An event free neo-Davidsonian syntax-semantics interface

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Motivations for this work

- Overlapping concerns
  - interface between syntax and semantics: glue logic for deriving logical forms from syntactic structures
  - nature of modification
  - lexical semantics and linking
- Concentrate here on inferential properties of modification and a relatively simple model of syntax-semantics interface with a uniform mode of composition
  - for individual-denoting and quantificational arguments and modifiers

Overview

- The problem
  - arity expansion by modifiers
  - logic of modifiers: diamond entailments
  - meaning vs. valence
- Davidsonian solution
- Composition in event semantics
- Linking semantics

Arity expansion effected by modifiers

- how arity expansion of a basic predicate relation is brought about
  - e.g. basic binary relation *stab*, as in *Brutus stabbed Caesar*, is expanded to a ternary relation in *Brutus stabbed Caesar with a knife*
- what is the incremental contribution of modifiers such as *with a knife, to the city, from every candidate*?
- if types are part of the meaning is it possible to separate meaning and valence?
  - argument alternations, e.g. can ternary *give*, as in *I gave John the book*, be given the same meaning as that of binary *give*, as in *I gave the book to John*?

Diamond entailments

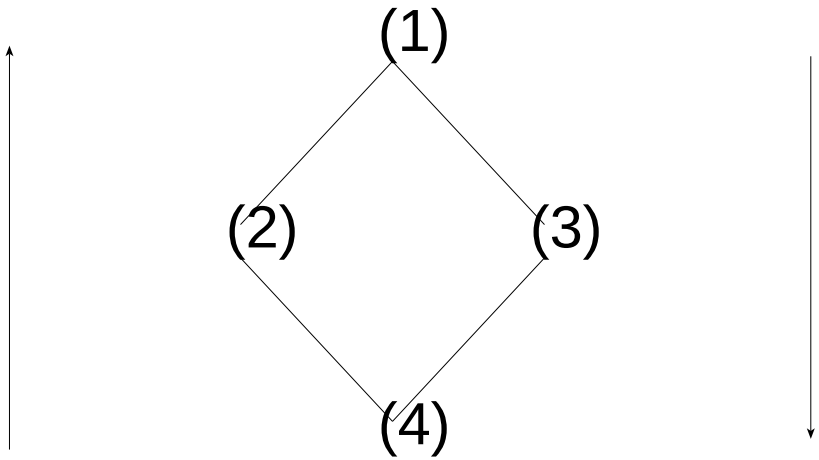
- Of the sentences below, (1) is the least informative (entailed by all others), (4) is the most informative (entailing all others), and (2), (3) are incomparable (neither entails the other).

(1) Felix miaowed.

(2) Felix miaowed loudly.

(3) Felix miaowed in the kitchen.

(4) Felix miaowed loudly in the kitchen.



entailment

specificity

The Davidsonian solution

- verbs have an implicit argument
- modifiers apply to this argument
- that implicit argument denotes an event
- and is existentially closed off
- so modifiers are conjunctively added to the verbal predication
- they are co-predicates on the event variable

Events as hooks

- use events to tie together modifiers with the predication they are modifying

(5) $\exists e \mathit{miaow}'(e, \mathit{felix}')$

(6) $\exists e(\mathit{miaow}'(e, \mathit{felix}') \wedge \mathit{loud}'(e))$

(7) $\exists e(\mathit{miaow}'(e, \text{felix}') \wedge \text{loc}(e, ix.\mathit{kitchen}'(x))$

(8) $\exists e(\mathit{miaow}'(e, \mathit{felix}') \wedge \mathit{loc}(e, ix.\mathit{kitchen}'(x) \wedge \mathit{loud}'(e))$

- *miaow* corresponds to a binary predicate throughout
- logic of modifiers reduced to conjunctive elimination

The Neo-Davidsonian move

- verbal predicates are unary predicates over events
- arguments and modifiers alike associate via thematic relations

(9) $\exists e(\textit{miaow}'(e) \wedge \textsc{agent}(e, \textit{felix}'))$

(10) $\exists e(\textit{miaow}'(e, \text{felix}') \wedge \textsc{loc}(e, ix.\textit{kitchen}'(x)))$

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

- connect the (neo-) Davidsonian conceptual apparatus with a general framework for the syntax-semantics interface and semantic interpretation
  - fix the type of verbal predicates
  - mode of composition: arguments and modifiers in general
  - interaction of the event variable with quantification
  - interaction of the event variable with negation
  - integrate with the semantics of tense

Composition in Event Semantics cont.

