Variable-free Meaning Representations

Johan.Bos@rug.nl

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Current Meaning Representations

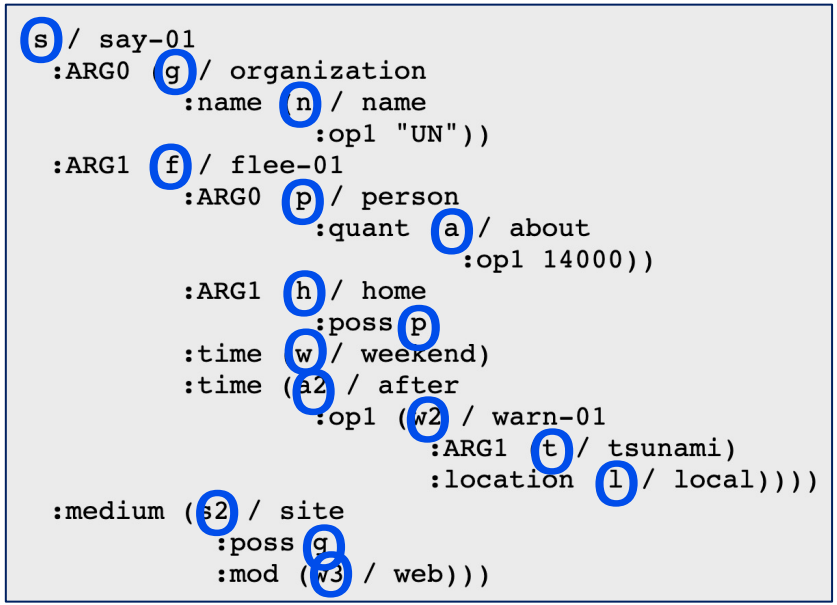
```
(s / say-01
  :ARG0 (g / organization
          :name (n / name
                   :op1 "UN"))
  :ARG1 (f / flee-01
          :ARG0 (p / person
                   :quant (a / about
                             :op1 14000))
          :ARG1 (h / home
                   :poss p)
          :time (w / weekend)
          :time (a2 / after
                   :op1 (w2 / warn-01
                            :ARG1 (t / tsunami)
                            :location (l / local))))
  :medium (s2 / site
            :poss g
            :mod (w3 / web)))
```

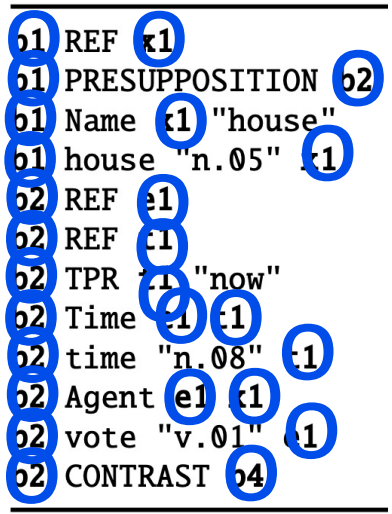
```
b1 REF x1
b1 PRESUPPOSITION b2
b1 Name x1 "house"
b1 house "n.05" x1
b2 REF e1
b2 REF t1
b2 TPR t1 "now"
b2 Time e1 t1
b2 time "n.08" t1
b2 Agent e1 x1
b2 vote "v.01" e1
b2 CONTRAST b4
```

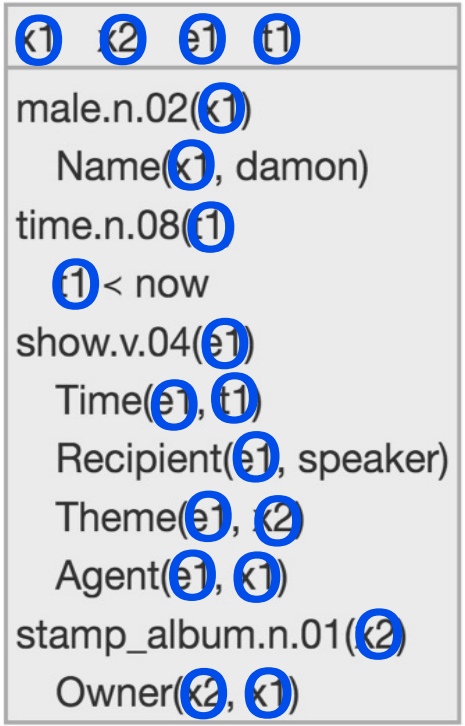
x1	x2	e1	t1

male.n.02(x1)
  Name(x1, damon)
time.n.08(t1)
  t1 < now
show.v.04(e1)
  Time(e1, t1)
  Recipient(e1, speaker)
  Theme(e1, x2)
  Agent(e1, x1)
stamp_album.n.01(x2)
  Owner(x2, x1)

Current Meaning Representations



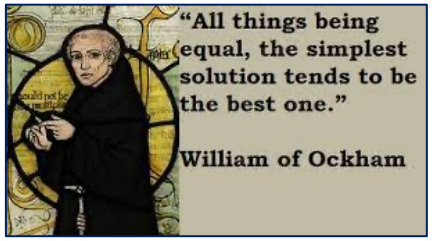




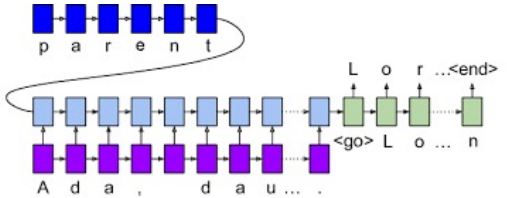
The point of this talk

- Nearly all meaning representations make use of **variables**
- But variables can also **problematic** for humans or for machines
- Can we replace current meaning representations with **variable-free** variants?(without losing expressive power)

Motivation



- Purely **theoretical**:
  simpler is better
- Practical (humans):
  simplify manual **annotation**
- Practical (machines):
  simplify input for **neural nets**



Semantic annotation (human)

- Two main approaches:
  - without syntactic analysis: AMR
  - with syntactic analysis:
    HPSG -> EDS, CCG -> PMB
- Which approach is better?
  - with syntax: systematic, but coverage problems
  - VP Ellipsis, pro-drop, one-anaphora, concord, comparatives, multi-word expressions, quotation, summation, lists, parenthesis

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- Which approach is better?
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DRS

- scope
- cumbersome for humans
- discourse
- overdose of variables

x e y
person(x) Name(x,”Tom”) see(e) Experiencer(e,x) Stimulus(e,y) mouse(y)

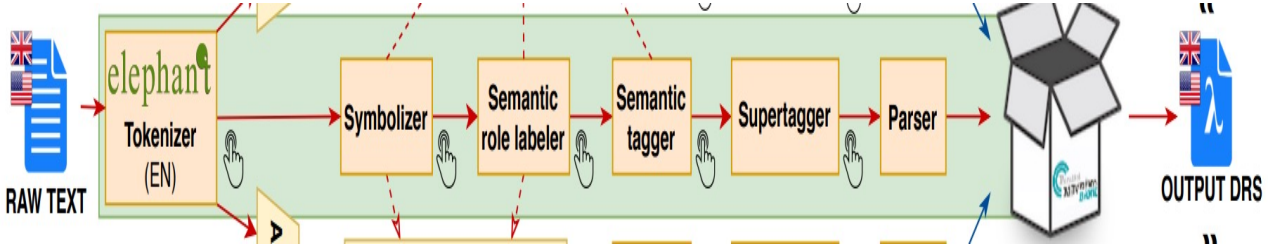
AMR

- compact
- no redundancies
- no scope
- alignment hard

```
(e / see
   :ARG0 (x / person
            :name “Tom”)
   :ARG1 (y / mouse))
```

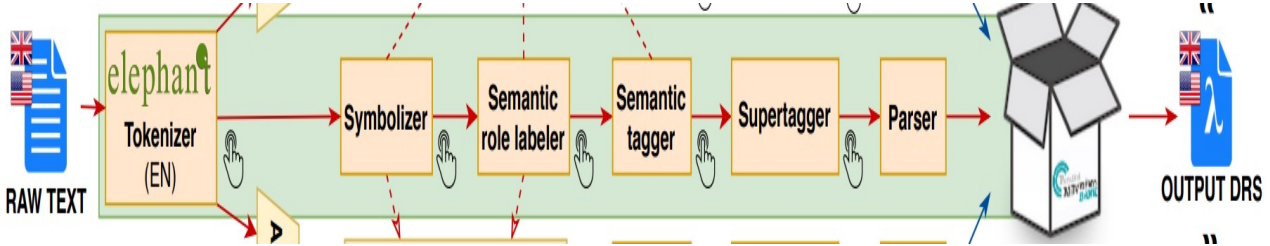
Semantic Parsing (Boxer)

Classic Boxer pipeline

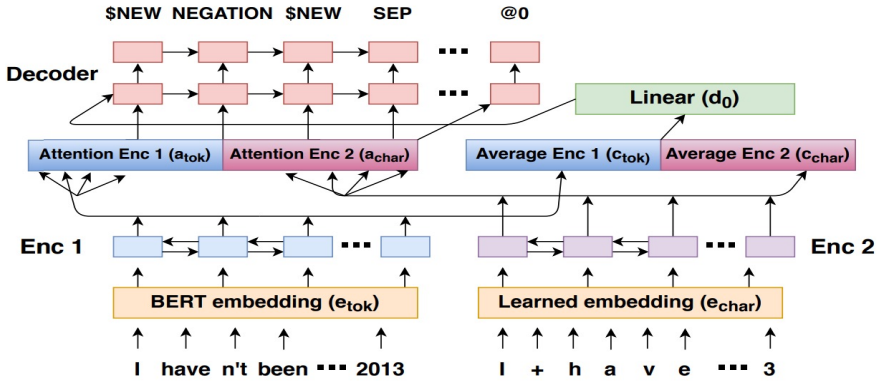


Semantic Parsing (Boxer)

Classic Boxer
pipeline



Neural Boxer
seq2seq

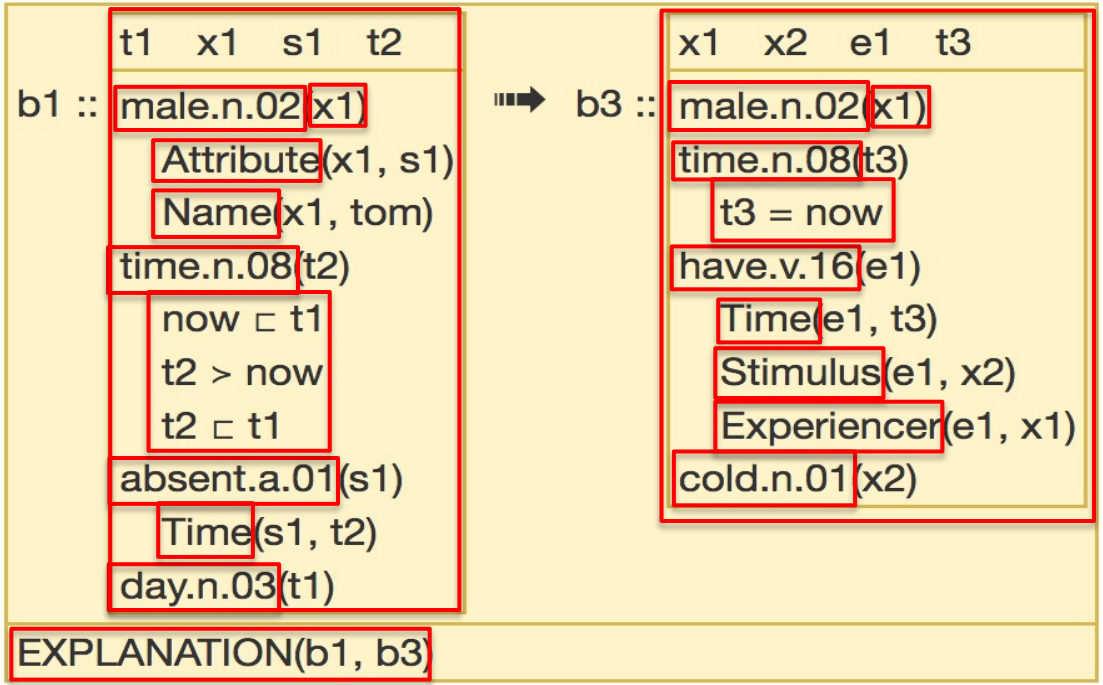


Plan of this talk

1. Focus on DRS (from PMB)
2. Simplify DRS (remove variables)
3. Present a new MR language (SBN)
4. Reflection
5. Side effects:
   annotation, information structure, graphs

