TRUTH AND HPSG (PART 2)

Seminar on Comparative Introduction to Lexicalist Syntactic Theories
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contents

truth

- truth in HPSG
- strong and well-defined necessary condition
- succession of interim theses
  - intuitions concerning truth
  - finding fault
  - incremental improvement

goal: satisfactory thesis

- linguistic tokens as basis of truth
- SRL signature imposes P&S94 sort hierarchy structure on linguistic token

$\Rightarrow$ grammar is true of a natural language

$\Longleftrightarrow$

- it can be construed as system of linguistic tokens
- meeting conditions imposed upon them by signature

interim thesis 1

Interim Thesis 1: $\forall$ gammar $\Gamma = (\Sigma, \theta)$, $\forall$ natural language I
Γ is true of I
$\Rightarrow$ I is an interpretation of Σ

unfortunately:

- theory component does not play a role $\Rightarrow$ absurd
- thesis true, but by far not strong enough
- theory states linguistic principles
- must hold for truth
- obvious improvement: SRL grammar is true
  =only if$\Rightarrow$
  each description in the theory component
  is true in the natural language

interim thesis 2

Interim Thesis 2: $\forall$ gammar $\Gamma = (\Sigma, \theta)$, $\forall$ natural language I
Γ is true of I
$\Rightarrow$ I is an interpretation of Σ
$\quad\wedge$ I models θ in Σ

- stronger, but:
  - empty theory doesn't claim anything about the entities
  - should only be true of an empty natural language
  - each interpretation models empty theory
    $\Rightarrow$ IT2 may judge grammar with empty theory true for non-empty language

  $\Rightarrow$ still to weak:

- need relationship between

true grammar
$\Updownarrow$
entities *not* in the natural language

interim thesis 2 (cont)

- consider two languages $I' \uplus \{\text{window}\} = I, \Gamma = (\Sigma, \theta)$ a true grammar of I
- by IT2 $\Rightarrow$ I and I' are interpretations of Σ and model θ in Σ
- but
  - truth should say something about words not in I'
  - θ true of these linguistic tokens

  intuition: Γ should be false of I'
- idea: SRL grammar is true
  =only if$\Rightarrow$
  theory component of the grammar
  false of each entity not in the natual language

interim thesis 3

Interim Thesis 3: $\forall$ gammar $\Gamma = (\Sigma, \theta)$, $\forall$ natural language I
Γ is true of I
$\Rightarrow$ I is an interpretation of Σ
$\quad\wedge$ I models θ in Σ (1)
$\quad\wedge$ $\forall$ interpretation I' of Σ, $\forall \upsilon' \in I'$
$\qquad \upsilon' \in \Theta_{I'}(\theta) \Rightarrow \upsilon' \in I \qquad (2)$

problem:

- $\Gamma :=$ Grammar for English of HPSG94; $\upsilon :=$ "[Kim [[walks] Sandy Fido]]"
- $\upsilon' :=$ "[[walks] Sandy Fido]"
- each principle in P&S94 true of υ
- subcategorization principle not true of υ'

interim thesis 3 (cont)

- Assume IT3 is correct.
  Γ is true of English
  $\stackrel{\text{IT3(2)}}{\Longrightarrow} \upsilon \in \text{English} \wedge \upsilon' \notin \text{English}$
  $\stackrel{\text{IT3(1)}}{\Longrightarrow} \underbrace{\upsilon' \in \text{English} \wedge \upsilon' \notin \text{English}}_{\lightning}$

- Γ indeed false of English

- however: no false aspects of Γ used in proof
  $\Rightarrow$ by reduction ad absurdum, IT3 false (too strong)

interim thesis 3 (cont)

idea: grammar true of a natural language
$\Longleftrightarrow$
theory component false of *some constituent*
of each entity not in the natural language

- signature Σ
- interpretation I of Σ
- $C_I : U \to Pow(U)$,

$$\forall \upsilon \in I : C_I(\upsilon) = \{\upsilon' \in I \mid \exists \tau \in \mathsf{T}_\Sigma : T_I(\tau)(\upsilon) = \upsilon'\}$$

