CHAPTER 9: EVENTS AND PLURALITY

9.1. Neo-Davidsonian event semantics.

"Strange goings on! Jones did it slowly, deliberately, in the bathroom, with a knife, at
midnight. What he did was butter a piece of toast." Donald Davidson 1967, *The logical
form of action sentences*.

From Landman 2000:
- arguments for the event argument
- similarities and differences between adverbials and adjective

**Neo-Davidsonian semantics**

TYPE: 1. e, \( \eta \), i, s, t \( \in \text{TYPE} \)
- if a, b \( \in \text{TYPE} \) then \(<a,b> \in \text{TYPE}\)

e, t, s are as usual the type of individuals, truth values and possible worlds
\( \eta \) is the type of events, i is the type of periods of time (intervals).

Models for the language: \( M = <D, E, I, W, \{0,1\}, \tau, \perp, F> \)
- D: set of individuals
- E: set of events
- I: set of periods of time (ordered at least by temporal precedence \(<\) and temporal
  inclusion \(\subseteq\) )
- W: set of worlds
- \( \perp \): the undefined object, which is not in any semantic domain.
- \( \tau \) is the temporal trace function (see below)

We will not deal properly with undefinedness here (since life is short).
We already allowed undefinedness in \( \sigma(P) \) without being very explicit about how this
affects truth conditions of complex formulas. We will allow more undefinedness now in
the following way.

In a Davidsonian event theory, we will associate with verbs predicates of events of type
\(<\eta,t>\)

\[ \text{kiss} \quad \text{KISS}_{\eta,t} \quad \text{the set of kissing events} \]
\[ \text{walk} \quad \text{WALK}_{\eta,t} \quad \text{the set of walking events} \]

We call the type \(<\eta,t>\) the type of event types, so event types are sets of events.
Hence we associate lexically with verbs event types.

In a Neo- Davidsonian theory we associate with argument places of the verbs thematic
roles, like agent and theme.

We assume a set of thematic roles containing the roles of agent (Ag) and theme
(Th), and we assume that thematic roles are partial functions from events to individuals:
Thematic roles specify the participants of events. Lexical constraints will constrain which roles are defined for which events:

Example:

**lexical constraint on kiss**
For every \( e \in E \): if \( e \in F(\text{KISS}) \) then \( F(\text{Ag})(e) \neq \bot \) and \( F(\text{Th})(e) \neq \bot \)

Every kissing event has an agent (the kisser) and a theme (the kissee).

We assume roles as partial functions from events to individuals. But this generalizes, in particular, we assign time and location to events (we ignore location here).

The temporal trace function \( \tau \) is a partial function from worlds and events into periods:

\[ \tau : E \times W \rightarrow I \]

\( \tau \) specifies the running time of events in worlds.

So: if \( e \in \text{WALK} \) and \( \text{Ag}(e) = \text{Fred} \) and \( \tau(e,w) \neq \bot \), then world \( w \) contains at some interval of time an event of Fred walking.

We assume that \( \tau \) links the verbal predicates to the world \( w \). So, we do not assume that the verb predicates have themselves a world variable \( \text{KISS}(w,e) \), the world variable is provided via \( \tau \).

We are not forcing nouns into the Neo-Davidsonian format here (though some people propose that too). This means that we do assume for nouns a world index.

Thus, we interpret nouns as relations between individuals and worlds:

\[ \text{boy} \quad \text{BOY} \in \text{CON}_{<w,<e,t>>} \]

Just to get the flavor of it, ultimately, we will interpret (1a) as (1b):

(1) a. A senator stabbed Caesar
   \[ \exists e [ \text{STAB}(e) \land \exists x [\text{SENATOR}_w(x) \land \text{Ag}(e) = x] \land \text{Th}(e) = \text{Caesar} \land \tau(e,w) < \text{now} ] \]

There is a stabbing event with as agent someone who is a senator in \( w \) and as theme Caesar, and that stabbing event is located in \( w \) before now.

226
The grammar:
Verbs: \(<e^n,<\eta,t>>\),
where \(<e^1,a> = <e,a>\)
\(<e^2,a> = <e,<e,a>>\)
\(<e^3,a> = <e,<e,<e,a>>>\)

Transitive verbs
Lexical item: kiss
Type: \(<e,<e,<\eta,t)>>\)
Interpretation: \(\lambda y\lambda x\lambda e.\text{KISS}(e) \land \text{Ag}(e)=x \land \text{Th}(e)=y\)

Intransitive verbs
Lexical item: walk
Type: \(<e,<\eta,t>>\)
Interpretation: \(\lambda x\lambda e.\text{WALK}(e) \land \text{Ag}(e)=x\)