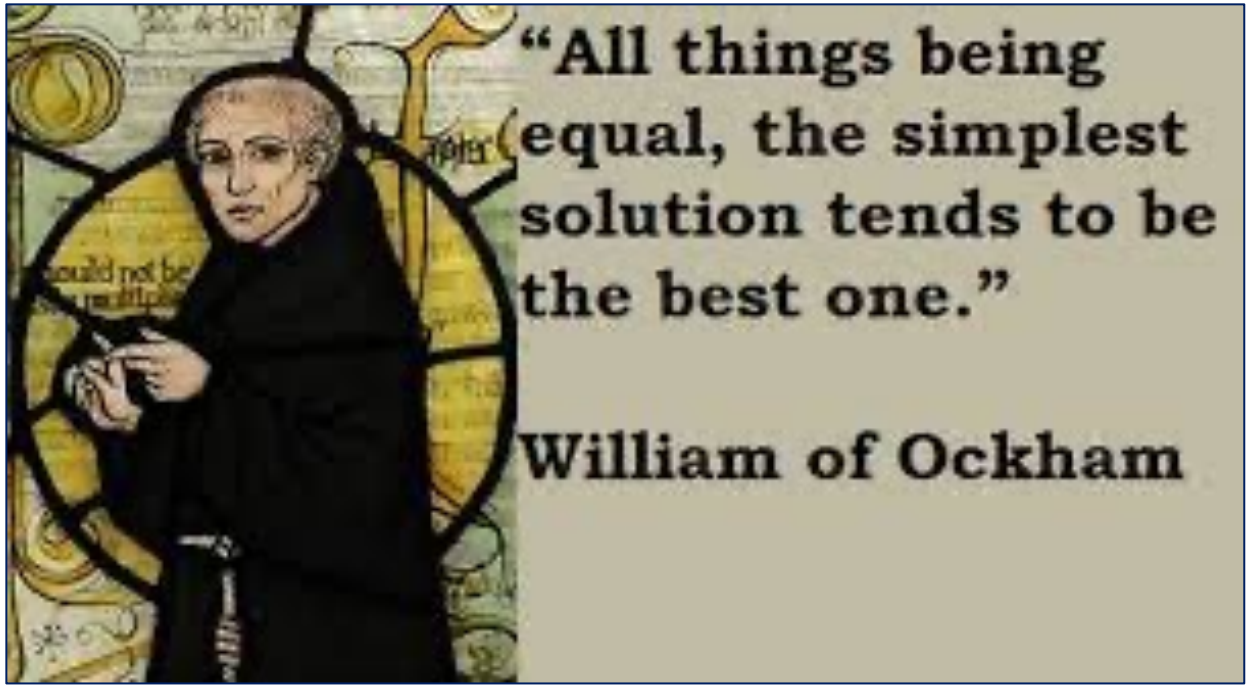
Holistic View

- word senses (WordNet)
- thematic roles (VerbNet)
- co-reference (DRT)
- tense (DRT)
- scope/negation (DRT)
- presupposition (PDRT)
- discourse relations (SDRT)

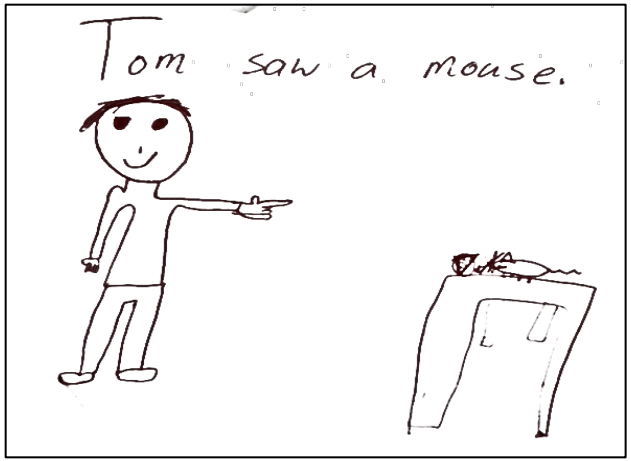


Tom will be absent today because he has a cold.

Simplifying DRS

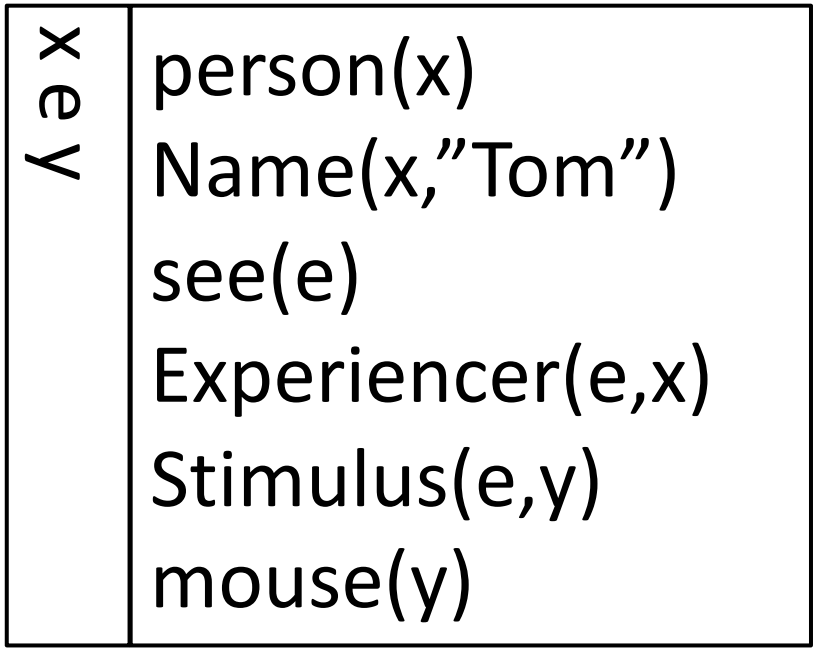


Tom saw a mouse.



x e y
person(x) Name(x,”Tom”) see(e) Experiencer(e,x) Stimulus(e,y) mouse(y)

Let's move the domain to the left...



… and do a bit of re-positioning …

x	person(x)
	Name(x,”Tom”)
e	see(e)
	Experiencer(e,x)
	Stimulus(e,y)
y	mouse(y)

Now look at these redundancies!

x	person(x)
	Name(x,”Tom”)
e	see(e)
	Experiencer(e,x)
	Stimulus(e,y)
y	mouse(y)

These are "conceptual" predicates!

x	person(x)
	Name(x,"Tom")
e	see(e)
	Experiencer(e,x)
	Stimulus(e,y)
y	mouse(y)

Assume that every ref is represented by exactly one concept, we can as well leave out the ref …

person(x)
Name(x,”Tom”)
see(e)
Experiencer(e,x)
Stimulus(e,y)
mouse(y)

Dual purpose of one-place predicates: (1) introduce a referent, (2) introduce concept (ISA)

person(x)
  Name(x,"Tom")
see(e)
  Experiencer(e,x)
  Stimulus(e,y)
mouse(y)

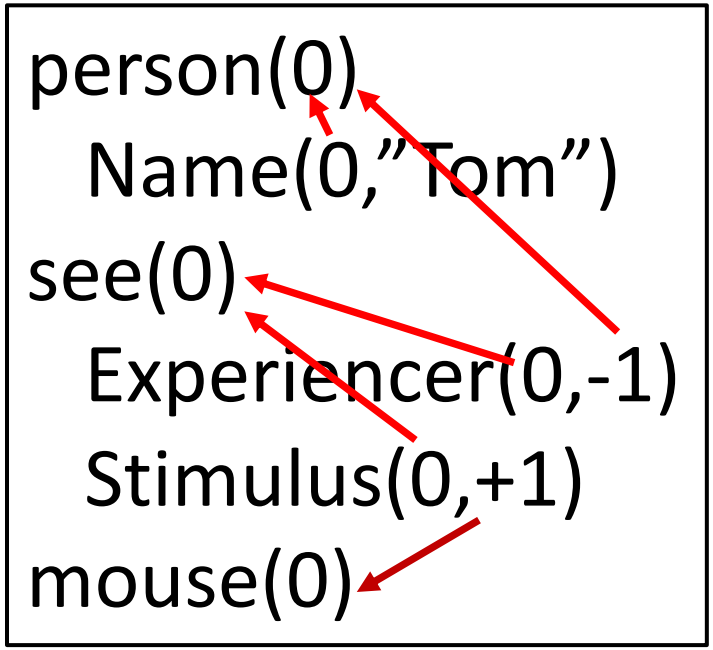
Roles

person(x)
  Name(x,”Tom”)
see(e)
  Experiencer(e,x)
  Stimulus(e,y)
mouse(y)

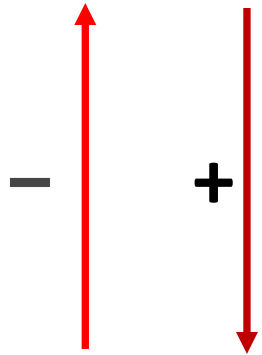
The roles can always be placed next to their "player"

person(x)
  Name(x,"Tom")
see(e)
  Experiencer(e,x)
  Stimulus(e,y)
mouse(y)

Represent variables by indices (de Bruijn)



0: current discourse referent
-1: previously introduced
+1: future discourse referent



Van Noord et al. (2018): *Exploring Neural Methods for Parsing Discourse Representation Structure*. TACL.

… drop the zeroes …

person
  Name(”Tom”)
see
  Experiencer(-1)
  Stimulus(+1)
mouse

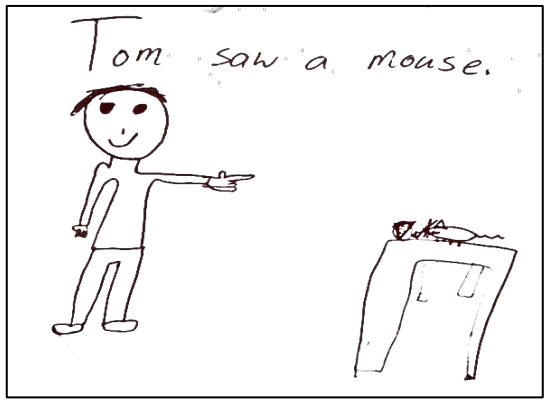
… drop the brackets …

person
  Name ”Tom”
see
  Experiencer -1
  Stimulus +1
mouse

… and drop the box!

person
  Name ”Tom”
see
  Experiencer -1
  Stimulus +1
mouse

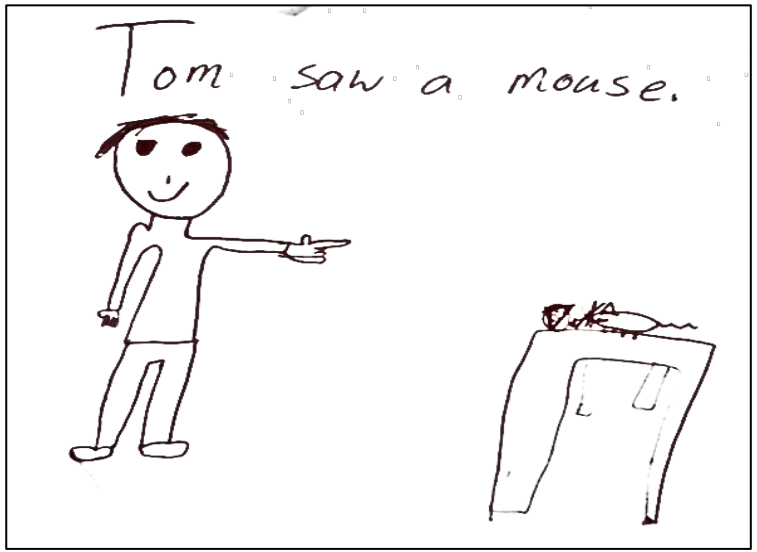
SBN (Simplified Box Notation)



person
  Name ”Tom”
see
  Experiencer -1
  Stimulus +1
mouse

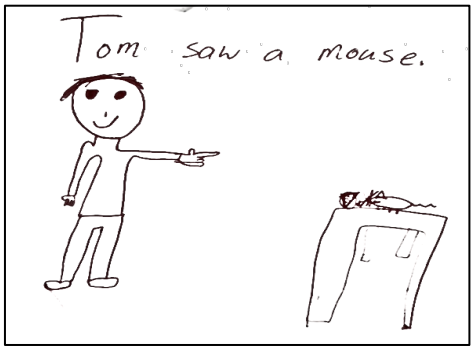
SBN (Sequential Box Notation)

person Name ”Tom” see Experiencer -1 Stimulus +1 mouse



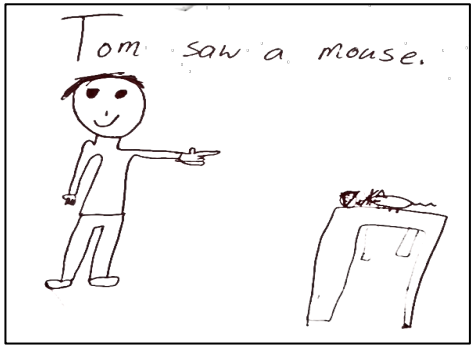
SBN (Sequential Box Notation)

```
person Name "Tom"
see Experiencer -1 Stimulus +1
mouse
```