- υ': constituents of υ in I
- more general than traditional linguistic notion:
  first entity can be constituent regardless of either being a sign

interim thesis 4

Interim Thesis 4: $\forall$ gammar $\Gamma = (\Sigma, \theta)$, $\forall$ natural language I
Γ is true of I
$\Rightarrow$ I is an interpretation of Σ
$\quad\wedge$ I models θ in Σ
$\quad\wedge$ $\forall$ interpretation I' of $\Sigma, \forall \upsilon' \in I'$
$\qquad C_{I'}(\upsilon') \subseteq \Theta_{I'}(\theta) \Rightarrow \upsilon' \in I$

- sufficiently weaker: solves problem of absurdity
- but: consider $I_1 = (U_1, S_1, F_1)$, $I_2 = (U_2, S_2, F_2)$ of signature Σ
- entity υ has exactly same constituents in both
- for some $\tau \in \mathsf{T}_\Sigma$,
  $T_{I_1}(\tau)(\upsilon)$ defined, but $T_{I_2}(t)(\upsilon)$ undefined
  $\vee\ T_{I_1}(\tau)(\upsilon) \neq T_{I_2}(\tau)(\upsilon)$
  $\vee\ S_1(T_{I_1}(\tau)(\upsilon)) \neq S_2(T_{I_2}(\tau)(\upsilon))$

interim thesis 4 (cont)

Adam thought Bill had crashed his car

$\Downarrow$ $\Downarrow$

Adam's car Bill's car

- consider:
  - $I =$ english language
  - $\Gamma = (\Sigma, \theta)$ true SRL grammar of I

from IT4 $\Rightarrow$

- – I is an interpretation
  - θ is true of each entity in I,
  - θ is false of some constituent of each entity not in I
- consider $I' = I$, every instance with "Adam's car" changed to "Bill's car"
- intuitively: Γ false of I' since: I' has no instances of "Adam's car"

interim thesis 4 (cont)

- but: IT4 still satisfied for I', does not judge Γ false of I'

$\Rightarrow$ IT4 can fail to judge false grammar to be false of natural language

idea: grammar is true of a natural language
=only if$\Rightarrow$
theory component of the grammar
false of some constituent of each entity
with a constituent configuration in the natural language

formal: $\forall \Sigma =$ (S, F, A), $\forall$ interp. $I_1 = (U_1, S_1, F_1)$, $I_2 = (U_2, S_2, F_2)$ of Σ, $\forall \upsilon$
I_1 and I_2 *share* υ in Σ
$:\Longleftrightarrow$
$\upsilon \in U_1 \land \upsilon \in U_2$
$\land\ C_{I_1}(\upsilon) = C_{I_2}(\upsilon)$
$\land\ \forall \upsilon' \in C_{I_1}(\upsilon) : S_1(\upsilon') = S_2(\upsilon')$
$\land\ \forall \upsilon' \in C_{I_1}(\upsilon), \forall \varphi \in$ F :
$F_1(\varphi)(\upsilon')$ defined $\Leftrightarrow F_2(\varphi)(\upsilon')$ defined
$F_1(\varphi)(\upsilon') = F_2(\varphi)(\upsilon')$

interim thesis 5

Interim Thesis 5: $\forall$ gammar $\Gamma = (\Sigma, \theta)$, $\forall$ natural language I
Γ is true of I
$\Rightarrow$ I is an interpretation of Σ
$\wedge$ I models θ in Σ
$\wedge$ $\forall$ interpretation I' of Σ $\forall v' \in I'$
$C_{I'}(v') \subseteq \Theta_{I'}(\theta) \Rightarrow I$ and I' share v' in Σ

- but: simple shortcomings, easily overlooked

- natural language must be either:
  - empty
  - or proper class

  $\Rightarrow$ annoying, but can be tolerated

interim thesis 5 (cont)

- not toleratable however:
  - consider grammar true of a natural language under IT5
  - theory component true of each constituent of an entity in some interp.
    $\Rightarrow$ entity must also be in the natural language

  however:
  - nontrivial interpretation models a theory

    $\Rightarrow$

    one consisting of nonlinguistic (mathematical) entities also models theory

  so grammar of true language:
  - either empty
  - or contains nonlinguistic entities

