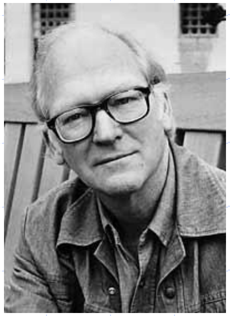
Lecture II. Event Semantics

This lecture

1. Davidsonian event semantics
2. Dependent event types
   - DETs in simple type theory (Montague's setting)
     - Focus: stepping stone for easier understanding
     - Adequacy: conservativity over Church's simple type theory
   - DETs in modern type theories (MTT-event semantics)
3. Three applications of DETs
   - Event quantification problem and its DET solution
   - Temporal semantic constructions (*)
   - Selection restriction in MTT-event semantics (*)

See (Luo & Soloviev 2017, Chatzikyriakidis & Luo 2020, Luo 2023), where those marked with (*) are new.

II.1. Davidsonian event semantics



- Original motivation: adverbial modifications
  - (1) John buttered the toast.
  - (2) John buttered the toast with the knife in the kitchen.
- Do we have (2) $\Rightarrow$ (1)? How?
  - Cumbersome in MG with meaning postulates
  - Davidson (1967): verbs tacitly introduce existentially quantified events, doing away with meaning postulates.

Two MG approaches without events

- (1) John buttered the toast.
  - (1″) butter(j,t)
  - Here, butter : $\mathbf{e}^2 \rightarrow \mathbf{t}$ and j, t : $\mathbf{e}$
- (2) John buttered the toast with the knife in the kitchen.
  - A1: change type of butter to butter* : $\mathbf{e}^4 \rightarrow \mathbf{t}$, with k_1, k_2 : $\mathbf{e}$
    (2″) butter*(j,t,k_1,k_2)
  - A2: keep butter : $\mathbf{e}^2 \rightarrow \mathbf{t}$, with knife/kitchen : $(\mathbf{e} \rightarrow \mathbf{t}) \rightarrow (\mathbf{e} \rightarrow \mathbf{t})$
    (2‴) kitchen(knife(butter(j)))(t)
- Both need *ad hoc* meaning postulates to get (2″)/(2‴) ⇒ (1″).
  - E.g., we may assume $\forall x{:}\mathbf{e}$.knife(p,x)/kitchen(p,x)⇒p(x), then (2‴) ⇒ (1″).

Neo-Davidsonian event semantics

- Neo-Davidsonian (Parsons 1990) with thematic roles (next slide)

(1) John buttered the toast.
(1′) ∃v:Event. butter(v) & agent(v)=john & patient(v)=toast

(2) John buttered the toast with the knife in the kitchen.
(2′) ∃v:Event. butter(v) & agent(v)=john & patient(v)=toast & with(v,knife) & at(v,kitchen)

Obviously, (2′) $\Rightarrow$ (1′)

Thematic roles like agent/patient/time

Major thematic relations [edit]

Here is a list of the major thematic relations.[3]

- **Agent**: deliberately performs the action (e.g., **Bill** ate his soup quietly.).
- **Experiencer**: the entity that receives sensory or emotional input (e.g. **Susan** heard the song. **I** cried.).
- **Stimulus**: Entity that prompts sensory or emotional feeling - not deliberately (e.g. David Peterson detests **onions!**).
- **Theme**: undergoes the action but does not change its state (e.g., We believe in one **God**. I have **two children**. I put **the book** on the table. He gave **the gun** to the police officer.) (Sometimes used interchangeably with patient.)
- **Patient**: undergoes the action and changes its state (e.g., The falling rocks crushed **the car**.). (Sometimes used interchangeably with theme.)
- **Instrument**: used to carry out the action (e.g., Jamie cut the ribbon **with a pair of scissors**.).
- **Force** or **Natural Cause**: mindlessly performs the action (e.g., **An avalanche** destroyed the ancient temple.).
- **Location**: where the action occurs (e.g., Johnny and Linda played carelessly **in the park**. I'll be **at Julie's house** studying for my test.).
- **Direction** or **Goal**: where the action is directed towards (e.g., The caravan continued on **toward the distant oasis**. He walked **to school**.).
- **Recipient**: a special kind of goal associated with verbs expressing a change in ownership, possession. (E.g., I sent **John** the letter. He gave the book **to her**.)
- **Source** or **Origin**: where the action originated (e.g., The rocket was launched **from Central Command**. She walked **away from him**.).
- **Time**: the time at which the action occurs (e.g., The pitcher struck out nine batters **today**)
- **Beneficiary**: the entity for whose benefit the action occurs (e.g.. I baked **Reggie** a cake. He built a car **for me**. I fight **for the king**.).
- **Manner**: the way in which an action is carried out (e.g., **With great urgency**, Tabitha phoned 911.).
- **Purpose**: the reason for which an action is performed (e.g., Tabitha phoned 911 right away **in order to get some help**.).
- **Cause**: what caused the action to occur in the first place; not *for what*, rather *because of what* (e.g., **Because Clyde was hungry**, he ate the cake.).