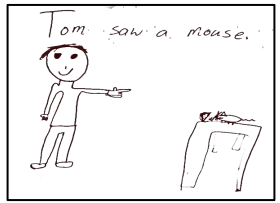
SBN (Sequential Box Notation)

```
person Name "Tom"                          % Tom
see Experiencer -1 Stimulus +1 % saw
mouse                                      % a mouse.
```



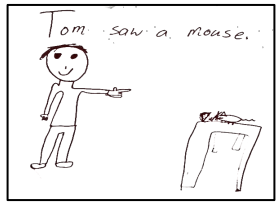
SBN (Sequential Box Notation)

```
person                                  % Tom
     Name "Tom"
see                                     % saw
     Experiencer -1
     Stimulus +1
mouse                                   % a mouse.
```



SBN (Sequential Box Notation)

```
person.n.01                          % Tom
     Name "Tom"
see.v.01                             % saw
     Experiencer -1
     Stimulus +1
mouse.n.01                           % a mouse.
```



The SBN System

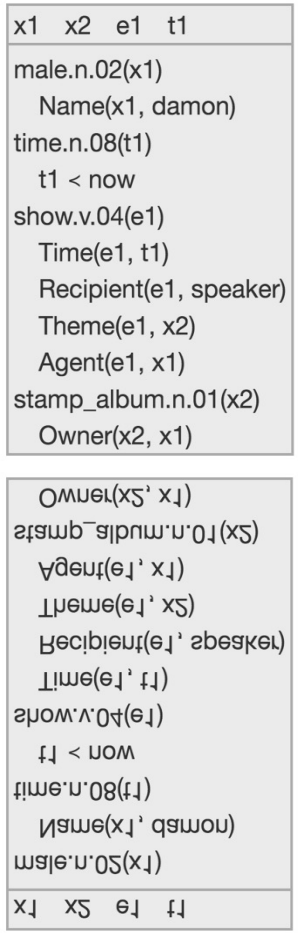
- A set of **concepts** (cat.n.01, see.v.03, …)
- A set of **roles** (Agent, Theme, Experiencer, …)
- A set of negative and positive **indices** (…, -2, -1, +1, …)
- A set of **constants** (“Mary”, speaker, 20, …)
- A set of **separators** (NEG, AND, …)
- A set of **connectors** (… ,<2, <1, >1, …)

Related Work

- De Bruijn 1972 (lambda calculus)
- Kaplan & Bresnan 1981 (LFG)
- Jacobson 1999
- Van Eijck 2001 (DRT)
- Oepen and Lønning 2006 (EDS)
- Dekker 2016 (DRT)
- Van Noord et al. 2018 (DRS parsing)

A moment of reflection

- comparison with DRS & AMR
- discourse structure & modularity
- negation & disjunction
- alignment & role inversion



DRS

- scope
- cumbersome for humans
- discourse
- overdose of variables

x e y
person(x) Name(x,”Tom”) see(e) Experiencer(e,x) Stimulus(e,y) mouse(y)

SBN

- compact
- no redundancies
- scope
- discourse
- no variables
- alignment

```
person
    Name “Tom”      % Tom
see                 % saw
    Experiencer -1
    Simulus +1
mouse               %  a mouse.
```

AMR

- compact
- no redundancies
- no scope
- alignment hard

```
(e / see
   :Experiencer (x / person
                   :Name “Tom”)
   :Stimulus (y / mouse))
```

SBN with discourse structure

DRS -1

```
person.n.01     Name “John”       % John
buy.v.01        Agent -1          % bought
                Beneficiary +1    %
                Theme +2          %
person.n.01     Name “Mary”       % Mary
sandwich.n.01                     % a sandwich.
                NARRATION(-1,0)   %
```

DRS 0

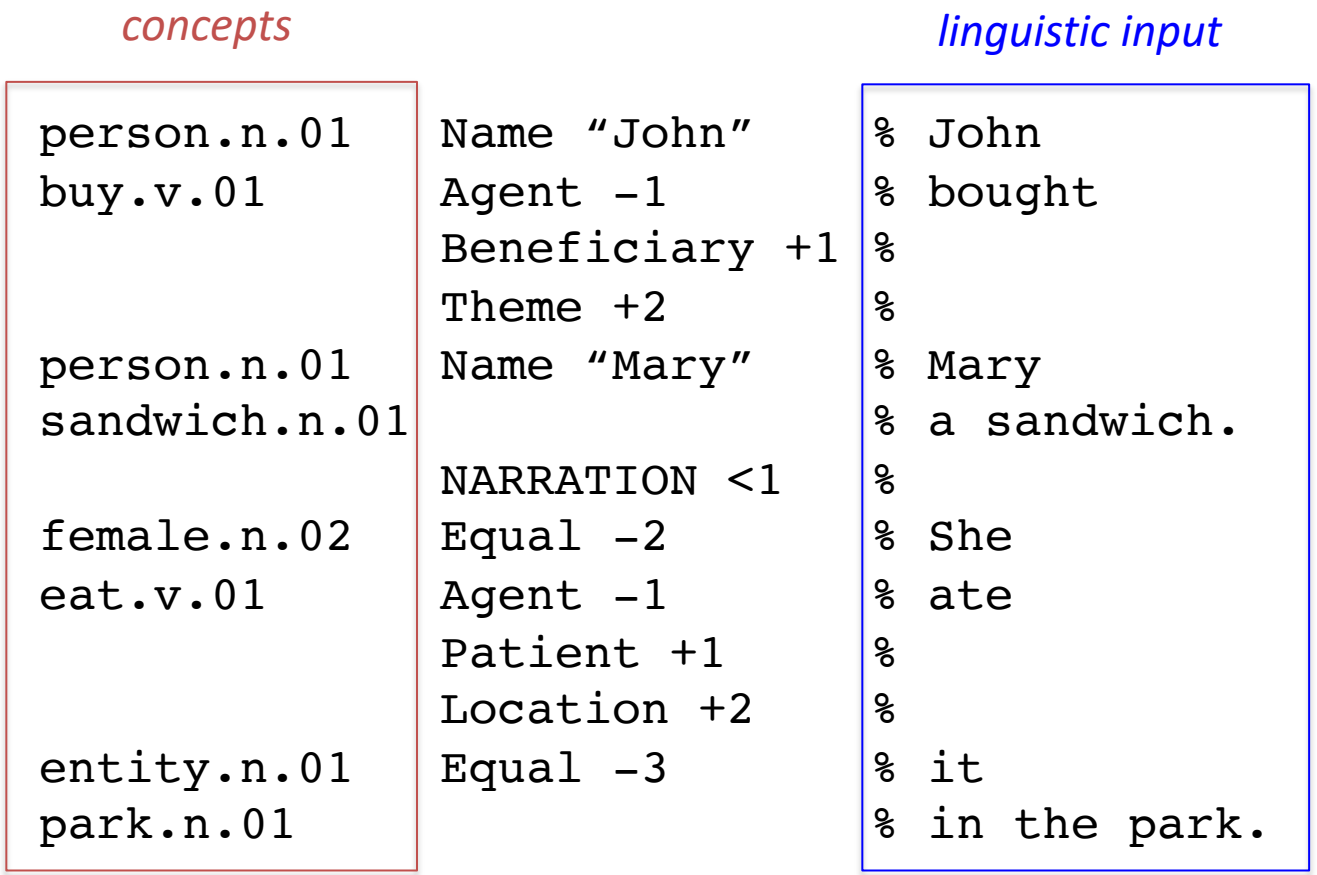
```
female.n.02     Equal -2          % She
eat.v.01        Agent -1          % ate
                Patient +1        %
                Location +2       %
entity.n.01     Equal -3          % it
park.n.01                         % in the park.
```

SBN with discourse structure

```
person.n.01    Name “John”      % John
buy.v.01       Agent -1         % bought
               Beneficiary +1   %
               Theme +2         %
person.n.01    Name “Mary”      % Mary
sandwich.n.01                   % a sandwich.
               NARRATION <1     %
female.n.02    Equal -2         % She
eat.v.01       Agent -1         % ate
               Patient +1       %
               Location +2      %
entity.n.01    Equal -3         % it
park.n.01                       % in the park.
```

linguistic input

```
person.n.01    Name “John”       % John
buy.v.01       Agent -1          % bought
               Beneficiary +1    %
               Theme +2          %
person.n.01    Name “Mary”       % Mary
sandwich.n.01                    % a sandwich.
               NARRATION <1      %
female.n.02    Equal -2          % She
eat.v.01       Agent -1          % ate
               Patient +1        %
               Location +2       %
entity.n.01    Equal -3          % it
park.n.01                        % in the park.
```


concepts
linguistic input
person.n.01
buy.v.01
person.n.01
sandwich.n.01
female.n.02
eat.v.01
entity.n.01
park.n.01
Name “John”
Agent -1
Beneficiary +1
Theme +2
Name “Mary”
NARRATION <1
Equal -2
Agent -1
Patient +1
Location +2
Equal -3
% John
% bought
%
%
% Mary
% a sandwich.
%
% She
% ate
%
%
% it
% in the park.

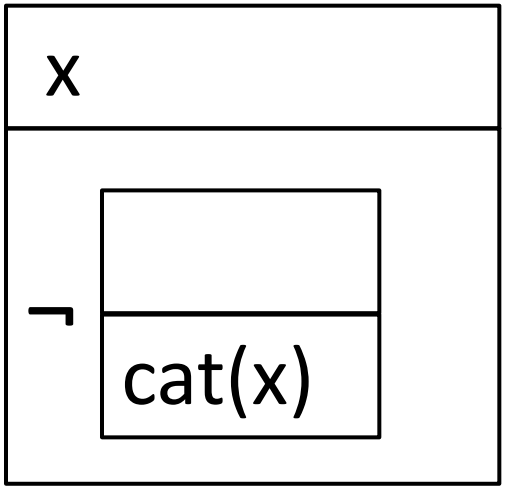
concepts	*relations*	*linguistic input*
person.n.01	Name “John”	% John
buy.v.01	Agent -1	% bought
	Beneficiary +1	%
	Theme +2	%
person.n.01	Name “Mary”	% Mary
sandwich.n.01		% a sandwich.
	NARRATION <1	%
female.n.02	Equal -2	% She
eat.v.01	Agent -1	% ate
	Patient +1	%
	Location +2	%
entity.n.01	Equal -3	% it
park.n.01		% in the park.