- intuition for possible circumvention:
  grammar is true of natural language
  =only if$\Rightarrow$
  theory false of some constituent of each *linguistic* entity
  with a constituent configuration not in the natural language

interim thesis 6

Interim Thesis 6: $\forall$ gammar $\Gamma = (\Sigma, \theta), \forall$ natural language I
Γ is true of I
$\Rightarrow$ I is an interpretation of Σ
$\wedge$ I models θ in Σ
$\wedge$ $\forall$ interpretation I' of Σ, $\forall \upsilon' \in I'$, υ' linguistic
$C_{I'}(\upsilon') \subseteq \Theta_{I'}(\theta) \Rightarrow I$ and I' share υ' in Σ

- problem: fundamentally flawed

- no formal definition of the property to be linguistic for an entity
  $\Rightarrow$ IT6 not well-defined

- idea: possibly distinct entities in possibly distinct interpretations
  $\Updownarrow$
  'identical twins'

interim thesis 6 (cont)

- constituents of identical twins isomorphically configured within respective intepretations

- intuition: grammar is true of a natural language
  =only if⇒
  theory is false of some constituent of each entity
  without an identical twin in the natural language.

- $\forall \Sigma = (\mathsf{S}, \mathsf{F}, \mathsf{A})$, $\forall$ interp. $I_1 = (U_1, S_1, F_1)$, $I_2 = (U_2, S_2, F_2)$ of Σ, $\forall \upsilon_1, \upsilon_2$:
  (υ_1, I_1) and (υ_2, I_2) are congruent in Σ
  $:\Longleftrightarrow$
  $\upsilon_1 \in U_1 \wedge \upsilon_2 \in U_2$
  $\wedge\ \exists$ bijection $\kappa : C_{I_1}(\upsilon_1) \to C_{I_2}(\upsilon_2)$
  $\quad \wedge\ \kappa(\upsilon_1) = \upsilon_2$
  $\quad \wedge\ \forall \upsilon' \in C_{I_1}(\upsilon_1) : S_1(\upsilon') = S_2(\kappa(\upsilon'))$
  $\quad \wedge\ \forall \upsilon' \in C_{I_1}(\upsilon_1), \forall \varphi \in \mathsf{F}$:
  $\quad\quad F_1(\varphi)(\upsilon')$ defined $\Leftrightarrow F_2(\varphi)(\kappa(\upsilon'))$ defined
  $\quad\quad \kappa(F_1(\varphi)(\upsilon')) = F_2(\varphi)(\kappa(\upsilon'))$

thesis 1

Thesis 1: $\forall$ gammar $\Gamma = (\Sigma, \theta)$, $\forall$ natural language I
Γ is true of I
$\Rightarrow$ I is an interpretation of Σ
$\quad \wedge$ I models θ in Σ
$\quad \wedge$ $\forall$ interpretation I' of Σ, $\forall v' \in I'$
$\quad\quad C_{I'}(v') \subseteq \Theta_{I'}(\theta) \Rightarrow \exists v \in I : (v, I)$ and (v', I') are congruent in Σ

- prefered thesis of King
- formally expresses three intuitions:
  grammar (Σ, θ) true of natural language
  =only if⇒
  - natural language
    - can be construed as system of linguistic tokens
    - meeting conditions imposed upon them by Σ
  - each description in θ true of each entity in the natural language
  - some description in θ is
    - false of some constituent of some entity for which
    - no entity in the language has isomorphically configured constituents

thesis 1 (cont)

however:

- Thesis 1
  - ugly
  - cumbersome

- idea: find elegant equivalent of congruence relation

  $\forall$ signature Σ, $\forall$ interpretation I_1, I_2 of Σ, $\forall \upsilon_1 \in I_1$, $\forall \upsilon_2 \in I_2$
  (υ_1, I_1) and (υ_2, I_2) are indiscernible in Σ
  $:\Longleftrightarrow \; \forall \delta \in \mathsf{D}_\Sigma : \upsilon_1 \in D_{I_1}(\delta) \Leftrightarrow \upsilon_2 \in D_{I_2}(\delta)$