Events? Event structure?

- What is an event?
  - Mysterious concept … Philosophically argued for (and against …)
  - Are they individuals/entities? Event < **e**? Formally, either is possible – we leave it open.
  - Do events have structures/properties/classifications?
- We propose to introduce
  - Dependent event types (DETs), dependent on thematic roles
- This
  - Solves the problems such as "EQP" (see later)
  - Facilitates semantic constructions of tensed sentences
  - Solves selection restriction problem in MTT-event semantics

but doesn't attempt to answer the above questions.

II.2. Dependent event types

- Dependent event types (Luo & Soloviev 2017)
  - Refining event structure by (dependent) typing
- How:

  Refining event structure:

  Event → Evt(a)/Evt(a,p)/Evt(a,p,t)

  which are event types dependent on thematic roles

  a/p/t (agents/patients/times),

  respectively.

DETs and their subtyping relationships

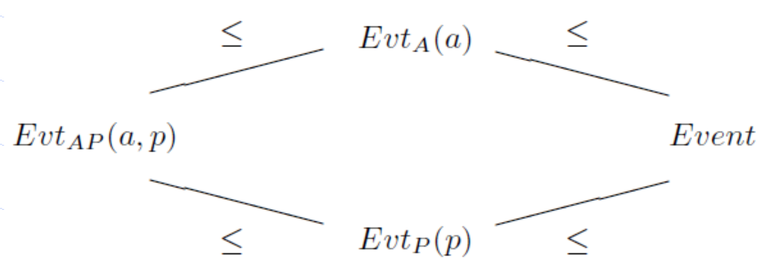
- For a:Agent and p:Patient, consider DETs

  $$Event,\ Evt_A(a),\ Evt_P(p),\ Evt_{AP}(a,p)$$

- Subtyping ($A \le B$ means that any a of type A is also of type B)

  $$\frac{a : A \quad A \le B}{a : B}$$

- Subtyping between DETs



  - Any event with agent a and patient p is an event with agent a.
  - Any event with agent a is an event.

Two systems with DETs

- Extension of Montague's simple TT with DETs
  - C_e extends Church's simple type theory (1940) with DETs
  - Montague's system is familiar for many – hopefully better understanding of DETs.

We shall focus on this – stepping stone for easier understanding.

- Extension of modern type theories with DETs
  - T[E] extends MTT T with DETs; e.g., T = UTT (Luo 1994).
  - This shows how DETs work with MTTs – "MTT-event sem."

Only informally/briefly in dealing with selection restriction in MTT-event semantics

DETs in Montagovian setting

- Eg. John talked loudly.
  - talk, loud : Event→**t**
  - agent : Event→**e**→**t**
- (neo-)Davidsonian event semantics

$$\exists e : Event.\ talk(e)\ \&\ loud(e)\ \&\ agent(e, j)$$

- Dependent event types in Montagovian setting:

$$\exists e : Evt_A(j).\ talk(e)\ \&\ loud(e)$$

which is well-typed because $Evt_A(j) \leq Event$.

C_e: Church's simple TT with DETs (Luo 2023)

- First, Church's simple type theory C (1940)
  - Employed in Montague's semantics (c.f., Gallin 1975)
  - Its rules are presented in the Natural Deduction style as follows.
- Rules for sorts/judgements and λ-calculus

$$\frac{}{\mathbf{e}\ type} \qquad \frac{}{\mathbf{t}\ type} \qquad \frac{}{x : A\ [x : A]} \qquad \frac{}{P\ true\ [P\ true]}$$

$$\frac{A\ type \quad B\ type}{A \to B\ type} \qquad \frac{b : B\ [x : A] \quad x \notin FV(B)}{\lambda x{:}A.b : A \to B} \qquad \frac{f : A \to B \quad a : A}{f(a) : B}$$

Note: the side condition in the λ-rule is there only for DETs.