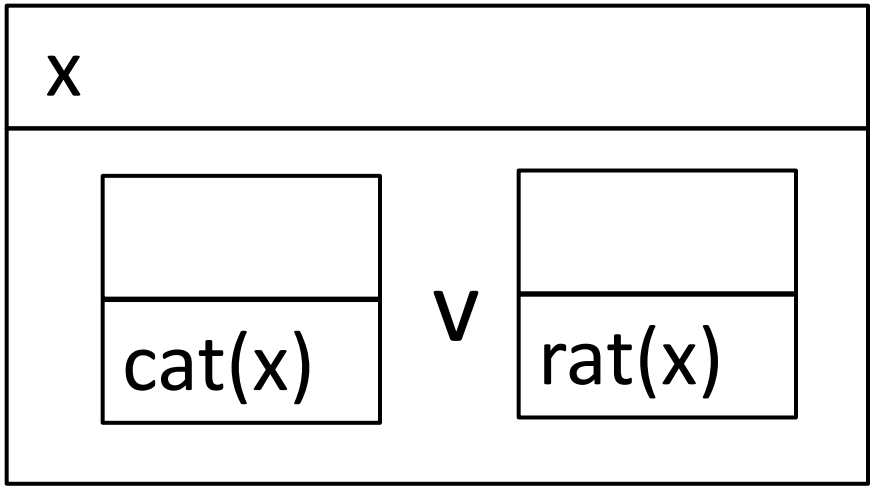
discourse structure

linguistic input

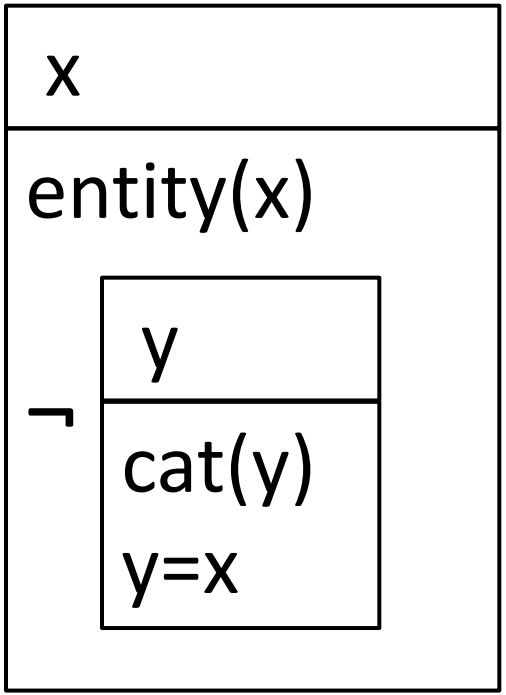
```
person.n.01     Name “John”          % John
buy.v.01        Agent -1             % bought
                Beneficiary +1       %
                Theme +2             %
person.n.01     Name “Mary”          % Mary
sandwich.n.01                        % a sandwich.
                NARRATION <1         %
female.n.02     Equal -2             % She
eat.v.01        Agent -1             % ate
                Patient +1           %
                Location +2          %
entity.n.01     Equal -3             % it
park.n.01                            % in the park.
```