- specification of the meaning of quantificational NPs
- mechanism to produce multiple scopings
- entailment reversal effect of negation: scope or meaning?

Diamond entailments with existentially quantified args/mods

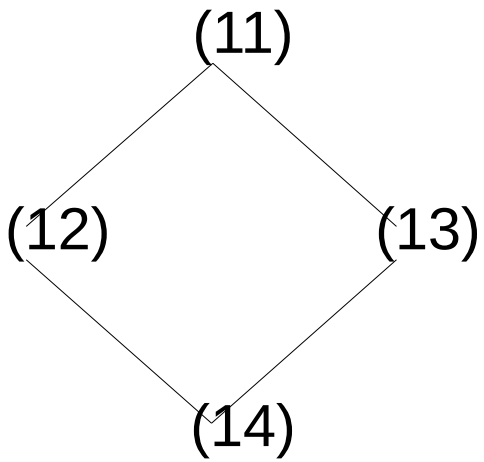
- Direction of entailment preserved

(11) A cat miaowed.

(12) A cat miaowed loudly.

(13) A cat miaowed in the kitchen.

(14) A cat miaowed loudly in the kitchen.



Diamond entailments with universally quantified args/mods

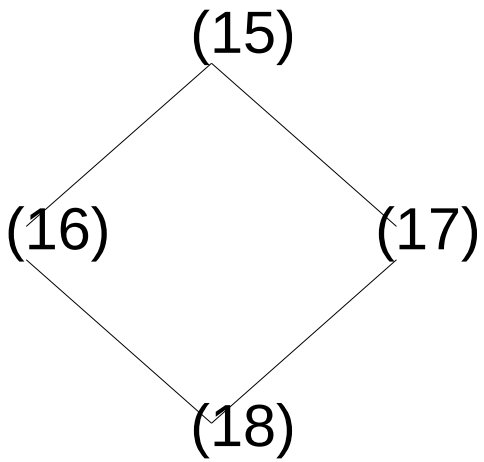
- Direction of entailment preserved

(15) Every cat miaowed.

(16) Every cat miaowed loudly.

(17) Every cat miaowed in the kitchen.

(18) Every cat miaowed loudly in the kitchen.



Diamond entailments with Negation

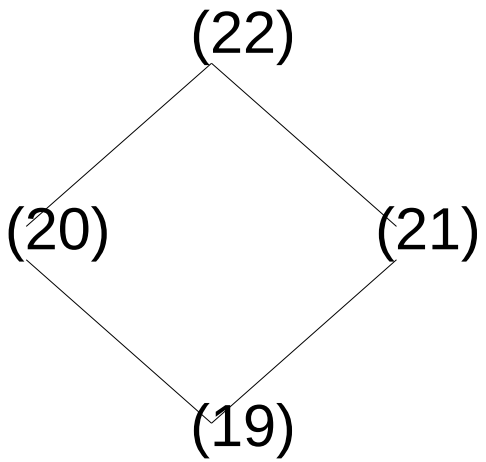
- Direction of entailment reversed

(19) Felix did not miaow.

(20) Felix did not miaow loudly.

(21) Felix did not miaow in the kitchen.

(22) Felix did not miaow loudly in the kitchen.