- Rules for truth of logical formulas

$$\frac{P : \mathbf{t} \quad Q : \mathbf{t}}{P \supset Q : \mathbf{t}} \qquad \frac{Q\ true\ [P\ true]}{P \supset Q\ true} \qquad \frac{P \supset Q\ true \quad P\ true}{Q\ true}$$

$$\frac{A\ type \quad P : \mathbf{t}\ [x : A]}{\forall(A, x.P) : \mathbf{t}} \qquad \frac{P\ true\ [x : A]}{\forall(A, x.P)\ true} \qquad \frac{\forall(A, x.P[x])\ true \quad a : A}{P[a]\ true}$$

- Rule for "conversion" of logical formulas (λ-conversion omitted)

$$\frac{P\ true \quad Q : \mathbf{t}}{Q\ true} \quad (P \simeq Q)$$

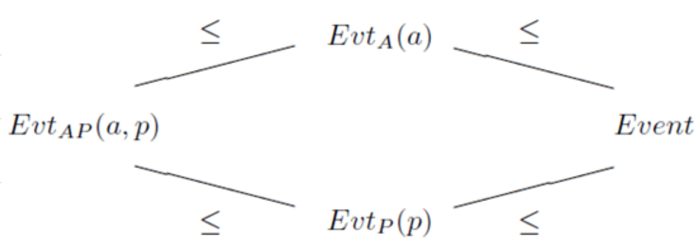
Dependent event types in C_e

$$\frac{\Gamma\ valid}{\Gamma \vdash Event\ type}$$

$$\frac{\Gamma \vdash a : \mathbf{e}}{\Gamma \vdash Evt_A(a)\ type} \qquad \frac{\Gamma \vdash p : \mathbf{e}}{\Gamma \vdash Evt_P(p)\ type} \qquad \frac{\Gamma \vdash a : \mathbf{e} \quad \Gamma \vdash p : \mathbf{e}}{\Gamma \vdash Evt_{AP}(a, p)\ type}$$

$$\frac{A\ type}{A \le A} \qquad \frac{A \le B \quad B \le C}{A \le C} \qquad \frac{A' \le A \quad B \le B'}{A \to B \le A' \to B'}$$

$$\frac{A \simeq B}{A \le B} \qquad \frac{a : A \quad A \le B}{a : B}$$



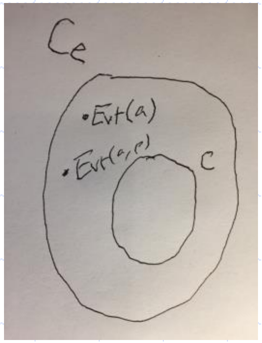
Conservativity (Luo & Soloviev 2020, Luo 2023)

Background notes

(1) Conservative extension: "J in C and |- J in C_e, then |- J in C."

(2) Logical consistency is preserved by conservative extensions.

Theorem. C_e is a conservative extension over Church's simple type theory.



Proof. Define R : C_e ➔ C that preserves derivations.

- R maps event types (DETs) Event/Evt(…) to **e**.
- R(t)=t for t∈C.

For any C_e-derivation D, R(D) is a C-derivation. Therefore, any derivable C-judgement in C_e can also be derived in C.

Corollary. C_e is logically consistent.

II.3. Applications of DETs

- In this course, three applications of DETs:
  - DET solution to event quantification problem (EQP)
  - Temporal semantic constructions with DETs
  - Selection restriction in MTT-event semantics

II.3.1. Incompatibility problems in event sem.

- Introducing an extra/artificial existential event quantifier "∃v" may lead to interference with other quantifiers.
  - E.g., "event quantification problem" (EQP, Winter & Zwarts 2011)
  - Incompatibility between event semantics and MG (Champollion 2015)

(1) Nobody talked.