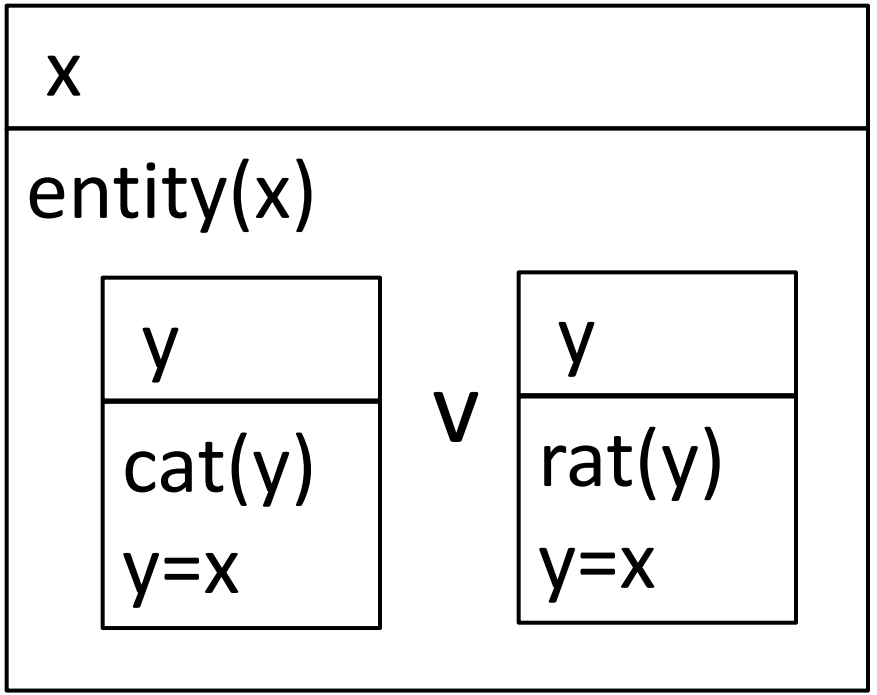
Negation & Disjunction



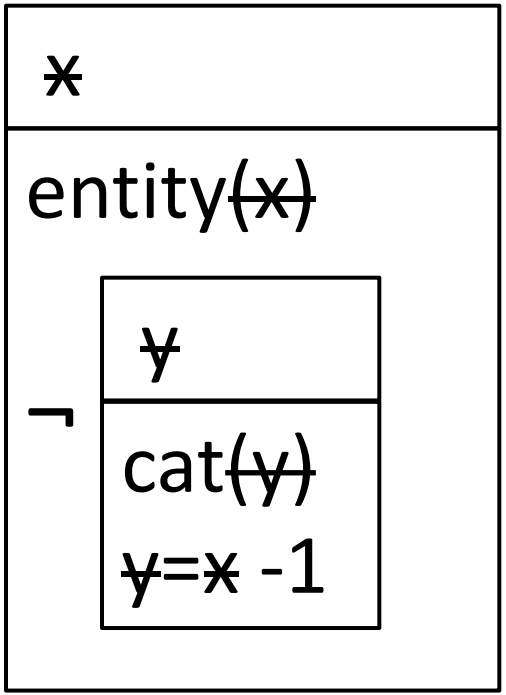


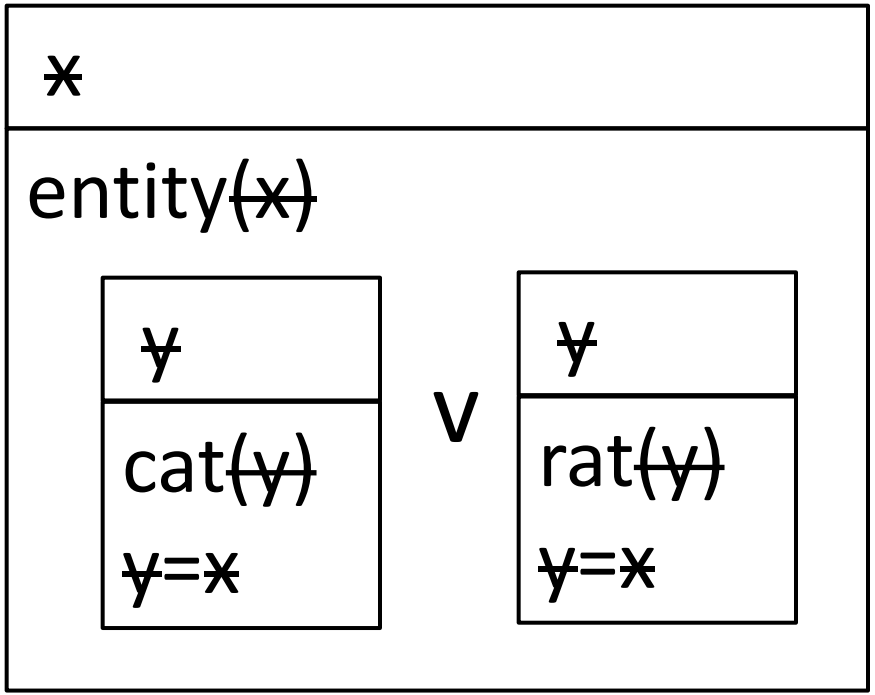
Negation & Disjunction



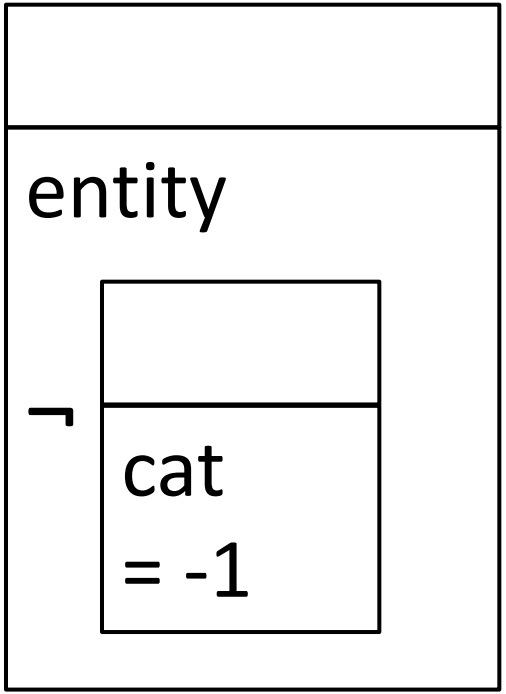


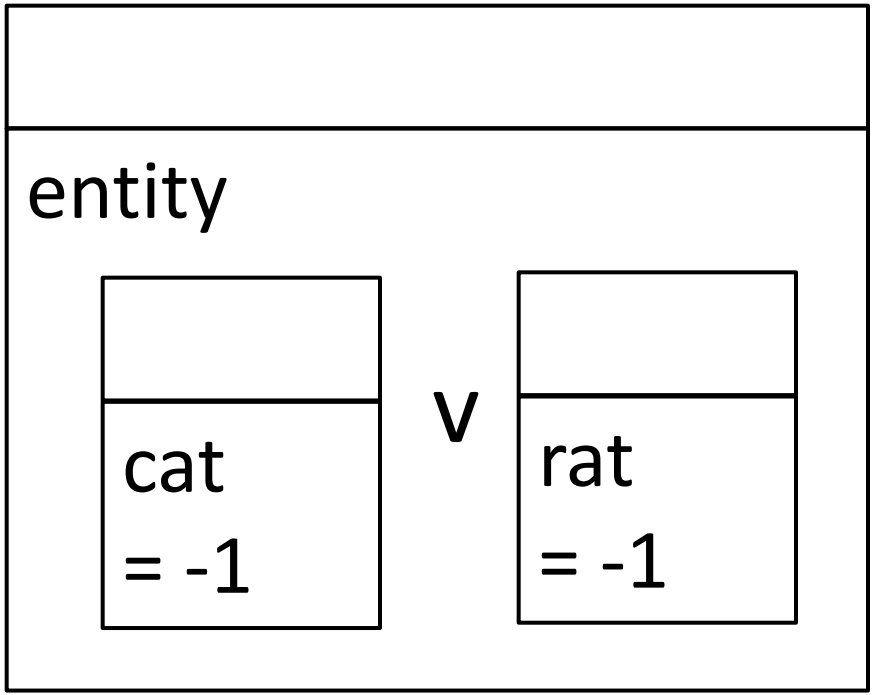
Negation & Disjunction



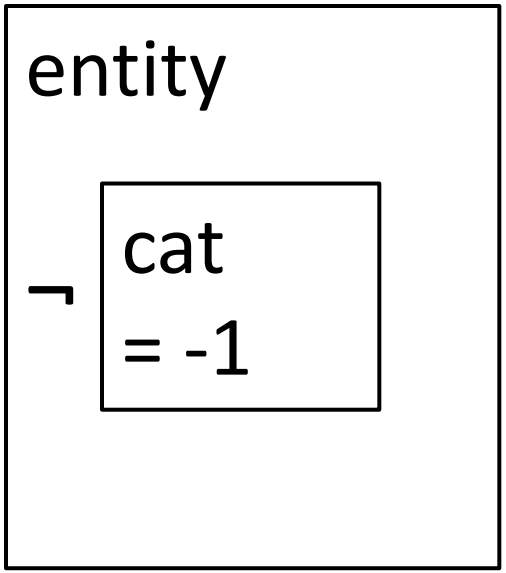


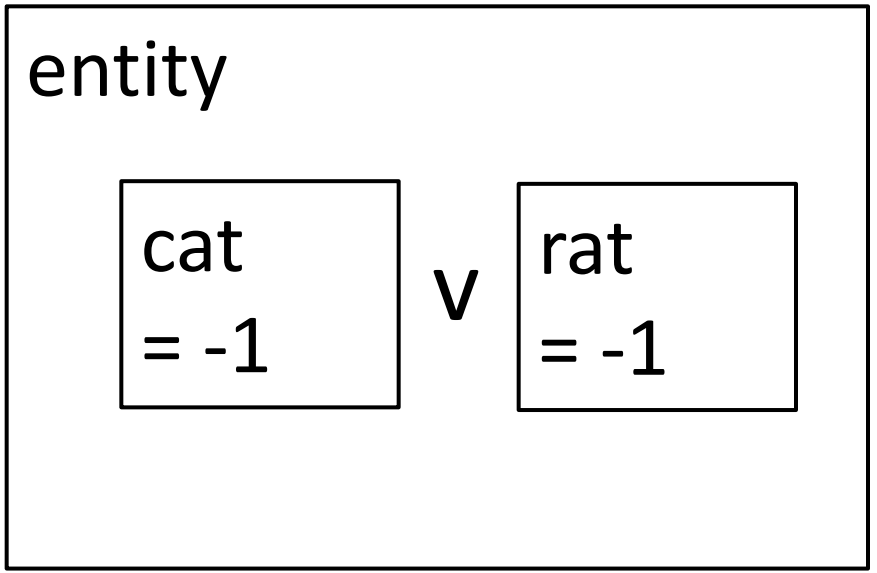
Negation & Disjunction



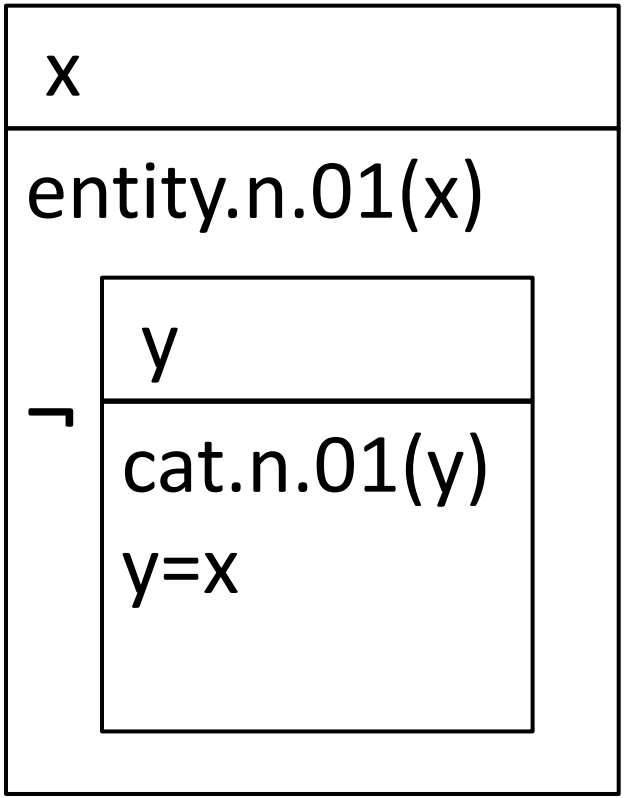


Negation & Disjunction



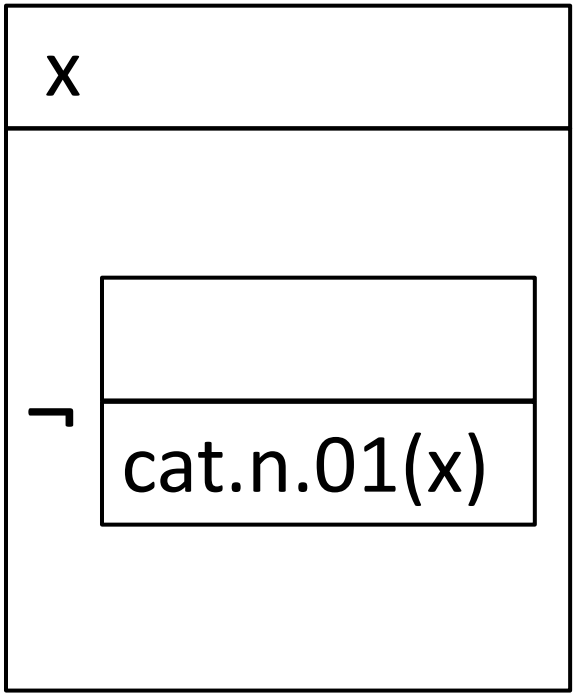


Negation




```
                entity.n.01      % Not
NOT <1 cat.n.01 = -1             % a cat
```

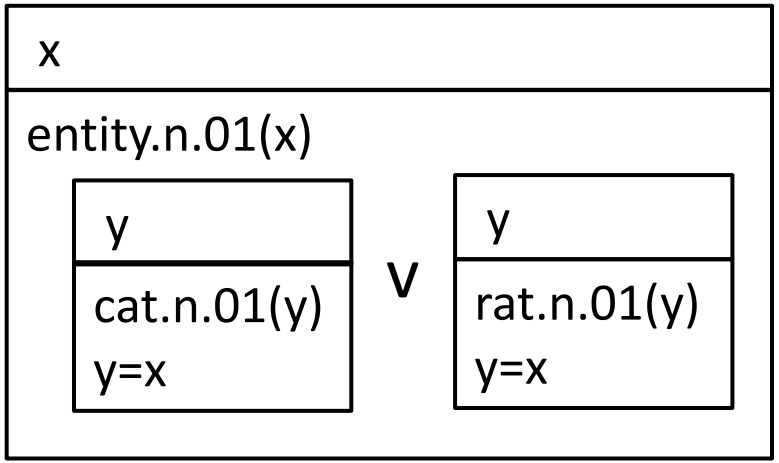
Negation




```
                entity.n.01      % Not
NOT <1          cat.n.01 = -1    % a cat
```

Disjunction

```
        entity.n.01
NOT <1
NOT <1 cat.n.01 = -1
NOT <2 rat.n.01 = -1
```

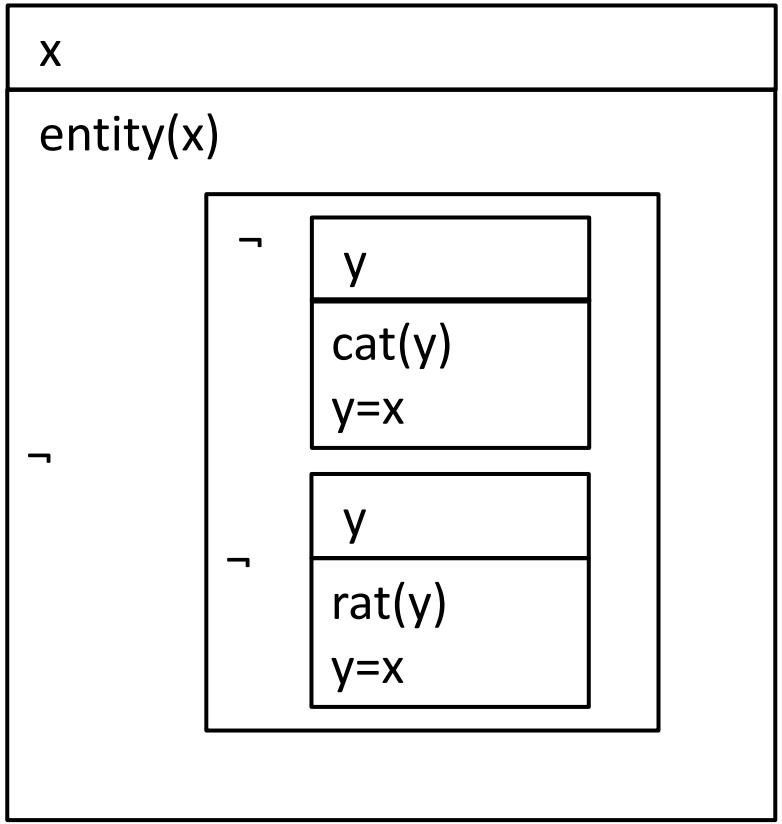


$(p \vee q) \leftrightarrow \neg(\neg p \,\&\, \neg q)$

Disjunction

```
        entity.n.01
NOT <1
NOT <1 cat.n.01 = -1
NOT <2 rat.n.01 = -1
```

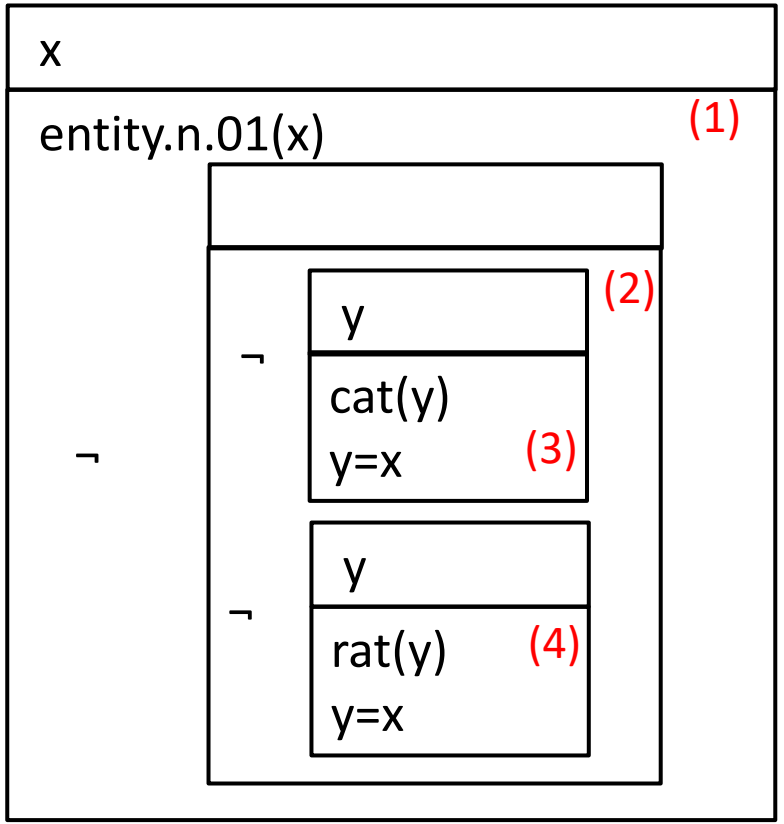
$(p \vee q) \leftrightarrow \neg(\neg p \,\&\, \neg q)$



Disjunction

```
        entity.n.01      (1)
NOT <1                   (2)
NOT <1  cat.n.01 = -1    (3)
NOT <2  rat.n.01 = -1    (4)
```

(p v q) <-> ¬(¬p & ¬q)



Alignment

To what extent can we align text with concepts, roles and separators?

SBN

```
person.n.01    Name “John”
buy.v.01       Agent -1
               Beneficiary +1
               Theme +2
person.n.01    Name “Mary”
sandwich.n.01
               NARRATION <1
female.n.02    Equal -2
eat.v.01       Agent -1
               Patient +1
               Location +2
entity.n.01    Equal -3
park.n.01
```

alignment

```
% John
% bought
%
%
% Mary
% a sandwich.
%
% She
% ate
%
%
% it
% in the park.
```

Role Inversion

$\forall R \forall x \forall y\ (R(x,y) \leftrightarrow R\mathrm{Of}(y,x))$

person.n.01
  Name ”Tom”
see.v.01
  Experiencer -1
  Stimulus +1
mouse.n.01

person.n.01
  Name ”Tom”
see.v.01
  Experiencer -1
mouse.n.01
  StimulusOf -1

Role Inversion

$\forall R \forall x \forall y\ (R(x,y) \leftrightarrow R\text{Of}(y,x))$

person.n.01
  Name ”Tom”
see.v.01
  Experiencer -1
  Stimulus +1
mouse.n.01

person.n.01
  Name ”Tom”
see.v.01
  Experiencer -1
mouse.n.01
  StimulusOf -1

person.n.01
  Name ”Tom”
  ExperiencerOf +1
see.v.01
mouse.n.01
  StimulusOf -1

Alignment

We can move roles, but they can not always be perfectly aligned! (without giving up 0-drop)

SBN

```
person.n.01     Name “John”
buy.v.01        Agent -1
                Beneficiary +1
                Theme +2
person.n.01     Name “Mary”
sandwich.n.01
                NARRATION <1
female.n.02     Equal -2
eat.v.01        Agent -1
                Patient +1
entity.n.01     Equal -3
park.n.01       LocationOf -2
```

alignment

```
% John
% bought
%
%
% Mary
% a sandwich.
%
% She
% ate
%
% it
% in the park.
```

Universal Quantification

```
NOT <1 person.n.01                  % Everyone
NOT <1 shout.v.01 Agent -1          % shouts.
```

$(p \Rightarrow q) \leftrightarrow \neg(p \,\&\, \neg q)$

Universal Quantification

```
NOT <1 person.n.01                  % Everyone
NOT <1 shout.v.01 Agent -1          % shouts.

       person.n.01 Name “Ann”       % Ann
NOT <1 person.n.01                  %
NOT <1 invite.v.01 Agent -2         % invited
                   Theme -1         % everyone.
```

$(p \Rightarrow q) \leftrightarrow \neg(p \,\&\, \neg q)$

Universal Quantification

```
NOT <1 person.n.01                  % Everyone
NOT <1 shout.v.01 Agent -1          % shouts.

       person.n.01 Name “Ann”       % Ann
NOT <1                              %
NOT <1 invite.v.01 Agent -1         % invited
                   Theme +1         %
AND <2 person.n.01                  % everyone.
```

$(p \Rightarrow q) \leftrightarrow \neg(p \,\&\, \neg q)$

Universal Quantification

```
NOT <1 company.n.01                          % A representative
NOT <1 representative.n.01 Of -1             % of every company
       visit.v.04 Agent -1 Theme +1          % visited
       person.n.01 Sub speaker               % us.
```

¬ ∃x (company(x) ∧ ¬ ∃y (representative(y,x) ∧ visited-us(y)))

Universal Quantification

```
NOT <1
NOT <1 representative.n.01 Of +1     % A representative
AND <2 company.n.01                  % of every company
AND <2 visit.v.04 Agent -1 Theme +1  % visited
       person.n.01 Sub speaker       % us.
```

¬ ([| ¬ ([y | representative(y,x)] + [| visited-us(y)])] + [x | company(x)])