Davidson-style and hybrid approaches

- hybrid approaches involve a mixture of Fregean functional composition and neo-Davidsonian composition via roles
- the arity and type of the verbal predicate depend on the number of syntactically required arguments
  - λ-abstraction over the overt arguments and the event argument, e.g. in hybrid approaches $\lambda x \lambda e.\mathit{meaow}'(e) \wedge \textsc{agent}(e,x)$
  - λ-abstraction introduces an artificial ordering in composition
- verbal predicate applies to individual-denoting arg's
- quantified arguments are quantified in
- modifiers are predicates of events or indexed to roles

Pure neo-Davidsonian approaches

- verbs and verbal projections are uniformly predicates over events
- arguments and adjuncts are modifiers on such predicates and associate via roles

$\textit{miaow} \quad \leadsto \quad \lambda e.\textit{miaow}'(e)$

$\textit{Felix}_{\text{AG}}(\textit{meaow}) \quad \leadsto \quad \lambda e.\textit{meaow}'(e) \wedge \text{AGENT}(e, \textit{felix}')$

$\textit{in the kitchen}_{\text{LOC}}(\textit{meaow}) \quad \leadsto$

$\lambda e.\textit{meaow}'(e) \wedge \text{LOC}(e, ix.\textit{kitchen}'(x))$

Quantification in pure neo-Davidsonian approaches

- Pure neo-Davidsonian approaches use a uniform mode of composition.
- In these approaches different scopings correspond to different orders of application.
- 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 composition (e.g. $\lambda x \lambda e[P(e) \wedge \text{AGENT}(e,x)]$).

Quantification in neo-Davidsonian approaches cont.

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

(23) Every man jumped.

(24) $\lambda e.\forall x(\mathit{man}'(x) \rightarrow \exists e'\,(e' \sqsubseteq e \wedge \mathit{jump}'(e') \wedge \textsc{agent}(e',x))) \wedge e = \bigoplus \lambda e'.\exists y(\mathit{man}'(y) \wedge \mathit{jump}'(e') \wedge \textsc{agent}(e',y))$

Names and Quantified Args and Modifiers

$$\textit{felix}_R \quad \leadsto \quad \lambda P \lambda e.P(e) \wedge R(e, \textit{felix}')$$

$$\textit{a cat}_R \quad \leadsto \quad \lambda P \lambda e.\exists x(\textit{cat}'(x) \wedge P(e) \wedge R(e,x))$$

$$\textit{every cat}_R \quad \leadsto \quad \lambda P \lambda e.\forall x(\textit{cat}'(x) \rightarrow \exists e' (e' \sqsubseteq e \wedge P(e') \wedge R(e',x)) \wedge$$
$$e = \bigoplus \lambda e'.\exists y(\textit{cat}'(y) \wedge P(e') \wedge R(e',y))$$

The grammatical burden of events

- more fine-grained event individuation than one might intuitively want
  - e.g., the buying and the selling of a single transaction cannot be the same event
- need for complex events
  - e.g. the event of every man jumping at some time or other, the event of everything that happens within a given stretch of time

This talk

- Our approach is based on the desire to separate model-theoretic semantics from linking theory and the syntax-semantics interface.
- We will explore the consequences of assuming a uniform neo-Davidsonian mode of composition, but reworking the Davidsonian framework using syntactic argument roles.

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
  - e.g. *The visit took place last year*
    The meeting lasted a long time
- Focus here on non-cascading modifiers
  - e.g. cascading temporal modifiers
    He visited us on some day every week last year

Main Ideas

- dispense with the need of ordered application of arguments using roles and coupling roles with their values (individuals in a model)
- encode arity in something other than the type of the predicate
- dynamic perspective on semantic composition
  - open possibilities about how things may yet be specified
  - as arguments/modifiers are processed, assumptions are ruled out

Basic Proposal

- We use syntactic role labels e.g. SUBJ, OBJ1, TIME, RATE.
- Will not discuss here lexical projection mechanisms determining how syntactic roles correspond to semantic (thematic) roles, and which syntactic roles are obligatory.
- Partial assignment functions (AFs) map role labels to individuals, e.g. $f(\text{SUBJ}) = \text{FELIX}$.

Basic Proposal (cont.)