Inflection
Lexical Item: Past tense -ed
Type: \(<<e,\eta,t>>, \<e,\eta,t>>\)
Interpretation: \(\lambda \alpha \lambda x\lambda e.\alpha(e,x) \land \tau(e,w) < \text{now} \quad \text{where} \ \alpha \in \text{VAR}_{<e,\eta,t>>}\)

Nouns:
Lexical item: boy
Type: \(<w,<e,t>>\)
Interpretation: \(\text{BOY}_w\)

Determiners: as before

At the IP level we derive a type \(<\eta,t>\).
We assume that the interpretation of the complementizer C requires (minimally) a t-input
(when necessary lifted to \(<s,t>\)).
We add default existential closure to the type shifting theory:

**Existential closure**
\(\text{EC}: <\eta,t> \rightarrow t\)
\(\text{EC}[\alpha] = \exists e[\alpha(e)] \quad \text{(in other words:} \ \alpha \neq \emptyset)\).

In-situ application enters noun phrase interpretations into event types
Let \(\alpha\) be a verbal or inflectional interpretation of type \(<e^n,<\eta,t>>\) and \(\beta\) a nounphrase
interpretation.

Resolving \(\text{APPLY}[\alpha, \beta]\) without storage we call \textit{in situ application}.

We will need new type shifting rules for this.
Type shifting rules:

Observation: what was a one-place predicate before is now a two-place predicate. So we apply the type shifting principle we had for two-place predicates to what was the one-place predicate. Similarly, we generalize to three-place predicates:

LIFT: \(<e,e,<\eta,t>>\) \rightarrow \langle\langle e,t>,<e,\eta,t>>\)
LIFT[\alpha] = \lambda T \lambda e. T(\lambda y. \alpha(e,x,y))

LIFT: \(<e,\eta,t>> \rightarrow \langle\langle e,t>,<\eta,t>>\)
LIFT[\alpha] = \lambda T \lambda e. T(\lambda x. \alpha(e,x,y))

Scopal problems in the Davidsonian theory:

Event type principle (See extensive discussion in Landman 2000)
Non-scopal noun phrases can be entered into event types, Scopal noun phrases cannot be entered into event types.

This means in the sample grammar we give here that scopal noun phrases must be stored and retrieved.

Retrieval: Retrieval takes place as before at type t.

Consequence: retrieval takes place after event existential closure.

-Extensions to the theory of plurality, see Landman 2000 and references there.

**Adverbials:** <\eta,t>

**Prepositions:** <e,<\eta,t>>

**Typeshifting:**

LIFT: \(<\eta,t>> \rightarrow \langle\langle e^a, \eta,t>>\),<e^a,\eta,t>>\)

LIFT[\alpha] = \lambda \Pi \lambda x_n…\lambda x_1\lambda e. \Pi(e,x_1,…x_n) \land \alpha(e)

From Landman 2000
-examples
-passives
9.2. Some aspects of plurality

9.2.1. Semantic pluralization.

Link 1983 proposes that the domain of individuals forms a complete atomic Boolean algebra, and he lets singular and plural count nouns denote sets of Boolean elements. He assumes that singular predicates denote sets of atoms, and that semantic pluralization is closure under sum:

Let P be a subset of B:
\[ *P = \{ b \in B : \text{for some } X \subseteq P: b = \sqcup X \} \]
The set of all sums of P-elements.

For example, let the singular noun girl denote GIRL, where  
GIRL = \{ lee, kim, sam \}.

Then the plural noun girls denotes *GIRL, where  
*GIRL = \{ 0, lee \cup kim, lee \cup sam, kim \cup sam, lee \cup kim \cup sam \}
9.2.2. Definiteness.

Sharvy 1980 generalizes Russell’s definite description operation to a presuppositional sum operation, the sigma operation: if the noun *nomen* denotes N, then the definite noun phrase *the nomen* denotes $\sigma(N)$. And the semantics for $\sigma$ is specified as follows:

$$
\sigma(N) = \begin{cases} 
\sqcup N & \text{if } \sqcup N \in N \\
\bot & \text{otherwise} 
\end{cases} 
$$

(where $\bot$ stands for undefined)

We assume that *girl* denotes GIRL and GIRL = {lee, kim, sam}.
We assume that *boy* denotes BOY and BOY = {pat}.
Then the following sums are given:

$$
\sqcup \text{GIRL} = \sqcup *\text{GIRL} = \text{lee} \sqcup \text{kim} \sqcup \text{sam} \\
\sqcup \text{BOY} = \text{pat}
$$

With this we get the following noun phrase interpretations:

- *the girl* is interpreted as $\sigma(\text{GIRL})$
  - $\sigma(\text{GIRL}) = \bot$ because lee $\sqcup$ kim $\sqcup$ sam $\not\in$ GIRL

- *the girls* is interpreted as $\sigma(*\text{GIRL})$
  - $\sigma(*\text{GIRL}) = \text{lee} \sqcup \text{kim} \sqcup \text{sam}$ because lee $\sqcup$ kim $\sqcup$ sam $\in$ *GIRL

- *the boy* is interpreted as $\sigma(\text{BOY})$
  - $\sigma(\text{BOY}) = \text{pat}$ because pat $\in$ BOY
### 9.2.3. Numerical noun phrases.

