, \text{elix, kitchen})
\]

(6)

\[
((\exists e) \text{loud} \land (\forall e) \text{miaow}(e, \text{elix}))
\]

(7)

\[
(\exists e) \text{miaow}(e, \text{elix}) \land (\forall e) \text{loc}(e, \text{elix})
\]

(8)

Events as hooks

use events to tie together modifiers with the predication

they are modifying

Events as hooks
The Neo-Davidsonian move

Verbal predicates are unary predicates over events

Arguments and modifiers alike associate via thematic relations

\(((\exists x)(\text{miao}w(e,\text{Teilix}) \land \text{loc}(e,\text{ix.Kitchen})) \land (\exists e)(\text{miao}w(e,\text{Teilix}) \land \text{agent}(e,\text{Felix})))\)
Events and Roles Grammaticized

Role Specification
For each lexical predicate A, it is specified which roles are defined for that predicate and which among them are obligatory.

Unique Role Requirement
If a thematic role is specified for an event, it is uniquely specified (thematic relations are functions).
Composition in Event Semantics

- Integrate with the semantics of tense
- Interaction of the event variable with negation
- Interaction of the event variable with quantification
- General mode of composition: arguments and modifiers in general
- Fix the type of verbal predicates
- Interface and semantic interpretation

Interconnect the (neo-) Davidsonian conceptual apparatus with a general framework for the syntax-semantics

Composition in Event Semantics
Composition in Event Semantics cont.

- Entailment reversal effect of negation: scope or meaning?
- Mechanism to produce multiple scopings
- Specification of the meaning of quantificational NPs

Composition in Event Semantics cont.
Direction of entailment preserved

Diamond entailments with existentially quantified args/mods

A cat miaowed loudly in the kitchen.
A cat miaowed in the kitchen.
A cat miaowed loudly.
A cat miaowed.

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Every cat miaowed loudly in the kitchen.

Every cat miaowed in the kitchen.

Every cat miaowed loudly.

Every cat miaowed.

Direction of entailment preserved

Diamond entailments with universally quantified args/nodes
Felix did not miaow.

Felix did not miaow loudly.

Felix did not miaow in the kitchen.

Felix did not miaow loudly in the kitchen.

Direction of entailment reversed

Diamond entailments with Negation
Davidson-style and hybrid approaches

- Predicates are indexes of events or indexed to roles
- Quantified arguments are quantified in
- Verbal predicators apply to individual-denoting arg's
- Composition
  - \( \lambda \) - abstraction introduces an artificial ordering in
    \[ \lambda x. \text{meow}(e) \land \text{AGENT}(x, e) \]
  - \( \lambda \) - abstraction over the over arguments and the event
  - Quantified arguments in hybrid approaches iteratively required arguments
  - The arity and type of the verbal predicator depend on the number of syntactically required arguments
- Composition and neo-Davidsonian composition via roles

Hybrid approaches involve a mixture of Fregean functional

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Verbs and verbal projections are unitarily predicates over events.

Arguments and adjoincts are modifiers on such predicates.

In the kitchendoc (meow)

\(\lambda e: \text{meow}(e) \land \text{AG}(e, \text{Felix})\)

\(\leadsto\)

\(\lambda e: \text{meow}(e) \leadsto \lambda e: \text{meow}(e)\)

and associate via roles

\(\text{meow}(e)\)

\(\lambda e: \text{meow}(e) \leadsto \lambda e: \text{meow}(e)\)

Pure neo-Davidsonian approaches

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Quantification in pure neo-Davidsonian approaches

Composition

- Pure neo-Davidsonian approaches use a uniform mode of

The resulting theory of scope requires no traces.

- This is a nice property that we would like to preserve, but which is missing in approaches that used mixed modes of

Different orders of application.

In these approaches, different scopings correspond to

Composition.
Semantics is complicated by the need for minimality/maximality conditions. Ontology is complicated by the need to allow for arbitrary non-temporal subpart relations between events and for a non-temporal subpart relation between events.

Quantification in neo-Davidsonian approaches cont.
The grammatical burden of events

given stretch of time

other, the event of everything that happens within a

– e.g., the event of every man jumping at some time or

need for complex events •

cannot be the same event
– e.g., the buying and the selling of a single transaction

intuitively want

more fine-grained event individuation than one might

The grammatical burden of events
Our approach is based on the desire to separate syntax-semantics interface. We will explore the consequences of assuming a uniform model-theoretic semantics from linking theory and the Davidsonian framework using syntactic argument roles. Our approach is based on the desire to separate the syntax-semantics interface. This talk...
Caveats

*Event-free* refers to the way verbal predicates combine with their arguments and with modifiers.

