Three Improvements to the HPSG Model Theory

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HPSG 2021

28 July 2021

Problems with HPSG model theory

Aim: propose **three orthogonal improvements to the standard HPSG model theory** (RSRL; Richter 2004):

- solve the long-standing **"Höhle's problem"** of spurious ambiguities,
- solve various problems stemming from the insistence on **exhaustive models**,
- propose a **second-order extension** to deal with the analysis of unlike category coordination in Yatabe 2004.

The first two problems are to some extent dealt with in Richter 2007: "Closer to the Truth: A New Model Theory for HPSG".

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The following problem dubbed "**Höhle's problem**", e.g., in Pollard 2001, 2014: 113.

- *She says she loves you.*
- 2 × *she* (assume different *ref*s):

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                      HEAD  [ noun
                              CASE nom ]
                      VAL   [ valence
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              CONT  [ ppro
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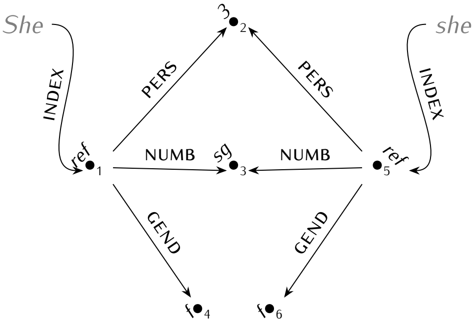

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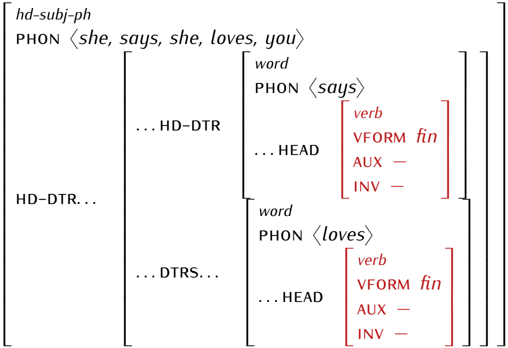

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hd-subj-ph
PHON ⟨*she, says, she, loves, you*⟩
HD-DTR…
- …HD-DTR
  - *word*
  - PHON ⟨*says*⟩
  - …HEAD [*verb*, VFORM *fin*, AUX −, INV −]
- …DTRS…
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Partial solutions

There are **partial solutions** in the literature.

Unique Empty List Condition (Richter 2007: 102):

- $\forall \boxed{1} \forall \boxed{2} ((\boxed{1} \sim elist \wedge \boxed{2} \sim elist) \rightarrow \boxed{1} \approx \boxed{2})$

General Identity Principle (GIP; Sailer 2003: 116):

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Fuller solution

Problem with making GIP universal:

- the **standard HPSG binding theory** relies on same-looking INDEX values not being necessarily same,
- **otherwise**, reliance on the non-identity of indiscernibles **very rare** in HPSG, but not unheard of:
  - Höhle 1999: §2.4 assumes that some "identities are not token but type identities",
  - Meurers 1998: 326, fn. 42 assumes "that the HEAD values of different head projections are never (accidentally) token identical, which could be explicitly enforced by a constraint on unembedded signs."

Solution:

- make **GIP universal by default**,
- but allow grammars to specify that **objects of certain sorts** (e.g., *ref*) **escape GIP**.

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This is a **complete solution** if the grammar does not produce any other cyclic structures.

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- the grammar writer deals with that (aka 'not my problem'),
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Typical **cyclicity** in HPSG grammars:

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In the following, assume the two NPs *the dog* have the same INDEX value:

- *A man with **the dog** likes **the dog**.*

Then there are **two analyses**, with the indiscernible NPs identical or not.

A **possible** (ugly) **solution**:

- **if** two *different* phrases $\boxed{1}$ and $\boxed{2}$ (here: *with the dog* and *likes the dog*)
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In the following, assume the two NPs *the dog* have the same INDEX value:

- *A man with **the dog** likes **the dog**.*

Then there are **two analyses**, with the indiscernible NPs identical or not.