- 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)
  - to the lexical predicate *miaow* corresponds a set of functions each mapping SUBJ onto a particular cat, LOC onto a place where the cat miaows, and TIME onto the set of all intervals in which the cat miaowed at the given location
  - understand assignment functions f as a conjunctive set of assumptions
  - understand sets F of assignment functions as a big disjunction over these conjunctions

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

- Linking structures are pairs consisting of a set of roles (corresponding to the set of roles processed up to given point) and a set of assignment functions (the set of open possibilities about how things may be specified)
  - $L = \langle D, F \rangle$
- The set of open possibilities can only be about roles not yet processed
  - for any linking structure $L = \langle D, F \rangle$
    $(\forall f \in F)\text{dom}(f) \cap D = \emptyset$

Initial State

- 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 U of some model M
- Least informative linking structure: $L_0 = \langle \emptyset, F_0 \rangle$

Lexical Linking Structures

- To every verb V there corresponds a set of formulas Φ_V composed of variable arity predicates and free variables in $\mathcal{R}$
  - e.g. $\Phi_{meaow} =$ $\{meaow^2(\underline{\text{SUBJ}}, \underline{\text{TIME}}), meaow^3_1(\underline{\text{SUBJ}}, \underline{\text{TIME}}, \text{LOC}),$ $meaow^3_2(\underline{\text{SUBJ}}, \underline{\text{TIME}}, \text{MANNER}),$ $meaow^4(\underline{\text{SUBJ}}, \underline{\text{TIME}}, \text{LOC}, \text{MANNER}), \ldots\}$
- A lexical projection mechanism (not discussed here) determines
  - how syntactic roles correspond to semantic roles
  - which syntactic roles are obligatory (marked by underlining)

Lexical Linking Structures (cont.)

- *The principle of optionality*: for any V, if there is a predicate in Φ_V applied to some set of optional roles, then for any subset of that set there is a predicate in Φ_V applied just to the roles in that subset plus the obligatory ones
  - e.g., given that $meaow^4(\underline{\text{SUBJ}}, \underline{\text{TIME}}, \text{LOC}, \text{MANNER}) \in \Phi_{meaow}$, the principle of optionality guarantees that $meaow^3_1(\underline{\text{SUBJ}}, \underline{\text{TIME}}, \text{LOC}) \in \Phi_{meaow}$

Lexical Linking Structures

- $V \rightsquigarrow \langle \emptyset, F_V \rangle$, where
  $F_V = \{ f \in F_0 \mid (\exists \phi \in \Phi_V) M \models \phi[f] \}$
- Take $\models$ to be in effect truth **within** an interval rather than truth **at** an interval
- *Temporal closure property*: every lexical LS L_V is such that if F_V contains an assignment that maps TIME to some interval t, then, for any superinterval t' of t, F_V will also contain an assignment that maps TIME to t'

Example

$$\textit{miaow} \quad \rightsquigarrow \quad L_{\textit{miaow}} = \langle \emptyset, F_{\textit{miaow}} \rangle$$

$$\textit{felix}_{\textsc{subj}} \quad \rightsquigarrow \quad \langle D, F \rangle \mapsto \langle D \cup \{\textsc{subj}\}, \{ f \mid f \cup \{\langle \textsc{subj}, \textit{felix}' \rangle\} \in F \}$$

$$\textit{felix}_{\textsc{subj}}(\textit{miaow}) \quad \rightsquigarrow$$

$$\langle \{\textsc{subj}\}, \{ f \mid f \cup \{\langle \textsc{subj}, \textit{felix}' \rangle\} \in F_{\textit{miaow}} \} \rangle$$

The Dynamics of Composition: Example

- Suppose Felix meaowed in the kitchen at time t_1 and Minnie meaowed in the bedroom at time t_2.
- Then assignments like f, f_1, g, g_1 will be among those in F_{miaow}:

f:	SUBJ	$\mapsto$	**f**
	TIME	$\mapsto$	t_1
f_1	SUBJ	$\mapsto$	**f**
	TIME	$\mapsto$	t_1
	LOC	$\mapsto$	**k**
g:	SUBJ	$\mapsto$	**m**
	TIME	$\mapsto$	t_2
g_1:	SUBJ	$\mapsto$	**m**
	TIME	$\mapsto$	t_2
	LOC	$\mapsto$	**b**

The Dynamics of Composition: Example (cont.)