  Proposition 1: (υ_1, I_1) and (υ_2, I_2) are congruent in Σ
  $\Leftrightarrow (\upsilon_1, I_1)$ and (υ_2, I_2) are indiscernible in Σ

  I_1 simulates I_2 in Σ
  $:\Longleftrightarrow \; \forall \upsilon_2 \in I_2 : \exists \upsilon_1 \in I_1 : (\upsilon_1, I_1)$ and (υ_2, I_2) are indiscernible in Σ

thesis 2

$\forall \theta \subseteq \mathsf{D}_\Sigma$, $\forall$ interpretation I of Σ
I exhaustively models θ in Σ
$:\iff$ I models θ in Σ
$\wedge$ $\forall$ interpretation I' of Σ : I' models θ in $\Sigma \Rightarrow I$ simulates I' in Σ

Proposition 2: I exhaustively models θ in Σ
$\iff$ I models θ in Σ
$\wedge$ $\forall$ interpretation I' of $\Sigma, \forall v' \in I'$:
$C_{I'}(v') \subseteq \Theta_{I'}(\theta) \Rightarrow \exists v \in I : (v, I)$ and (v', I') are congruent in Σ.

- based on these notions new thesis can be formulated, replaces:
  - more complex notions of constituency and congruence
  - by simper one of exhaustive model.

Thesis 2: $\forall$ SRL grammar $\Gamma = (\Sigma, \theta)$, $\forall$ natural language I
Γ is true of I
$\Rightarrow I$ is an interpretation of Σ
$\wedge$ I exhaustively models θ in Σ.

issues

two issues concerning consequent of IT5 too strong:

grammar is true of nonempty natural language under IT5

$\Rightarrow$

1. natural language must be proper class
2. natural language must contain nonlinguistic entities.

- congruence weaker than sharing
  $\Rightarrow$ consequence of T1/T2 weaker than IT5
- sufficiently weak for second issue $\Rightarrow$ work on verification (?)
- sufficiently weak for first issue?
- sufficiently strong to still be linguistically useful?

issues (cont)

first issue:

- for each theory construction of an exhaustive model can be prescribed
  $\Rightarrow$ each theory has an exhaustive model

- some theories have only nontrivial models
  $\Rightarrow$ some theories have nontrivial exhaustive models

- grammar true of nonempty natural language
  $\Rightarrow$ language need not be proper class

- construction of exhaustive model:
  - illuminating
  - very technical $\Rightarrow$ not here

theorem 1

Theorem 1: $\forall$ SRL grammar $\Gamma = (\Sigma, \theta)$:
$\exists$ interpretation I of Σ : I exhaustively models θ in Σ

- every theory has an exhaustive model: problem?
  - trivial interpretations allowed in SRL
  - incoherent theory precluding nontrivial models
    $\Rightarrow$ only trivial exhaustive models
  - coherent enough for allowing nontrivial models
    $\Rightarrow$ only nontrivial exhaustive models
  - example: empty theory
    $\Rightarrow$ nontrivial models in almost all Σ

  $\Rightarrow$ unlike IT5: grammar true of natural language unter T1:
  - natural language not necessarily empty
  - not necessarily a proper class

  $\Rightarrow$ not problematic!

- incoherent grammars: problem?
  $\Rightarrow$ not really, coherence task of the HPSG grammar writer.

strong generative capacity

mathematical structures

idealized by ↗ generates set (SGC) of ↖ ↘ (singly generated) model of

linguistic token grammar

predicts ↖ ↙ is

linguistic theory

SGC (strong generative capacity): set of structures generated by grammar

1. no two members structurally isomorphic

2. grammar makes good predictions

   $\Rightarrow$

   tokens with struct. isomorphic to SGC members will be judged grammatical

strong generative capacity (cont)

two questions:

1. of what are linguistic tokens instances of?

- type, property? ⇒ empiricality problems.
- solution: call it by canonical representative of isomorphism class.

2. what is the SGC of a grammar?