A **possible** (ugly) **solution**:

- **if** two *different* phrases $\boxed{1}$ and $\boxed{2}$ (here: *with the dog* and *likes the dog*)
- have on their DTRS lists elements $\boxed{1d}$ and $\boxed{2d}$ (here: 2 × *the dog*),
- such that both $\boxed{1d}$ and $\boxed{2d}$ are of appropriate shape (involve specifiers),
- **then** $\neg(\boxed{1d} \approx \boxed{2d})$.

A **more general solution**? On the next two slides.

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Preventing accidental intensionality 2

Sailer 2003: 116:

$$\forall \boxed{1} \forall \boxed{2}\ \texttt{are-copies}(\boxed{1}, \boxed{2}) \leftrightarrow$$

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Idea: **recursion with memory**, immune to cycles – **nothing is intensional**:

$$\forall \boxed{1} \forall \boxed{2}\ \texttt{are-copies}(\boxed{1}, \boxed{2}) \leftrightarrow \texttt{Rcopies}(\langle\,\rangle, \boxed{1}, \langle\,\rangle, \boxed{2})$$

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Preventing accidental intensionality

Now we need to **make some structures intensional again**:

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Exhaustive models

King 1999 (and Richter 2004, 2007): **(R)SRL models are exhaustive**:

- **each** licensed **configuration** must actually be **present in the model**,
- intuition: (R)SRL models are **models of whole languages**, not models of single utterances.

This idea leads to **multiple problems** (cf. Richter 2007):

- **twin structures**: shared by different utterances,
- **(monster) stranded structures**: not parts of utterances,
- **ontological problem**: compatibility with the idea that objects in models are linguistic tokens (rather than mathematical idealisations).

Also:

- this intuition is **not shared by other mathematical / formal linguists** (Blackburn, Pullum, Kaplan…),
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Problem: Twin structures

Richter 2007: nothing in (R)SRL prevents configurations in which **different utterances share structure**.

For **example**:

Of course, **much larger configurations may be shared** (e.g., the whole word *she*).

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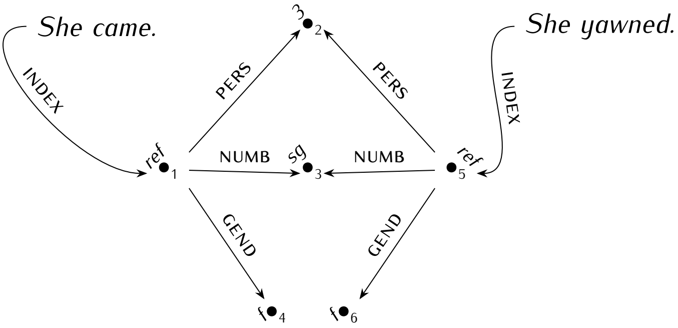

Of course, **much larger configurations may be shared** (e.g., the whole word *she*).

Problem: Twin structures

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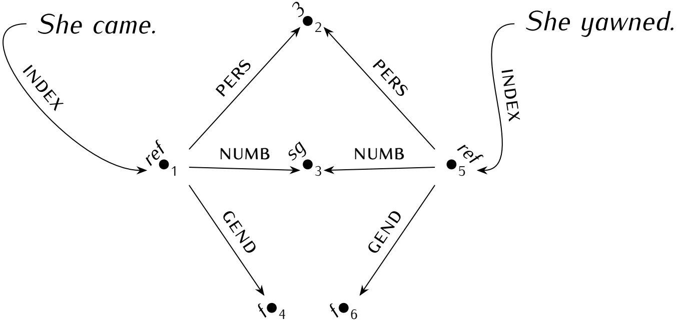

Of course, **much larger configurations may be shared** (e.g., the whole word *she*).

Problem: Stranded structures

Richter 2007: a typical HPSG grammar licenses as separate configurations, e.g., ***phrase*s with nonempty SLASH values**.

Elements of SLASH are **of sort *local***.

Various HPSG principles formulated as **constraints on *sign*s constrain *local* configurations** within those *sign*s.

But **unrealised elements of SLASH are not subject to such principles**; they may contain very strange *local* objects.