Intended neo-Davidsonian event semantics is (2):

(2) $\neg\exists x{:}\mathbf{e}.\ [\mathrm{human}(x)\ \&\ \exists v{:}\mathrm{Event}.\ \mathrm{talk}(v)\ \&\ \mathrm{agent}(v){=}x]$

But the incorrect semantics (#) is also possible (well-typed!)

(#) $\exists v{:}\mathrm{Event}.\ \neg\exists x{:}\mathbf{e}.\ \mathrm{human}(x)\ \&\ \mathrm{talk}(v)\ \&\ \mathrm{agent}(v){=}x$

It moves the event quantifier "∃v:Event" in (2) to the beginning.

Some proposed solutions to EQP

- Many different proposals (only mentioning two below)
  - Purpose: to force scope of event quantifier to be narrower.
- Champollion's quantificational event semantics (2015)
  - Trick: taking a set E of events as argument, but **talk**(e) …
    - talk : (Event→**t**)→**t** with talk(E) = ∃e:Event. e∈E & **talk**(e)
  - Debatable: intuitive meanings, compositionality & complexity
- Winter-Zwarts (2011) & de Groote (2014)
  - Use Abstract Categorial Grammar (ACG, de Groote 2001)
    - ACG structure prevents incorrect interpretation.
  - Seemingly coincidental (and what if one does not use ACG?)
- Our proposal: dependent event types (solution to EQP & …)

DET-solution to EQP

(1) Nobody talked.

Neo-Davidsonian semantics (repeated):

(2) $\neg\exists x{:}\mathbf{e}.\ human(x)\ \&\ \exists v{:}Event.\ talk(v)\ \&\ agent(v,x)$

(3) $\exists v{:}Event.\ \neg\exists x{:}\mathbf{e}.\ human(x)\ \&\ talk(v)\ \&\ agent(v,x)$

where (2) is intended, while (3) is incorrect, but well-typed.

Dependent event types in Montague's setting:

(4) $\neg\exists x{:}\mathbf{e}.\ human(x)\ \&\ \exists v{:}Evt_A(x).\ talk(v)$

(#) $\exists v{:}Evt_A(x).\ \neg\exists x{:}\mathbf{e}.\ human(x)\ \&\ talk(v)$

where (#) is ill-typed since the first "x" is outside scope of "$\exists x{:}\mathbf{e}$".

II.3.2. Tense and time-indexed DETs

- Event typed dependent on times, for example:
  - $Evt_{AT}(a,t)$: type of events whose agents are a and which occur at time t.
  - $Evt_{AT^2}(a,t_1,t_2)$: type of events whose agents are a and which occur during interval (t_1,t_2).
- A simple model of time
  - Time (a type)
  - $<$: Time → Time → **t**
  - Corresponding relation $\leq$ is a total order.

$$\frac{a : \mathbf{e} \quad t : Time}{Evt_{AT}(a,t) \ \ type} \qquad \frac{a : \mathbf{e} \quad t_1 : Time \quad t_2 : Time}{Evt_{AT^2}(a,t_1,t_2) \ \ type}$$

- Intervals as predicates: $t \in (t_1,t_2)$ means $t_1 < t < t_2$.
  - Similarly for the other intervals $[t_1,t_2]$, $(t_1,t_2]$ and $[t_1,t_2)$.

DET-semantics of tensed sentences

- Let's assume
  - now : Time (standing for the speech time)
  - ref : Time (standing for the reference time)

Example	Event semantics with DETs
John is talking	$\exists e{:}Evt_{AT}(j, now).\ talk(e)$
John talked	$\exists t{:}Time.\ t < now \wedge \exists e{:}Evt_{AT}(j, t).\ talk(e)$
John will talk	$\exists t{:}Time.\ now < t \wedge \exists e{:}Evt_{AT}(j, t).\ talk(e)$
John had talked	$\exists t{:}Time.\ t < ref < now \wedge \exists e{:}Evt_{AT}(j, t).\ talk(e)$
John will have talked	$\exists t{:}Time.\ now < t < ref \wedge \exists e{:}Evt_{AT}(j, t).\ talk(e)$

Table 1: Simple examples in event semantics with DETs

Remarks

- Temporal logic?
  - Numerous work based on traditional logics such as propositional logic or FOL (Prior (1967), van Benthem 1991, …)
    - A workshop at this ESSLLI (focusing on non-linguistic issues)
  - Unclear how to study modal/temporal logics for MTTs (on-going, mainly model-theoretically; unclear at all proof-theoretically)
- How to relate events with time/tense?
  - Event → time (in set theory; Kamp 1979)
    - Question: how can one benefit from such connections?
  - In DETs, we only assume that events are dependent on their occurrence times, but that's all.
    - Is this appropriate? Otherwise, what …?