- definition:
  1. set of canonical representatives of the insomorphism classes
  2. of singly generated models of the grammar
- satisfies (1) and (2)
- no ontological commitment to utterance types

strong generative capacity (cont)

idea: use SRL grammar's theory's models as its SGC
$\Rightarrow$ mathematical simplicity

many problems:

- possibly many models of grammar, not necessarily isomorphic
- some models 'too small': tokens not corresponding to objects of model
- models may differ in linguistically irrelevant ways
  example: number of objects corresponding to a token

intuition: abstraction from instances/tokens, only isomorphism classes

first approximation from idea: objects in a model of the grammar
$\Updownarrow$ $\searrow$ how?
HPSG practice: linguistic entities $\leftarrow$represented by$\rightarrow$ feature structures

strong generative capacity (cont)

how?

- model of a grammar: interpretation of the grammar's signature
- interpretation: unary partial algebra
- given object of interpretation: look at
  - singly generated subalgebra
  - generated in the interpretation by that object
- intuitively clear: singly generated algebra

  $\Downarrow$ determines in a natural way

  unique feature structure
  - take generating object as root of feature structure
  - objects in the subalgebra as its nodes
  - use obvious operations for defining feature structure's labelled transtitions

strong generative capacity (cont)

thus:

interpretation
$\Downarrow$determines in simple and natural way
unique set of feature strcutures
$\uparrow$
only these of interest concerning SGC, not the model itself

problem: two objects in model can determine isomorphic feature structures
$\Updownarrow$
linguists: only interested in the set's feature structures *up to isomorphism*

P&S94:

- linguistic types
- unnecessary ontological commitment
  $\Rightarrow$ 'type' should be replaced by 'isomorphism class'

strong generative capacity (cont)

abstract feature structure distinct feature structures

$\Updownarrow \leftarrow$ well known means of associating $\rightarrow \Updownarrow$

isomorphism class of feature structures distinct isomorphism classes

idea:

- each object υ in interpretation I

  $\uparrow$

  associate with

  $\downarrow$

  $Abst_I(\upsilon)$:

  - abstract feature structure
  - associated with the isomorphism class
  - of the feature structures determinded by υ

- if interpretation happens to model given grammar
  $\Rightarrow$ SGC of the grammar could be thought of as set of $Abst_I(\upsilon)$

strong generative capacity (cont)

problems:

1. set of $Abst_I(v)$ not necessarily the same for all models
   - given model
   - any subalgebra of the model is also a model
   - subalgebra might determine smalle set

2. model might be too small
   - some object in some other model
   - associated $Abst_I(v)$ not in the set of small model

strong generative capacity (cont)

three valid solutions:

1. use set of $Abst_I(v)$ of any object v of any model of the grammar
2. choose set of $Abst_I(v)$ for *exhaustive* model of the grammar
3. • consider set of abstract feature structures
   • choose subset of those which are models

summary:

SGC of an HPSG grammar
=
set of its models which are abstract feature structures

conclusion

- King:
  - grammar: is scientific theory
  - predicts grammaticality of linguistic tokens

  $\Rightarrow$ truth: grammar $\longleftrightarrow$ linguistic tokens?

- Pollard:
  - grammar: generates structures
  - set of generated structures = strong generative capacity

  $\Rightarrow$ grammar $\longleftrightarrow$ structures?

THE END

The truth. It is a beautiful and terrible thing, and should therefore be treated with great caution.

— *Albus Dumbledore*

(Joanne K. Rowling's Harry Potter and the Philosopher's Stone)

references

The base articles for this presentation are:

[1] Paul John King: Towards Truth in Head-Driven Phrase Structure Grammar. *Tübingen Studies in Head-Driven Phrase Structure Grammar* (1999), Valia Kordoni (ed.), Sonderforschungsbereich 340, Arbeitspapiere des SFB 340, Bericht Nr. 132 (ISSN 0947-6954/99, in 2 volumes, 527pp.), 301–352, Seminar für Sprachwissenschaft, Universität Tübingen.

[2] C. J. Pollard: Strong Generative Capacity in HPSG. *Lexical and Constructional Aspects of Linguistic Explanation* (1999), G. Webelhuth, J.-P. Koenig and A. Kathol (Eds.), 281–297, CSLI Publications.