Hence, exhaustive models contain **configurations of *phrase*s** (with non-empty SLASH values) that **never occur in utterances**.

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component/2

Extension of theory:

- UNIQUE U-SIGN CONDITION:
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Solves the above problems:

- **no twin structures**: everything is a component of a single *u_sign*,
- **no stranded structures**: ditto (assuming *u_sign* → empty SLASH, etc.).

At a cost:

- **more complex signature** (and theory),
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King 1999 posits two **contradictory requirements about models**:

- that they be **exhaustive**,
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Exhaustivity implies that models contain all licensed configurations.

But **not all configurations correspond to actual utterance tokens**.

So there must be **non-actual** utterance **tokens**.

"To Pollard [(p.c. to Richter)], **the concept of non-actual tokens is contradictory and nonsensical**" (Richter 2004: 119).

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A **solution** to all of the above (see extended slides for RSRL technicalities):

- **rooted models**,
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Solves all the problems above:

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Solution: Technicalities 1

Assume the standard notion of **signature** (we ignore chains throughout):

Definition (signature)

Σ is a signature iff
Σ is a septuple $\langle S, \sqsubseteq, S_{max}, A, F, R, Ar \rangle$,
$\langle S, \sqsubseteq \rangle$ is a partial order,
$S_{max} = \{\sigma \in S \mid \text{for each } \sigma' \in S, \text{ if } \sigma' \sqsubseteq \sigma \text{ then } \sigma = \sigma'\}$,
A is a set,
F is a partial function from $S \times A$ to S,
for each $\sigma_1 \in S$, for each $\sigma_2 \in S$, for each $\phi \in A$,
    if $F(\sigma_1, \phi)$ is defined and $\sigma_2 \sqsubseteq \sigma_1$
    then $F(\sigma_2, \phi)$ is defined and $F(\sigma_2, \phi) \sqsubseteq F(\sigma_1, \phi)$,
R is a finite set, and
Ar is a total function from R to the positive integers.

Solution: Technicalities 2

We extend the notion of **terms** – $\mathring{r}$ will refer to the root of the utterance:

Definition (terms)

For each signature $\Sigma = \langle S, \sqsubseteq, S_{max}, A, F, R, Ar \rangle$, the set of terms T^{Σ} is the smallest set such that
$\mathring{r} \in T^{\Sigma}$,
$: \in T^{\Sigma}$,
for each $x \in V$, $x \in T^{\Sigma}$,
for each $\phi \in A$ and each $\tau \in T^{\Sigma}$, $\tau\phi \in T^{\Sigma}$.

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Solution: Technicalities 3

Standard definition of **formulæ**:

Definition (formulæ)

For each signature $\Sigma = \langle S, \sqsubseteq, S_{max}, A, F, R, Ar \rangle$, the set of formulæ D^{Σ} is the smallest set such that

for each $\sigma \in S$, for each $\tau \in T^{\Sigma}$, $\tau \sim \sigma \in D^{\Sigma}$,

for each $\tau_1, \tau_2 \in T^{\Sigma}$, $\tau_1 \approx \tau_2 \in D^{\Sigma}$,

for each $\rho \in R$, for each $x_1, \ldots, x_{Ar(\rho)} \in V$, $\rho(x_1, \ldots, x_{Ar(\rho)}) \in D^{\Sigma}$,

for each $x \in V$, for each $\delta \in D^{\Sigma}$, $\exists x \delta \in D^{\Sigma}$, (analogous for $\forall$)

for each $\delta \in D^{\Sigma}$, $\neg\delta \in D^{\Sigma}$,

for each $\delta_1, \delta_2 \in D^{\Sigma}$, and $(\delta_1 \wedge \delta_2) \in D^{\Sigma}$. (analogous for $\vee, \rightarrow, \leftrightarrow$)

Solution: Technicalities 4

Trivial extension of the definition of **free variables** to handle the term $\mathring{r}$:

Definition (free variables)

For each signature $\Sigma = \langle S, \sqsubseteq, S_{max}, A, F, R, Ar \rangle$, FV is the function from terms and formulæ to free variables in them:

$FV(\mathring{r}) = \{\}$,

$FV(:) = \{\}$,

for each $x \in V$, $FV(x) = \{x\}$,

for each $\tau \in T^{\Sigma}$, for each $\phi \in A$, $FV(\tau\phi) = FV(\tau)$,

for each $\tau \in T^{\Sigma}$, for each $\sigma \in S$, $FV(\tau \sim \sigma) = FV(\tau)$,

for each $\tau_1, \tau_2 \in T^{\Sigma}$, $FV(\tau_1 \approx \tau_2) = FV(\tau_1) \cup FV(\tau_2)$,

for each $\rho \in R$, for each $x_1, \ldots, x_{Ar(\rho)} \in V$,

$FV(\rho(x_1, \ldots, x_{Ar(\rho)})) = \{x_1, \ldots, x_{Ar(\rho)}\}$,

for each $\delta \in D^{\Sigma}$, for each $x \in V$, $FV(\exists x \delta) = FV(\delta) \backslash \{x\}$, (also $\forall$)

for each $\delta \in D^{\Sigma}$, $FV(\neg\delta) = FV(\delta)$,

for each $\delta_1, \delta_2 \in D^{\Sigma}$, $FV((\delta_1 \wedge \delta_2)) = FV(\delta_1) \cup FV(\delta_2)$. (also $\vee, \rightarrow, \leftrightarrow$)

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Solution: Technicalities 5

Standard definition of **descriptions**:

Definition (descriptions)

For each signature Σ, the set of descriptions $D_0^{\Sigma} = \{\delta \in D^{\Sigma} | FV(\delta) = \{\}\}$.

Solution: Technicalities 6

Definition of **interpretation** now singles out one element of the universe:

Definition (interpretation)

For each signature $\Sigma = \langle S, \sqsubseteq, S_{max}, A, F, R, Ar \rangle$, $\mathsf{I} = \langle \mathsf{U}, \mathsf{r}, \mathsf{S}, \mathsf{A}, \mathsf{R} \rangle$ is an Σ interpretation iff

U is a set,

$\mathsf{r} \in \mathsf{U}$,

S is a total function from U to S_{max},

A is a total function from A to the set of partial functions from U to U,

for each $\phi \in A$ and each $u \in \mathsf{U}$

if $\mathsf{A}(\phi)(u)$ is defined

then $F(\mathsf{S}(u), \phi)$ is defined, and $\mathsf{S}(\mathsf{A}(\phi)(u)) \sqsubseteq F(\mathsf{S}(u), \phi)$, and

for each $\phi \in A$ and each $u \in \mathsf{U}$,

if $F(\mathsf{S}(u), \phi)$ is defined then $\mathsf{A}(\phi)(u)$ is defined,

R is a total function from R to the power set of $\bigcup_{n \in \mathbb{N}} \mathsf{U}^n$, and

for each $\rho \in R$, $\mathsf{R}(\rho) \subseteq \mathsf{U}^{Ar(\rho)}$.

Solution: Technicalities 6

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for each $\rho \in R$, $\mathsf{R}(\rho) \subseteq \mathsf{U}^{Ar(\rho)}$.

Solution: Technicalities 7

Standard definition of **variable assignments**:

Definition (variable assignments)

For each signature Σ, for each Σ interpretation $\mathsf{I} = \langle \mathsf{U}, \mathsf{r}, \mathsf{S}, \mathsf{A}, \mathsf{R} \rangle$,
$\mathsf{G}_{\mathsf{I}} = \mathsf{U}^{V}$ is the set of variable assignments in I.

Solution: Technicalities 8

Standard **term interpretation**, extended so that the interpretation of $\mathring{r}$ is r:

Definition (term interpretation)

For each signature $\Sigma = \langle S, \sqsubseteq, S_{max}, A, F, R, Ar\rangle$, for each Σ interpretation $\mathsf{I} = \langle \mathsf{U}, \mathsf{r}, \mathsf{S}, \mathsf{A}, \mathsf{R}\rangle$, for each $g \in \mathsf{G}_\mathsf{I}$, the term interpretation T^g_I is the total function from T^Σ to the set of partial functions from U to U such that for each $u \in \mathsf{U}$,