Reference to events by event-referring expressions is not at issue.

Focus here on non-cascading modifiers.

- *e.g.* The meeting lasted a long time.

- *e.g.* The visit took place last year.

He visited us on some day every week last year.

- *e.g.* Cascading temporal modifiers.
Main Ideas

- As arguments/modifiers are processed, assumptions are ruled out
- Specified
- Open possibilities about how things may yet be specified
- Disperse with the need of ordered application of arguments using roles and coupling roles with their values
- Encode arity in something other than the type of the predicate
- Dynamic perspective on semantic composition
- Individuals in a model

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We use syntactic role labels e.g. SUBJ, OBJ, TIME, RATE.

Partial assignment functions (AFs) map role labels to individuals, e.g. \( f(\text{subj}) = \text{Felix} \).

Will not discuss here lexical projection mechanisms.

Determining how syntactic roles correspond to semantic (thematic) roles, and which syntactic roles are obligatory.

Basic Proposal
Verbal projections are pairs consisting of the set of roles already saturated and a set of assignment functions. We term these pairs Linking Structures (LS) – we term these pairs Linking Structures (LS) –

disjunction over these conjunctions

understand sets of assignment functions as a big

set of assignments

understand assignment functions as a conjunction

given location

the set of all intervals in which the cat miaows at the

loc onto a place where the cat miaows, and Time onto

functions each mapping Subj onto a particular cat,

– to the lexical predicate miaow corresponds a set of

Verbal projections are pairs consisting of the set of roles
Basic Proposal (cont.)

- Arguments and modifiers denote mappings from linking structures to linking structures.
  - so *eat, eat a donut, and eat a donut quickly* are all just linking structures.

- Parallelism with pure neo-Davidsonian approaches, where arguments and modifiers denote mappings from properties of events to properties of events.

- Each argument or modifier is indexed to a role, e.g. *felix*$_{\text{SUBJ}}$, and maps an LS to a new LS no longer defined for that role.
  - e.g. *felix*$_{\text{SUBJ}}$(*miaows*) is not defined for the role SUBJ.
Linking structures are pairs consisting of a set of roles

\[ \emptyset = \mathcal{A} \cup (f)_{f \in \text{dom}(\mathcal{A})} \]

\[ \langle \mathcal{A}, f \rangle = \mathcal{I} \]

- for any linking structure \( \mathcal{A} \)

The set of open possibilities can only be about roles not yet processed.

The set of open possibilities about how things may be specified (the set of open possibilities corresponding to the set of roles processed up to given point) and a set of assignment functions (the set of open possibilities about roles not yet processed).

Linking structures are pairs consisting of a set of roles...
Let $F_0$ be the set of all partial functions from the set of role labels $\mathcal{R}$ to appropriately sorted individuals in the universe of discourse $\mathcal{U}$ of some model of some framework $\mathcal{F}$. Let $H_0$ be the set of all partial functions from the set of role labels $\mathcal{R}$ to appropriately sorted individuals in the universe of discourse $\mathcal{U}$ of some model of some framework $\mathcal{F}$. Then the least informative linking structure is:

$$\langle H_0, \emptyset \rangle = \bigcap H_0$$
To every verb \( V \) there corresponds a set of formulas \( \Phi \) composed of variable arity predicates and free variables

\[
\{ \text{meaow}_1(\text{SUBJ},\text{TIME},\text{LOC},\text{MANNER}), \ldots \text{meaow}_g(\text{SUBJ},\text{TIME},\text{LOC}) \} = e.g. \Phi \text{ meaow}
\]

In \( \Psi \) there corresponds a set of formulas \( \Phi \) composed of variable arity predicates and free variables

\[
\text{Lexical Linking Structures}
\]

A lexical projection mechanism (not discussed here) determines which syntactic roles are obligatory (marked by underlining) — how syntactic roles correspond to semantic roles — how syntactic roles are obligatory (marked by underlining)

\( \text{To every verb } V \) there corresponds a set of formulas \( \Phi \) composed of variable arity predicates and free variables

\[
\{ \text{meaow}_1(\text{SUBJ},\text{TIME},\text{LOC},\text{MANNER}), \ldots \text{meaow}_g(\text{SUBJ},\text{TIME},\text{LOC}) \} = e.g. \Phi \text{ meaow}
\]