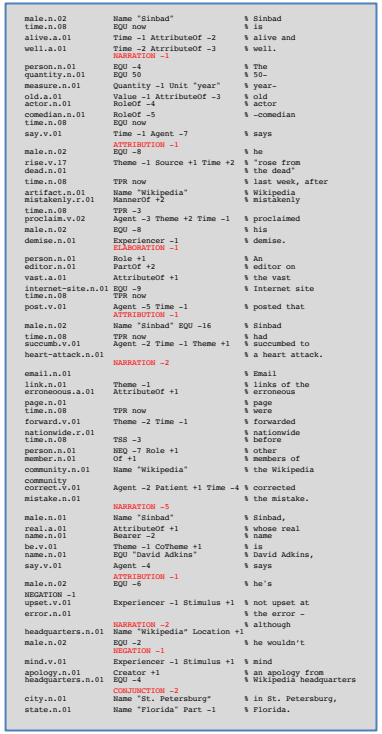
¬ [x| company(x) ¬ ([y | representative(y,x)] + [| visited-us(y)])]

¬ [x| company(x) ¬ [y | representative(y,x) visited-us(y)]]

Alignment in SBN

- Separators cannot be aligned (quantification)
- Roles can’t be perfectly aligned
  (without giving up 0-drop)
- Concepts seem to be able to align well
  with the text
  (disregarding discontinuous expressions)

Does SBN scale up?



```
male.n.02           Name "Sinbad"                 % Sinbad
time.n.08           EQU now                       % is
alive.a.01          Time -1 AttributeOf -2        % alive and
well.a.01           Time -2 AttributeOf -3        % well.
                    NARRATION -1

person.n.01         EQU -4                        % The
quantity.n.01       EQU 50                        % 50-
measure.n.01        Quantity -1 Unit "year"       % year-
old.a.01            Value -1 AttributeOf -3       % old
actor.n.01          RoleOf -4                     % actor
comedian.n.01       RoleOf -5                     % -comedian
time.n.08           EQU now
say.v.01            Time -1 Agent -7              % says
                    ATTRIBUTION -1
male.n.02           EQU -8                        % he
rise.v.17           Theme -1 Source +1 Time +2    % "rose from
dead.n.01                                         % the dead"
time.n.08           TPR now                       % last week, after
artifact.n.01       Name "Wikipedia"              % Wikipedia
mistakenly.r.01     MannerOf +2                   % mistakenly
time.n.08           TPR -3
proclaim.v.02       Agent -3 Theme +2 Time -1     % proclaimed
male.n.02           EQU -8                        % his
demise.n.01         Experiencer -1                % demise.
                    ELABORATION -1
person.n.01         Role +1                       % An
editor.n.01         PartOf +2                     % editor on
vast.a.01           AttributeOf +1                % the vast
internet-site.n.01  EQU -9                        % Internet site
time.n.08           TPR now
post.v.01           Agent -5 Time -1              % posted that
                    ATTRIBUTION -1
male.n.02           Name "Sinbad" EQU -16         % Sinbad
time.n.08           TPR now                       % had
succumb.v.01        Agent -2 Time -1 Theme +1     % succumbed to
heart-attack.n.01                                 % a heart attack.
                    NARRATION -2
email.n.01                                        % Email
link.n.01           Theme -1                      % links of the
erroneous.a.01      AttributeOf +1                % erroneous
page.n.01                                         % page
time.n.08           TPR now                       % were
forward.v.01        Theme -2 Time -1              % forwarded
nationwide.r.01                                   % nationwide
time.n.08           TSS -3                        % before
person.n.01         NEQ -7 Role +1                % other
member.n.01         Of +1                         % members of
community.n.01      Name "Wikipedia"              % the Wikipedia
community
correct.v.01        Agent -2 Patient +1 Time -4   % corrected
mistake.n.01                                      % the mistake.
                    NARRATION -5
male.n.01           Name "Sinbad"                 % Sinbad,
real.a.01           AttributeOf +1                % whose real
name.n.01           Bearer -2                     % name
be.v.01             Theme -1 CoTheme +1           % is
name.n.01           EQU "David Adkins"            % David Adkins,
say.v.01            Agent -4                      % says
                    ATTRIBUTION -1
male.n.02           EQU -6                        % he's
NEGATION -1
upset.v.01          Experiencer -1 Stimulus +1    % not upset at
error.n.01                                        % the error -
                    NARRATION -2                  % although
headquarters.n.01   Name "Wikipedia" Location +1
male.n.02           EQU -2                        % he wouldn't
                    NEGATION -1
mind.v.01           Experiencer -1 Stimulus +1    % mind
apology.n.01        Creator +1                    % an apology from
headquarters.n.01   EQU -4                        % Wikipedia headquarters
                    CONJUNCTION -2
city.n.01           Name "St. Petersburg"         % in St. Petersburg,
state.n.01          Name "Florida" Part -1        % Florida.
```

PMB 49/0501

Sinbad is alive and well. The 50-year-old actor-comedian says he "rose from the dead" last week, after Wikipedia mistakenly proclaimed his demise. An editor on the vast Internet site posted that Sinbad had succumbed to a heart attack. Email links of the erroneous page were forwarded nationwide before other members of the Wikipedia community corrected the mistake. Sinbad, whose real name is David Adkins, says he's not upset at the error - although he wouldn't mind an apology from Wikipedia headquarters in St. Petersburg, Florida.

```
male.n.02           Name "Sinbad"                % Sinbad
time.n.08           EQU now                      % is
alive.a.01          Time -1 AttributeOf -2       % alive and
well.a.01           Time -2 AtrributeOf -3       % well.
                    NARRATION -1
person.n.01         EQU -4                       % The
quantity.n.01       EQU 50                       % 50-
measure.n.01        Quantity -1 Unit "year"      % year-
old.a.01            Value -1 AttributeOf -3      % old
actor.n.01          RoleOf -4                    % actor
comedian.n.01       RoleOf -5                    % -comedian
time.n.08           EQU now
say.v.01            Time -1 Agent -7 Theme >1    % says
                    BOS
male.n.02           EQU -8                       % he
rise.v.17           Theme -1 Source +1 Time +2   % "rose from
dead.n.01                                        % the dead"
time.n.08           TPR now                      % last week, after
artifact.n.01       Name "Wikipedia"             % Wikipedia
mistakenly.r.01     MannerOf +2                  % mistakenly
time.n.08           TPR -3
proclaim.v.02       Agent -3 Theme +2 Time -1    % proclaimed
male.n.02           EQU -8                       % his
demise.n.01         Experiencer -1               % demise.
                    ELABORATION -1
person.n.01         Role +1                      % An
editor.n.01         PartOf +2                    % editor on
vast.a.01           AttributeOf +1               % the vast
internet~site.n.01  EQU -9                       % Internet site
time.n.08           TPR now
post.v.01           Agent -5 Time -1 Theme >1    % posted that
                    BOS
male.n.02           Name "Sinbad" EQU -16        % Sinbad
time.n.08           TPR now                      % had
succumb.v.01        Agent -2 Time -1 Theme +1    % succumbed to
heart~attack.n.01                                % a heart attack.
                    NARRATION -2
email.n.01                                       % Email
link.n.01           Theme -1                     % links of the
erroneoous.a.01     AttributeOf +1               % erroneous
page.n.01                                        % page
time.n.08           TPR now                      % were
forward.v.01        Theme -2 Time -1             % forwarded
nationwide.r.01                                  % nationwide
time.n.08           TSS -3                       % before
person.n.01         NEQ -7 Role +1               % other
member.n.01         Of +1                        % members of
community.n.01      Name "Wikipedia"             % the Wikipedia community
correct.v.01        Agent -2 Patient +1 Time -4  % corrected
mistake.n.01                                     % the mistake.
                    NARRATION -5
male.n.01           Name "Sinbad"                % Sinbad,
real.a.01           AttributeOf +1               % whose real
name.n.01           Bearer -2                    % name
be.v.01             Theme -1 CoTheme +1          % is
name.n.01           EQU "David Adkins"           % David Adkins,
say.v.01            Agent -4 Theme >1            % says
                    BOS
male.n.02           EQU -6                       % he's
                    NEGATION -1
upset.v.01          Experiencer -1 Stimulus +1   % not upset at
error.n.01                                       % the error -
                    NARRATION -2                 % although
headquarters.n.01   Name "Wikipedia" Location +1
male.n.02           EQU -2                       % he wouldn't
                    NEGATION -1
mind.v.01           Experiencer -1 Stimulus +1   % mind
apology.n.01        Creator +1                   % an apology from
headquarters.n.01   EQU -4                       % Wikipedia headquarters
                    CONJUNCTION -2
city.n.01           Name "St. Petersburg"        % in St. Petersburg,
state.n.01          Name "Florida" Part -1       % Florida.
```

A note about Information Structure

- The role of **order** is important in SBN
- This means that

  A dog chased a cat.

  and *A cat was chased by a dog*.

  get two different meaning representations!

  (syntactically, not semantically)

Visualisation

- Some examples that convert SBN into DRS and DRG
- All automatically produced

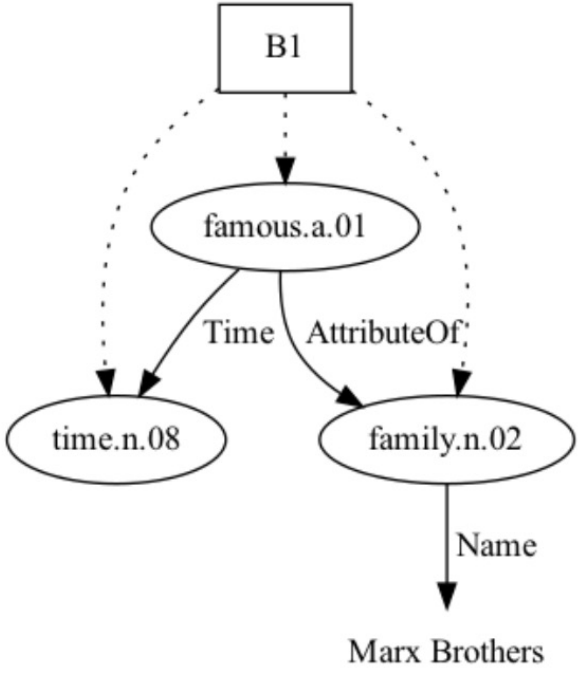
```
time.n.08                                %  Are
family.n.02   Name "Marx Brothers"       %  the Marx Brothers
famous.a.01   Time -2 AttributeOf -1     %  famous?
```

(a) SBN for q3

t1 x2 s3

time.n.08(t1)
family.n.02(x2)
  Name(x2, "Marx Brothers")
famous.a.01(s3)
  Time(s3, t1)
  AttributeOf(s3, x2)

(b) DRS for q3



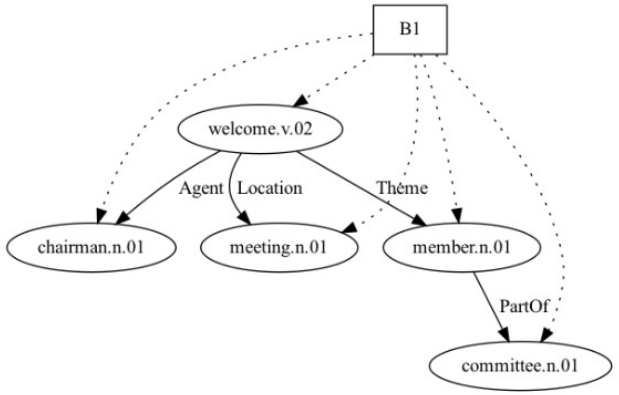
(c) DRG for q3

```
chairman.n.01                                  %  The chairman
welcome.v.02    Agent -1 Theme +2 Location +3  %  welcomed
committee.n.01                                 %  the committee
member.n.01     PartOf -1                      %  members
meeting.n.01                                   %  to the meeting.
```

(a) SBN for q2

x1 e2 x5 x3 x4
chairman.n.01(x1)
welcome.v.02(e2)
Agent(e2, x1)
Theme(e2, x3)
Location(e2, x4)
committee.n.01(x5)
member.n.01(x3)
PartOf(x3, x5)
meeting.n.01(x4)