II.3.3. MTT-event sem. and selection restriction

- Events can similarly be introduced into MTT-semantics.
  - Original motivations (eg, better adverbial modification) still applies.
  - It also leads to problems such as EQP.
  - DETs can be introduced in MTT-semantics, solving EQP etc.

  Exactly similar as in the Montagovian setting – omitted here.

- MTT-event semantics: a brief description
  - Let T be any modern type theory such as UTT (Luo 1994) and E the basic coercions characterizing DET-subtyping.
  - Then, $T_e[E]$ extends T with DET-subtyping (next page; Luo 2023).

$T_e[E]$ (presentation in LF, here only for completeness)

- Constant types/families:
  - $Agent,\ Patient : Type.$
  - $Event : Type,$
    $Evt_A : (Agent)Type,$
    $Evt_P : (Patient)Type,$ and
    $Evt_{AP} : (Agent)(Patient)Type.$
- Coercive subtyping in E for DETs:

$$Evt_{AP}(a,p) \leq_{c_1[a,p]} Evt_A(a), \quad Evt_{AP}(a,p) \leq_{c_2[a,p]} Evt_P(p),$$
$$Evt_A(a) \leq_{c_3[a]} Event, \quad Evt_P(p) \leq_{c_4[p]} Event,$$

where $c_3[a] \circ c_1[a,p] = c_4[p] \circ c_2[a,p].$

- $T_e[E]$ has nice properties such as normalisation and consistency if T does (Luo, Soloviev & Xue 2012, Luo 2023).

Selection restriction in MTT-event semantics

- (#) Tables talk.
  - Montague: $\forall x{:}\mathbf{e}.talk(x)$ – well-typed but false ($talk : \mathbf{e}\rightarrow\mathbf{t}$)
  - MTT-sem: $\forall x{:}Table.talk(x)$ – ill-typed ($talk : Human\rightarrow Prop$)
- What happens when we have events? ($talk : Event\rightarrow\mathbf{t}/Prop$)
  - Montague: $\forall x{:}\mathbf{e}\ \exists v{:}Event.\ talk(v)\ \&\ agent(v)=x$ (well-typed)
  - MTT-sem: $\forall x{:}Table\ \exists v{:}Evt_A(x).\ talk(v)$

    where we have $Table \leq Agent$. (Also well-typed!)

So? How to recover?

  - There are several approaches (Luo 2018).
  - We'll introduce "DETs with domains", the most flexible one.

DETs with domains

- Refined DETs with "domains" (Consider subtypes of Agent, wlg.)
  - Let $D \leq_k$ Agent.
    - $Evt_A[D] : D \rightarrow Type$
    - $Evt_A[D](d) = Evt_A(k(d))$

$$\frac{\langle\rangle \vdash D \leq_\kappa Agent \quad \Gamma \vdash d : D}{\Gamma \vdash Evt_A[D](d) = Evt_A(\kappa(d))}$$

  - Note: this is only a definitional extension.
- Examples
  - Men talk.
    - $\forall x{:}Man\ \exists v{:}Evt_A[Human](x).\ talk(v)$ (OK because Man≤Human)
  - Tables talk.
    - (#) $\forall x{:}Table\ \exists v{:}Evt_A[Human](x).\ talk(v)$ (ill-typed - x is not a human.)
  - John picked up and mastered the book.
    - $\exists v{:}Evt_{AP}[Human,P\bullet I](j,b).\ pick\text{-}up(v)\ \&\ master(v)$, where $b : Book \leq P\bullet I$

Related (and some future) work on DETs

- Original idea
  - Came from my treatment of an example in (Asher & Luo 2012)
    - Evt(h) to represent collection of events conducted by h : Human.
  - Further prompted by de Groote's talk at LENLS14 (on EQP etc.)
- Other applications of DETs
  - For example, problem with negation in event semantics
- DETs dependent on other parameters
  - Dependency on other kinds of parameters than thematic roles?