\( \in \Psi \)
The principle of optionality: for any $V$, if there is a predicate $\Phi$ applied to some set of optional roles, then for any subset of that set there is a predicate in applied $\wedge \Phi$ for any $\wedge$, if there is a
contain an assignment that maps \( \text{TIME} \) to \( \ell \), then, for any superinterval \( \ell' \) of \( \ell \), \( \Lambda_{F_{\ell}} \) will also contain an assignment that maps \( \text{TIME} \) to some \( \Lambda_{F_{\ell'}} \) that is such \( \Lambda_{L_{\ell}} \) is such

**Temporal closure property:** every lexical \( L_{\ell} \) is such

\[
\{ [f] \phi = W(\Lambda \phi \in \phi E) \mid \phi E \in f \} = \Lambda_{\ell} \]

where \( \langle \Lambda_{F_{\ell}}, \emptyset \rangle \sim \Lambda \)

*Lexical Linking Structures*
The Dynamics of Composition: Example

- Suppose Felix meowed in the kitchen at time $t_1$ and Minnie meowed in the bedroom at time $t_2$.
- Then assignments like $f, f_1, g, g_1$ will be among those in $F_{\text{miaow}}$. 
Any assignment which, like $g$ or $g_1$, maps \text{SUBJ} to something other than $f$ will not be in $F_{\text{felixSUBJ}(\text{miaow})}$. For instance, if $f$, $f_1$ will be in $F_{\text{felixSUBJ}(\text{miaow})}$ will only contain contractions of something other than $f$ will not be in $F_{\text{felixSUBJ}(\text{miaow})}$.

Any assignment which, like $g$ or $g_1$, maps \text{SUBJ} to $f$, $f_1$ will be in $F_{\text{felixSUBJ}(\text{miaow})}$.

The Dynamics of Composition: Example (cont.)
The condition \( \text{dom}(f) = f \text{TIME} \) ensures that all obligatory args have been saturated.

Tense and Truth

The condition \( \text{dom}(f) = f \text{TIME} \) ensures that all obligatory truth value.

Tense morpheme with widest scope and maps an LS to a

Tense and Truth
\{ I \in \{ \langle x' \rangle | f \} \} \cup f(\exists x \in A | f) \{ R \} \cup D \leftrightarrow \langle D', F \rangle \sim \text{every cat} R

\{ F \in \{ \langle x' \rangle | f \} \} \cup f(\exists x \in A | f) \{ R \} \cup D \leftrightarrow \langle D', F \rangle \sim \text{a cat} R

\{ F \in \{ \langle x' \rangle | f \} \} \cup f(\exists x \in A | f) \{ R \} \cup D \leftrightarrow \langle D', F \rangle \sim \text{telix} R

Names and Quantified Args and Modifiers
Similarly, the resulting theory of scope requires no traces. Corresponding to different orders of application composition, in this approach different scopings correspond to different neo-Davidsonian approaches to argument quantification: Scope.
(25) Every cat chased a mouse

\[ \text{every cat} \}_\text{SUBJ/} \text{some mouse}_\text{OBJ/} ( \text{chase} ) \]

\[ E < A \]

(26) Surface scope: Every cat chased a mouse

\[ \text{every cat}_\text{SUBJ/} \text{some mouse}_\text{OBJ/} ( \text{chase} ) \]

\[ E < A \]

(27) Inverse scope: A < E

\[ \text{some mouse}_\text{OBJ/} \text{every cat}_\text{SUBJ/} ( \text{chase} ) \]
Specificity relation between linking structures

Entailment between sentences cashed out as specificity

\[ f \supset f'(\mu I \in \mu E)(\mu I \in \mu A) \iff I \subseteq I' \]

where

A linking structure is at least as specific as a linking structure

Specificity relation between linking structures
Negation

- in downward monotone contexts the pattern of entailment is reversed

\[ \sim \langle D, (F_0 \setminus F)_{-D} \rangle \text{ where} \]

\[ F_{-D} = \{ f \in F \mid \text{dom}(f) \cap D = \emptyset \} \]

- if \( F_2 \sqsubseteq F_1 \) then \( F_0 \setminus F_2 \sqsubseteq F_0 \setminus F_1 \)
Unburdening events of their grammatical load

transaction event

- e.g. buy and sell can correspond to the same

standard event semantics

* event individuation need not be as fine-grained as in

* no need for complex events

- simplifies event structure in the model

- is compatible with events in the model

approach

• No events in the syntax-semantics interface but the

Unburdening events of their grammatical load
Conclusion

- Simplifies event structure in the model
- Is compatible with events in the model and in fact allows a movement-based account of scope without traces
- Makes no ontological commitment to events
- Gives a uniform type for all modifiers
- Linking Semantics gives a uniformly typed interpretation for all projections of the verb

Conclusion