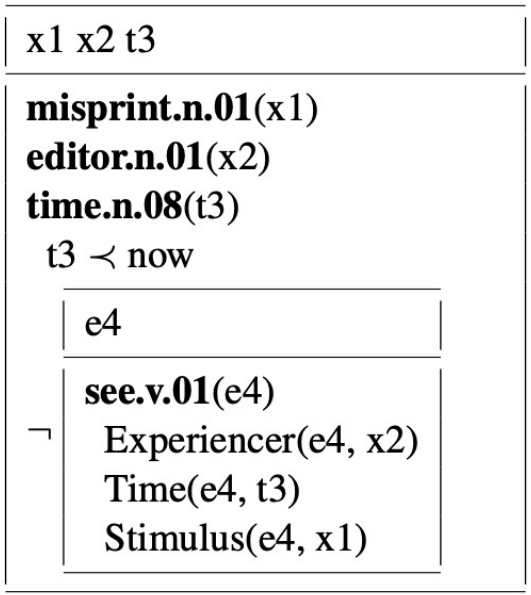
(b) DRS for q2



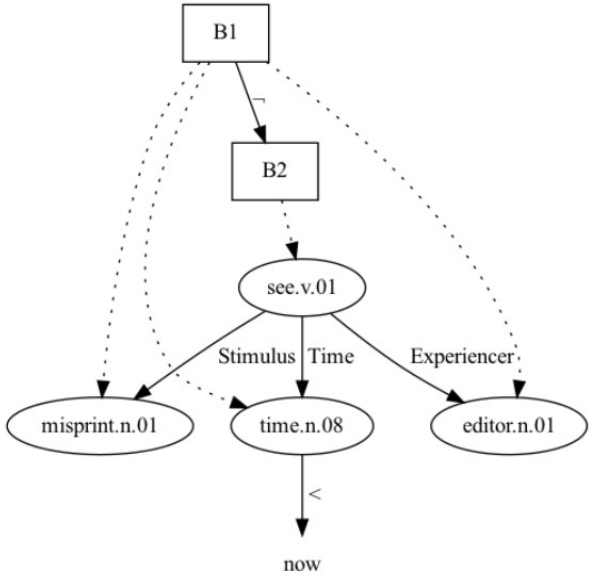
(c) DRG for q2

```
misprint.n.01                                  %
editor.n.01                                    %  The editors
time.n.08     TPR now                          %  did
              NEGATION -1                      %  n't
see.v.01      Experiencer -2 Time -1 Stimulus -3  %  see
```

(a) SBN for q1

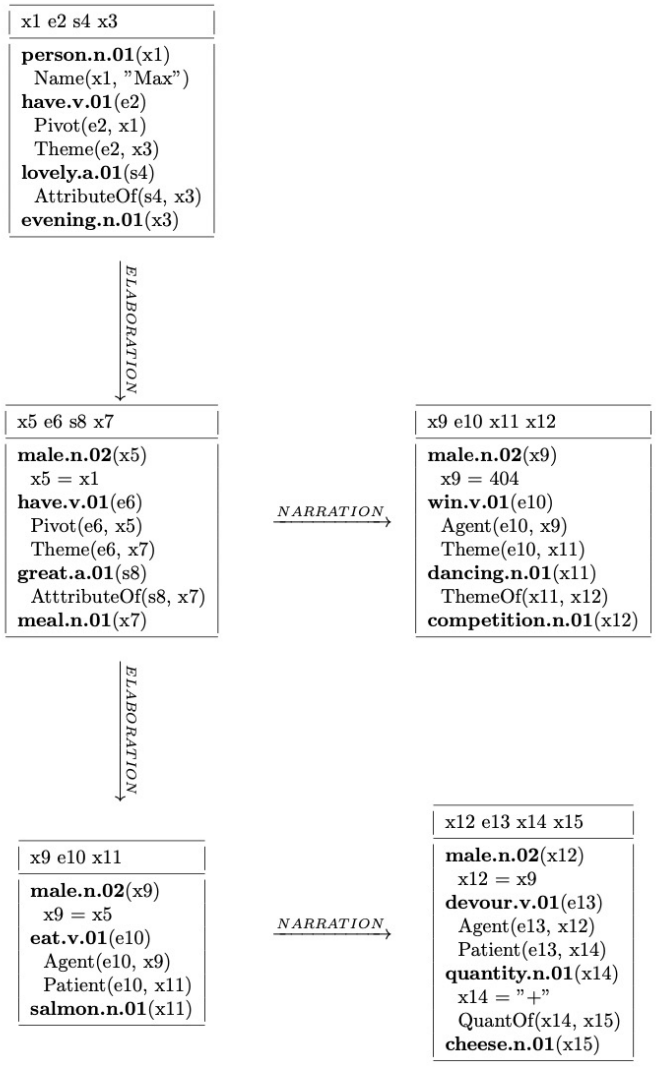


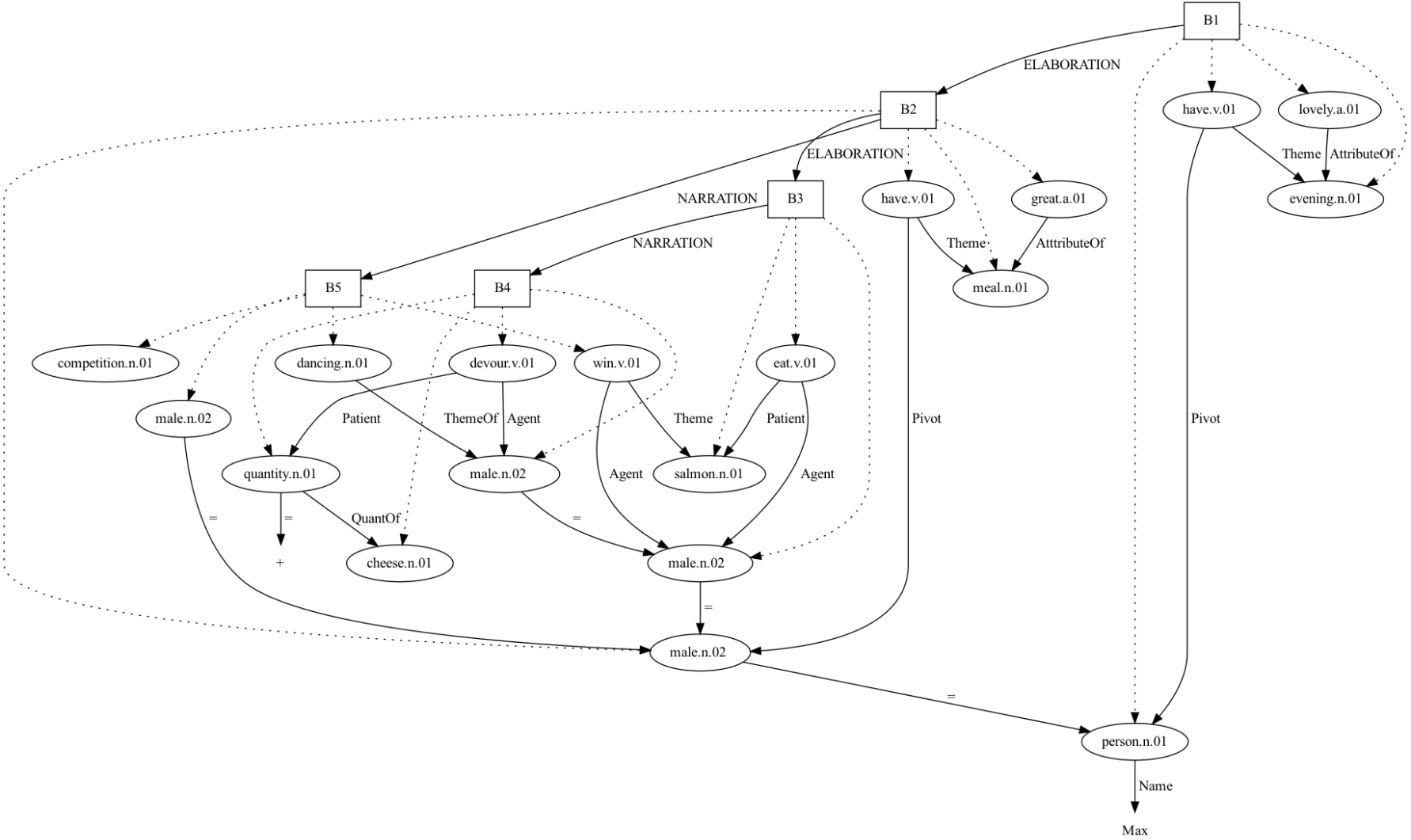
(b) DRS for q1



(c) DRG for q1

```
person.n.01 Name "Max"          % Max
have.v.01  Pivot -1 Theme +2    % had
lovely.a.01    AttributeOf +1   % a lovely
evening.n.01                    % evening.
            ELABORATION -1
male.n.02    EQU -4               % He
have.v.01    Pivot -1 Theme +2    % had
great.a.01   AtttributeOf +1      % a great
meal.n.01                        % meal.
            ELABORATION -1
male.n.02   EQU -4               % He
eat.v.01      Agent -1 Patient +1 % ate
salmon.n.01                      % salmon.
           NARRATION -1
male.n.02 EQU -3                   % He
devour.v.01    Agent -1 Patient +1 % devoured
quantity.n.01 EQU "+" QuantOf +1   % lots of
cheese.n.01                        % cheese.
           NARRATION -3
male.n.02 EQU -11              % He
win.v.01   Agent -1 Theme +1   % won
dancing.n.01 ThemeOf +1        % a dancing
competition.n.01               % competition.
```




B1
ELABORATION
B2
have.v.01
lovely.a.01
Theme
AttributeOf
evening.n.01
ELABORATION
NARRATION
B3
have.v.01
great.a.01
Theme
AtttributeOf
meal.n.01
NARRATION
B5
B4
competition.n.01
dancing.n.01
devour.v.01
win.v.01
eat.v.01
male.n.02
Patient
ThemeOf
Agent
Theme
Patient
Pivot
Pivot
quantity.n.01
male.n.02
Agent
salmon.n.01
Agent
=
=
QuantOf
=
+
cheese.n.01
male.n.02
=
male.n.02
=
person.n.01
Name
Max

Conclusions

- SBN **combines features** from DRS and AMR
- **No** explicit **variables** needed in meanings
- **Alignment** not perfect in SBN, but still **better** than in DRS or AMR
- SBN supports neat **graph** visualisation
- **Beneficial** for machines, perhaps for humans too
- Available in **PMB** release 4.0.0

References

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- Kaplan, R. & Bresnan (1981): Lexical-funcional grammar: A formal system for grammatical representation. Massachusetts Institute Of Technology, Center For Cognitive Science
- Jacobson, P. (1999): Towards a variable-free semantics. Linguistics & Philosophy 22(2): 117–184
- Van Eijck, J. (2001): Incremental dynamics. Journal of Logic, Language and Information 10: 319–351.
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- Dekker, P. (2016): Exclusively indexical deduction. Review of Symbolic Logic 9(3): 603–637.
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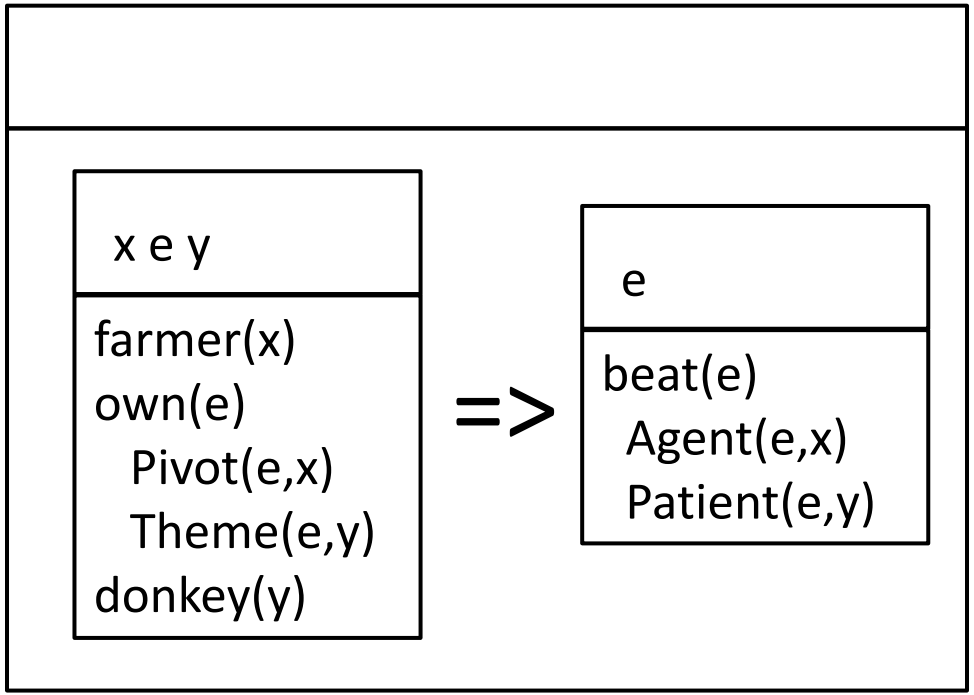
Donkey sentences