$\mathsf{T}^g_\mathsf{I}(\mathring{r})(u)$ is defined and $\mathsf{T}^g_\mathsf{I}(\mathring{r})(u) = \mathsf{r}$,

$\mathsf{T}^g_\mathsf{I}(:)(u)$ is defined and $\mathsf{T}^g_\mathsf{I}(:)(u) = u$,

for each $x \in V$, $\mathsf{T}^g_\mathsf{I}(x)(u)$ is defined and $\mathsf{T}^g_\mathsf{I}(x)(u) = g(x)$,

for each $\tau \in T^\Sigma$, for each $\phi \in A$,

$\mathsf{T}^g_\mathsf{I}(\tau\phi)(u)$ is defined iff $\mathsf{T}^g_\mathsf{I}(\tau)(u)$ is defined and $\mathsf{A}(\phi)(\mathsf{T}^g_\mathsf{I}(\tau)(u))$ is defined, and

if $\mathsf{T}^g_\mathsf{I}(\tau\phi)(u)$ is defined then $\mathsf{T}^g_\mathsf{I}(\tau\phi)(u) = \mathsf{A}(\phi)(\mathsf{T}^g_\mathsf{I}(\tau)(u))$.

Solution: Technicalities 8

Standard **term interpretation**, extended so that the interpretation of $\mathring{r}$ is r:

Definition (term interpretation)

For each signature $\Sigma = \langle S, \sqsubseteq, S_{max}, A, F, R, Ar \rangle$, for each Σ interpretation $\mathsf{I} = \langle \mathsf{U}, \mathsf{r}, \mathsf{S}, \mathsf{A}, \mathsf{R} \rangle$, for each $g \in \mathsf{G}_\mathsf{I}$, the term interpretation T^g_I is the total function from T^Σ to the set of partial functions from U to U such that for each $u \in \mathsf{U}$,

$\mathsf{T}^g_\mathsf{I}(\mathring{r})(u)$ is defined and $\mathsf{T}^g_\mathsf{I}(\mathring{r})(u) = \mathsf{r}$,

$\mathsf{T}^g_\mathsf{I}(:)(u)$ is defined and $\mathsf{T}^g_\mathsf{I}(:)(u) = u$,

for each $x \in V$, $\mathsf{T}^g_\mathsf{I}(x)(u)$ is defined and $\mathsf{T}^g_\mathsf{I}(x)(u) = g(x)$,

for each $\tau \in T^\Sigma$, for each $\phi \in A$,

$\mathsf{T}^g_\mathsf{I}(\tau\phi)(u)$ is defined iff $\mathsf{T}^g_\mathsf{I}(\tau)(u)$ is defined and $\mathsf{A}(\phi)(\mathsf{T}^g_\mathsf{I}(\tau)(u))$ is defined, and

if $\mathsf{T}^g_\mathsf{I}(\tau\phi)(u)$ is defined then $\mathsf{T}^g_\mathsf{I}(\tau\phi)(u) = \mathsf{A}(\phi)(\mathsf{T}^g_\mathsf{I}(\tau)(u))$.

Solution: Technicalities 9

Formula denotation – now quantification is over the whole universe (i.e., over all the components of the utterance, similarly to Richter 2007):

Definition (formula denotation)

For each signature $\Sigma = \langle S, \sqsubseteq, S_{max}, A, F, R, Ar\rangle$, for each Σ interpretation $\mathsf{I} = \langle \mathsf{U}, \mathsf{r}, \mathsf{S}, \mathsf{A}, \mathsf{R}\rangle$, for each $g \in \mathsf{G}_\mathsf{I}$, the formula denotation function D^g_I is the total function from D^Σ to the power set of U such that

for each $\tau \in T^\Sigma$, for each $\sigma \in S$,

$$\mathsf{D}^g_\mathsf{I}(\tau \sim \sigma) = \left\{ u \in \mathsf{U} \,\middle|\, \begin{array}{l} \mathsf{T}^g_\mathsf{I}(\tau)(u) \text{ is defined, and} \\ \mathsf{S}\left(\mathsf{T}^g_\mathsf{I}(\tau)(u)\right) \sqsubseteq \sigma \end{array} \right\},$$