- Any assignment which, like g or g_1, maps SUBJ to something other than **f** will not be in $F_{\textit{felix}_{\text{SUBJ}}(\textit{miaow})}$.
- $F_{\textit{felix}_{\text{SUBJ}}(\textit{miaow})}$ will only contain contractions of assignments which, like f or f_1 map SUBJ to **f**.
- For instance, f^-, f_1^- will be in $F_{\textit{felix}_{\text{SUBJ}}(\textit{miaow})}$:

f^-: TIME $\mapsto$ t_1

f_1^- TIME $\mapsto$ t_1

LOC $\mapsto$ **k**

Tense and Truth

- Tense morpheme with widest scope and maps an LS to a truth value
- The condition $\text{dom}(f) = \{\text{TIME}\}$ ensures that all obligatory args have been saturated

$$\textit{past}_I \quad \rightsquigarrow \quad \langle D, F\rangle \mapsto (\exists f \in F)\text{dom}(f) = \{\text{TIME}\} \wedge f(\text{TIME}) \subseteq I$$

if $I < \textit{now}$, else undefined

$$\textit{past}_I(\textit{felix}_{\text{SUBJ}}(\textit{miaow}))$$

$$\rightsquigarrow \quad (\exists f \in F_{\textit{miaow}})\, f(\text{SUBJ}) = \textit{felix}' \wedge f(\text{TIME}) \subseteq I$$

Names and Quantified Args and Modifiers

$$\textit{felix}_R \quad \rightsquigarrow \quad \langle D, F\rangle \mapsto \langle D \cup \{R\}, \{f \mid f \cup \{\langle R, \textit{felix}'\rangle\} \in F\}$$

$$\textit{a cat}_R \quad \rightsquigarrow \quad \langle D, F\rangle \mapsto \langle D \cup \{R\}, \{f \mid (\exists x \in \textit{cat}')\, f \cup \{\langle R, x\rangle\} \in F\}$$

$$\textit{every cat}_R \quad \rightsquigarrow \quad \langle D, F\rangle \mapsto \langle D \cup \{R\}, \{f \mid (\forall x \in \textit{cat}')\, f \cup \{\langle R, x\rangle\} \in F\}$$

Quantification: Scope

- As in the pure neo-Davidsonian approaches to argument composition, in this approach different scopings correspond to different orders of application
- Similarly, the resulting theory of scope requires no traces.

Quantification: Scope (cont.)

(25) Every cat chased a mouse

(26) surface scope: $\forall > \exists$
(every cat_{SUBJ}(some $\text{mouse}_{\text{OBJ}}$(chase)))

(27) inverse scope: $\exists > \forall$
(some $\text{mouse}_{\text{OBJ}}$(every cat_{SUBJ}(chase)))

Specificity relation between linking structures

- A linking structure $L = \langle D, F \rangle$ is at least as specific as a linking structure $L' = \langle D', F' \rangle$ iff $D' \subseteq D$ and $F \sqsubseteq F'$, where $F \sqsubseteq F'$ iff $(\forall f \in F)(\exists f' \in F')\, f \leq f'$
- Entailment between sentences cashed out as specificity relation between the corresponding linking structures

Negation

- in downward monotone contexts the pattern of entailment is reversed

$$\textit{not} \quad \rightsquigarrow \quad \langle D, F\rangle \mapsto \langle D, (F_0 \setminus F)_{-D}\rangle \text{ where}$$
$$F_{-D} = \{f \in F \mid dom(f) \cap D = \emptyset\}$$

- if $F_2 \sqsubseteq F_1$ then $F_0 \setminus F_1 \sqsubseteq F_0 \setminus F_2$

Unburdening events of their grammatical load

- No events in the syntax-semantics interface but the approach
  - is compatible with events in the model
  - simplifies event structure in the model
    - no need for complex events
    - event individuation need not be as fine-grained as in standard event semantics
      - e.g. *buy* and *sell* can correspond to the same transaction event

Conclusion

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