Landman 2004 proposes that numericals have the semantics of intersective adjectives:

\[
\text{three is interpreted as: } \lambda x. |x| = 3,
\text{the set of all sums of three atoms.}
\]

The intersective semantics gives the following noun phrase interpretations:

- \textit{three girls} is interpreted as \( \lambda x. \text{GIRL}(x) \land |x| = 3 \)
  \( = \{\text{lee}, \text{kim}, \text{sam}\} \)

- \textit{two girls} is interpreted as \( \lambda x. \text{GIRL}(x) \land |x| = 2 \)
  \( = \{\text{lee}, \text{kim}, \text{lee}, \text{sam}, \text{kim}, \text{sam}\} \)

The picture shows that these noun phrase denotations are not closed upward or downward within \( \text{GIRL} \):

![Diagram showing the denotations of numerical noun phrases](image)
at least three is interpreted as: \( \lambda x. |x| \geq 3, \)
the set of sums of at least three atoms.

The intersective semantics gives the following noun phrase interpretations:

at least three girls is interpreted as \( \lambda x. \text{GIRL}(x) \land |x| \geq 3 \)
= \{lee\|kim\|sam\}

at least two girls is interpreted as \( \lambda x. \text{GIRL}(x) \land |x| \geq 2 \)
= \{lee\|kim, lee\|sam, kim\|sam, lee\|kim\|sam \}

In this case the noun phrase denotations are closed upward within \( \text{GIRL} \):
*at most three* is interpreted as: 
\[ \lambda x. |x| \leq 3, \]
the set of sums of at most three atoms.

The intersective semantics gives the following noun phrase interpretations:

*at most three girls* is interpreted as 
\[ \lambda x. \text{GIRL}(x) \land |x| \leq 3 \]
= *GIRL

*at most two girls* is interpreted as 
\[ \lambda x. \text{GIRL}(x) \land |x| \leq 2 \]
= \{lee, kim, lee, sam, kim, sam, lee, kim, sam, 0\}

In this case the noun phrase denotations are closed downward within *GIRL:
This semantics gives the correct interpretations for the definite noun phrases:

**the girls**  
is interpreted as \( \sigma(*\text{GIRL}) \)  
\( \sigma(*\text{GIRL}) = \text{lee, kim, sam} \)

**the three girls**  
is interpreted as \( \sigma(\lambda x.*\text{GIRL}(x) \land |x|=3) \)  
\( \sigma(\lambda x.*\text{GIRL}(x) \land |x|=3) = \text{lee, kim, sam} \)

**the two girls**  
is interpreted as \( \sigma(\lambda x.*\text{GIRL}(x) \land |x|=2) \)  
\( \sigma(\lambda x.*\text{GIRL}(x) \land |x|=2) = \bot, \text{undefined} \)

Namely:  
\( \bigcup(\lambda x.*\text{GIRL}(x) \land |x|=2) = \text{lee, kim, sam} \), and  
\( \text{lee, kim, sam} \notin \lambda x.*\text{GIRL}(x) \land |x|=2 \)

**the at least two girls**  
is interpreted as \( \sigma(\lambda x.*\text{GIRL}(x) \land |x|\geq 2) \)  
\( \sigma(\lambda x.*\text{GIRL}(x) \land |x|\geq 2) = \text{lee, kim, sam} \)

**the boy**  
is interpreted as \( \sigma(\text{BOY}) \)  
\( \sigma(\text{BOY}) = \text{pat} \)

**the at most three girls**  
is interpreted as \( \sigma(\lambda x.*\text{GIRL}(x) \land |x|\leq 3) \)  
\( \sigma(\lambda x.*\text{GIRL}(x) \land |x|\leq 3) = \text{lee, kim, sam} \)

**the at most two girls**  
is interpreted as \( \sigma(\lambda x.*\text{GIRL}(x) \land |x|\leq 2) \)  
\( \sigma(\lambda x.*\text{GIRL}(x) \land |x|\leq 2) = \bot, \text{undefined} \)