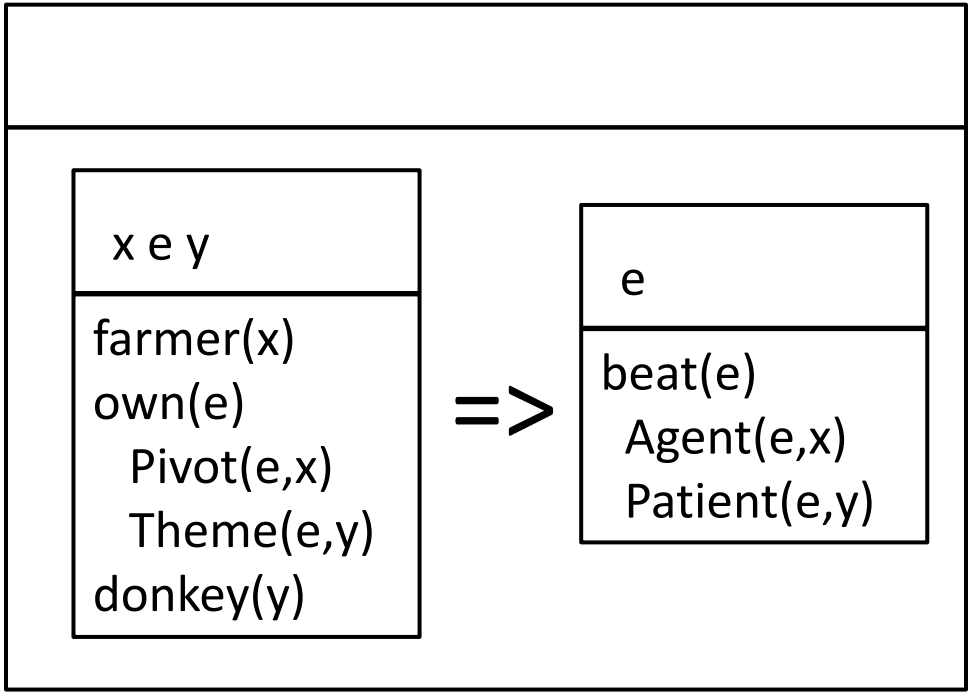
```
NOT <1          % Every
farmer          % farmer
own             % who owns
  Pivot -1      %
  Theme +1      %
donkey          % a donkey
NOT <1          %
beat            % beats
  Agent -3      %
  Patient -1    % it.
```

$(p \Rightarrow q) \leftrightarrow \neg(p \,\&\, \neg q)$



Donkey sentences

```
NOT <1          % Every
farmer          % farmer
  PivotOf +1    % who
own             % owns
  Theme +1      %
donkey          % a donkey
NOT <1          %
beat            % beats
  Agent -3      %
  Patient -1    % it.
```



```
male.n.02                % He
time.n.08 < now
like.v.03                % liked
   Time -1
   Experiencer -2
   Stimulus +1
female.n.02              % Ann
   Name "Ann"
   CONTRAST <1           % but then
person.n.01 Role +1
parent.n.01 Of +1        % his parents
male.n.02 = -6
time.n.08 < now          % did
   NEGATION <1           % n't.
like.v.03
   Time -1
   Experiencer -4
   Stimulus -5
```

Verb phrase ellipsis

```
measure.n.02
   Quantity +1           % The
   Unit +2
quantity.n.01 = 50       % fifty-
year.n.01                % year-
old.a.01                 % old
   Value -2
   AttributeOf +1
person.n.01
   Role +1 Role +2
actor.n.01               % actor-
comedian.n.01            % comedian
```

Hyphenated compounds

```
person.n.01 = speaker    % I
time.n.08 = now          % am
measure.n.02
   Quantity +1
   Unit +2
quantity.n.01 = 5        % five
feet.n.02                % feet
sum.n.02                 % ,
   Theme -3
   CoTheme +3
quantity.n.01 = 2        % two
inch.n.01                % inches
measure.n.02
   Unit -1
   Quantity -2
tall.a.01                % tall.
   Time -4
   Theme -5
   Value -3
```

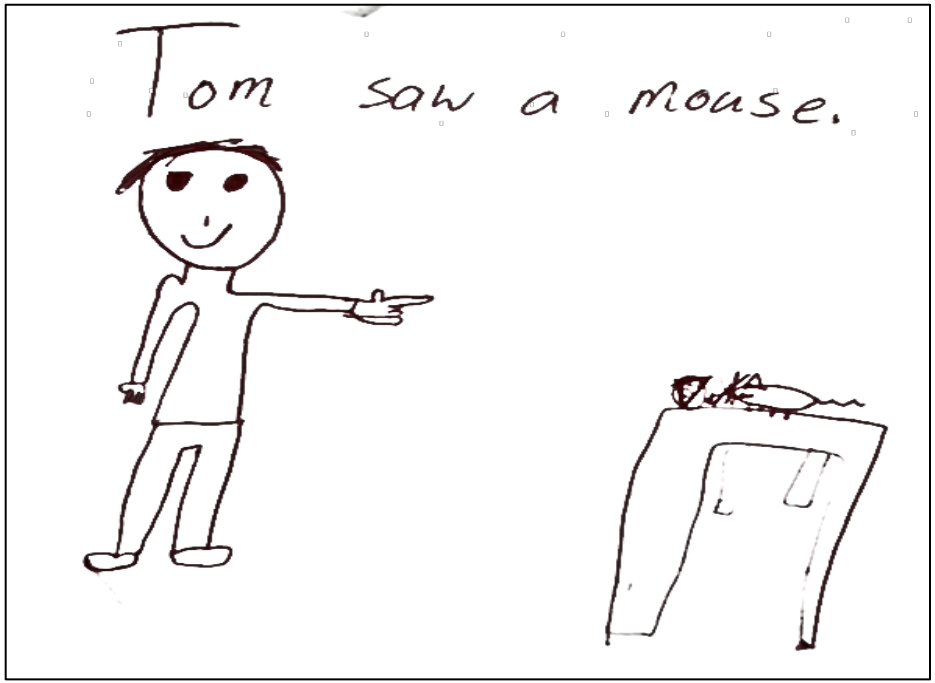
Complex measure phrases

```
time.n.08
hat.n.01          % The hat
cost.v.01         % costs
   Theme -1
   Time -2
   Degree +1
less.r.01         % less
   Theme -3
   CoTheme +1     % than
coat.n.01         % the coat.
```

Comparatives

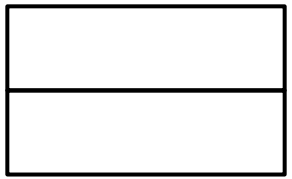
From SBN to DRS

```
person.n.01
    Name “Tom”      % Tom
time.n.08
    < now           % saw
see.v.01
    Time -1
    Experiencer -2
    Stimulus +1
mouse.n.01          % a mouse.
```



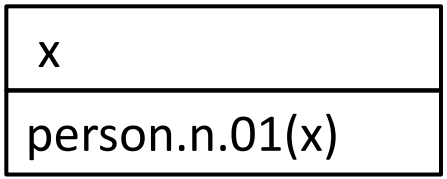
From SBN to DRS

person.n.01
    Name “Tom” % Tom
time.n.08
    < now % saw
see.v.01
    Time -1
    Experiencer -2
    Stimulus +1
mouse.n.01 % a mouse.



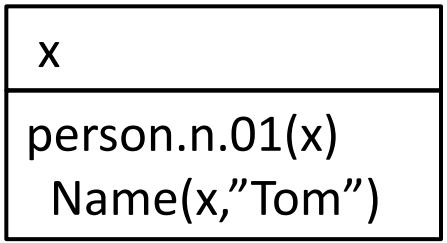
From SBN to DRS

```
person.n.01                          <= [0:x]
    Name “Tom”     % Tom
time.n.08
    < now          % saw
see.v.01
    Time -1
    Experiencer -2
    Stimulus +1
mouse.n.01         % a mouse.
```



From SBN to DRS

```
person.n.01                          <= [0:x]
    Name “Tom”     % Tom             <= [0:x]
time.n.08
    < now          % saw
see.v.01
    Time -1
    Experiencer -2
    Stimulus +1
mouse.n.01         % a mouse.
```



From SBN to DRS

```
person.n.01                          <= [0:x]
    Name “Tom”      % Tom            <= [0:x]
time.n.08                            <= [0:t,-1:x]
    < now           % saw
see.v.01
    Time -1
    Experiencer -2
    Stimulus +1
mouse.n.01          % a mouse.
```

x t
person.n.01(x) Name(x,”Tom”) time.n.08(t)

From SBN to DRS

```
person.n.01                          <= [0:x]
    Name “Tom”      % Tom            <= [0:x]
time.n.08                            <= [0:t,-1:x]
    < now           % saw             <= [0:t,-1:x]
see.v.01
    Time -1
    Experiencer -2
    Stimulus +1
mouse.n.01          % a mouse.
```

x t
person.n.01(x) Name(x,”Tom”) time.n.08(t) t < now

From SBN to DRS

```
person.n.01                          <= [0:x]
    Name “Tom”      % Tom            <= [0:x]
time.n.08                            <= [0:t,-1:x]
    < now           % saw             <= [0:t,-1:x]
see.v.01                             <= [0:e,-1:t,-2:x]
    Time -1
    Experiencer -2
    Stimulus +1
mouse.n.01          % a mouse.
```

x t e
person.n.01(x) Name(x,”Tom”) time.n.08(t) t < now see.v.01(e)

From SBN to DRS

```
person.n.01                          <= [0:x]
    Name “Tom”      % Tom            <= [0:x]
time.n.08                            <= [0:t,-1:x]
    < now           % saw             <= [0:t,-1:x]
see.v.01                             <= [0:e,-1:t,-2:x]
    Time -1                          <= [0:e,-1:t,-2:x]
    Experiencer -2
    Stimulus +1
mouse.n.01          % a mouse.
```

x t e
person.n.01(x) Name(x,”Tom”) time.n.08(t) t < now see.v.01(e) Time(e,t)

From SBN to DRS

```
person.n.01                          <= [0:x]
    Name “Tom”      % Tom            <= [0:x]
time.n.08                            <= [0:t,-1:x]
    < now           % saw             <= [0:t,-1:x]
see.v.01                            <= [0:e,-1:t,-2:x]
    Time -1                          <= [0:e,-1:t,-2:x]
    Experiencer -2                   <= [0:e,-1:t,-2:x]
    Stimulus +1
mouse.n.01          % a mouse.
```

x t e
person.n.01(x) Name(x,”Tom”) time.n.08(t) t < now see.v.01(e) Time(e,t) Experiencer(e,x)

From SBN to DRS

```
person.n.01                          <= [0:x]
    Name “Tom”      % Tom            <= [0:x]
time.n.08                            <= [0:t,-1:x]
    < now           % saw             <= [0:t,-1:x]
see.v.01                            <= [0:e,-1:t,-2:x]
    Time -1                          <= [0:e,-1:t,-2:x]
    Experiencer -2                   <= [0:e,-1:t,-2:x]
    Stimulus +1                      <= [+1:y,0:e,-1:t,-2:x]
mouse.n.01          % a mouse.
```

x t e
person.n.01(x) Name(x,”Tom”) time.n.08(t) t < now see.v.01(e) Time(e,t) Experiencer(e,x) Stimulus(e,y)

From SBN to DRS

```
person.n.01                          <= [0:x]
    Name “Tom”      % Tom            <= [0:x]
time.n.08                            <= [0:t,-1:x]
    < now           % saw             <= [0:t,-1:x]
see.v.01                            <= [0:e,-1:t,-2:x]
    Time -1                          <= [0:e,-1:t,-2:x]
    Experiencer -2                   <= [0:e,-1:t,-2:x]
    Stimulus +1                      <= [+1:y,0:e,-1:t,-2:x]
mouse.n.01          % a mouse. <= [0:y,-1:e,-2:t,-3:x]
```

x t e y
person.n.01(x) Name(x,”Tom”) time.n.08(t) t < now see.v.01(e) Time(e,t) Experiencer(e,x) Stimulus(e,y) mouse.n.01(y)

From SBN to DRS

```
person.n.01                          <= [0:x]
    Name “Tom”      % Tom            <= [0:x]
time.n.08                            <= [0:t,-1:x]
    < now           % saw             <= [0:t,-1:x]
see.v.01                            <= [0:e,-1:t,-2:x]
    Time -1                          <= [0:e,-1:t,-2:x]
    Experiencer -2                    <= [0:e,-1:t,-2:x]
    Stimulus +1                       <= [+1:y,0:e,-1:t,-2:x]
mouse.n.01          % a mouse.  <= [0:y,-1:e,-2:t,-3:x]
```

x t e y
person.n.01(x) Name(x,”Tom”) time.n.08(t) t < now see.v.01(e) Time(e,t) Experiencer(e,x) Stimulus(e,y) mouse.n.01(y)