Namely:  
\( \bigcup(\lambda x.*\text{GIRL}(x) \land |x|\leq 2) = \text{lee, kim, sam} \), and  
\( \text{lee, kim, sam} \notin \lambda x.*\text{GIRL}(x) \land |x|\leq 2 \)

**Distributive and Collective readings (Link)**

Three boys carried the piano upstairs.  
1. \( \exists x[\#\text{BOY}(x) \land |x|=3 \land \text{CARRY}(x,p)] \quad \text{Collective} \)  
2. \( \exists x[\#\text{BOY}(x) \land |x|=3 \land \text{D}\text{CARRY}(x,p)] \quad \text{Collective} \)

where \( \text{D}\text{CARRY}(x,p) \) iff \( \forall a \in \text{AT}_x; \text{CARRY}(a,p) \)

Link 1986 (Amsterdam Colloquium): use the same structures for events.
9.2.4. Event structures for plurality – Link, Krifka, Landman 1994, 2000

E = <E, ⊆, ∪, ATOM_E> is a complete atomic Boolean algebra, a structure of singular events (atoms) and pluralities.

**Thematic roles** are partial functions from events to individuals.

In particular:

Thematic roles are partial functions from singular events to singular individuals

Ag: ATOM_E → ATOM_D
Th: ATOM_E → ATOM_D etc.

Plural roles are partial functions from (singular and plural) events to (singular and plural) individuals:

*Ag: E → D
*Th: E → D etc.

*Ag(e) = \[ \bigcup\{Ag(e') : e' \in AT_e}\] if for every e' \in AT_e: Ag(e') ≠ ⊥
*Ag(e) = ⊥ otherwise

**Example:**

Let KISS ⊆ ATOM_E, let e_1, e_2, e_3 ∈ KISS
Let GIRL ⊆ ATOM_D, let lee, kim, sam ∈ GIRL
Let CAT ⊆ ATOM_D, let ronya, sima ∈ CAT

Let: Ag(e_1) = lee, Ag(e_2) = kim, Ag(e_3) = sam
Let: Th(e_1) = ronya, Th(e_2) = ronya, Th(e_3) = sima

Then:

KISS(e_1) ∧ Ag(e_1) = lee ∧ Th(e_1) = ronya
KISS(e_2) ∧ Ag(e_2) = kim ∧ Th(e_2) = ronya
KISS(e_3) ∧ Ag(e_3) = sam ∧ Th(e_1) = sima

Hence, by definition of *KISS and *Ag and *Th:

*KISS(e_1 ∪ e_2 ∪ e_3) ∧ *Ag(e_1 ∪ e_2 ∪ e_3) = lee ∪ kim ∪ sam ∧
*Th(e_1 ∪ e_2 ∪ e_3) = ronya ∪ sima
Hence:

\[ \exists e[\text{*KISS}(e) \land \text{*Ag}(e) = \text{lee} \sqcup \text{kim} \sqcup \text{sam} \land \text{*Th}(e) = \text{ronya} \sqcup \text{sim}] \]

and:

\[ \exists e[\text{*KISS}(e) \land \exists x[\text{GIRL}(x) \land |x|=3 \land \text{*Ag}(e) = x] \land \exists y[\text{CAT}(y) \land |y|=2 \land \text{*Th}(e) = y]] \]

Three girls kissed two cats    (Cumulative reading)

### 9.2.5 Groups

ATOM = IND ∪ GROUP

\[ \uparrow : \text{IND} \cup \text{GROUP} \rightarrow \text{ATOM} \]

such that:

1. for every \( a \in \text{ATOM} \): \( \uparrow(a)=a \)
2. for every \( b \in \text{IND} – \text{ATOM} \): \( \uparrow(b) \in \text{GROUP} \)
3. if \( x \neq y \) then \( \uparrow(x) \neq \uparrow(y) \)

Three boys carried a piano upstairs

\[ \exists x[\text{*BOY}(x) \land |x|=3 \land \text{*CARRY}(x)] \]

There is a sum of three boys and each atom carries a piano upstairs.

\[ \exists x[\text{*BOY}(x) \land |x|=3 \land \text{*CARRY}(\uparrow(x))] \]

There is a sum of three boys and as a group they carry a piano upstairs.

The boys and girls were separated and met in different dorms

\[ \exists e_1 \exists e_2[ e=e_1 \sqcup e_2 \land \text{SEP}(e_1) \land \text{Ag}(e_1) = \uparrow(\sigma(\text{*BOY})) \sqcup \uparrow(\sigma(\text{*GIRL})) \land \text{*MET}(e_2) \land \text{Ag}(e_2) = \uparrow(\sigma(\text{*BOY})) \sqcup \uparrow(\sigma(\text{*GIRL}))] \]

The meeting distributes to the group of boys and the group of girls.