for each $\tau_1, \tau_2 \in T^\Sigma$,

$$\mathsf{D}^g_\mathsf{I}(\tau_1 \approx \tau_2) = \left\{ u \in \mathsf{U} \,\middle|\, \begin{array}{l} \mathsf{T}^g_\mathsf{I}(\tau_1)(u) \text{ is defined,} \\ \mathsf{T}^g_\mathsf{I}(\tau_2)(u) \text{ is defined, and} \\ \mathsf{T}^g_\mathsf{I}(\tau_1)(u) = \mathsf{T}^g_\mathsf{I}(\tau_2)(u) \end{array} \right\},$$

for each $\rho \in R$, for each $x_1, \ldots, x_{Ar(\rho)} \in V$,

$$\mathsf{D}^g_\mathsf{I}\left(\rho(x_1, \ldots, x_{Ar(\rho)})\right) = \left\{ u \in \mathsf{U} \,\middle|\, \left\langle g(x_1), \ldots, g(x_{Ar(\rho)})\right\rangle \in \mathsf{R}(\rho) \right\},$$

...

Solution: Technicalities 10

Definition (formula denotation contd.)

. . . ,

for each $x \in V$, for each $\delta \in D^{\Sigma}$,

$$\mathsf{D}^{g}_{\mathsf{I}}(\exists x \delta) = \left\{ u \in \mathsf{U} \;\middle|\; \begin{array}{l} \text{for some } u' \in \mathsf{U} \\ u \in \mathsf{D}^{g[x \mapsto u']}_{\mathsf{I}}(\delta) \end{array} \right\},$$

for each $x \in V$, for each $\delta \in D^{\Sigma}$,

$$\mathsf{D}^{g}_{\mathsf{I}}(\forall x \delta) = \left\{ u \in \mathsf{U} \;\middle|\; \begin{array}{l} \text{for each } u' \in \mathsf{U} \\ u \in \mathsf{D}^{g[x \mapsto u']}_{\mathsf{I}}(\delta) \end{array} \right\},$$

for each $\delta \in D^{\Sigma}$, $\mathsf{D}^{g}_{\mathsf{I}}(\neg\delta) = \mathsf{U} \backslash \mathsf{D}^{g}_{\mathsf{I}}(\delta)$,

for each $\delta_1, \delta_2 \in D^{\Sigma}$, $\mathsf{D}^{g}_{\mathsf{I}}((\delta_1 \wedge \delta_2)) = \mathsf{D}^{g}_{\mathsf{I}}(\delta_1) \cap \mathsf{D}^{g}_{\mathsf{I}}(\delta_2)$

for each $\delta_1, \delta_2 \in D^{\Sigma}$, $\mathsf{D}^{g}_{\mathsf{I}}((\delta_1 \vee \delta_2)) = \mathsf{D}^{g}_{\mathsf{I}}(\delta_1) \cup \mathsf{D}^{g}_{\mathsf{I}}(\delta_2)$

for each $\delta_1, \delta_2 \in D^{\Sigma}$, $\mathsf{D}^{g}_{\mathsf{I}}((\delta_1 \rightarrow \delta_2)) = \big(\mathsf{U} \backslash \mathsf{D}^{g}_{\mathsf{I}}(\delta_1)\big) \cup \mathsf{D}^{g}_{\mathsf{I}}(\delta_2)$, and

for each $\delta_1, \delta_2 \in D^{\Sigma}$,

$$\mathsf{D}^{g}_{\mathsf{I}}((\delta_1 \leftrightarrow \delta_2)) = ((\mathsf{U} \backslash \mathsf{D}^{g}_{\mathsf{I}}(\delta_1)) \cap (\mathsf{U} \backslash \mathsf{D}^{g}_{\mathsf{I}}(\delta_2))) \cup (\mathsf{D}^{g}_{\mathsf{I}}(\delta_1) \cap \mathsf{D}^{g}_{\mathsf{I}}(\delta_2)).$$

Solution: Technicalities 10

Definition (formula denotation contd.)

…,

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Solution: Technicalities 11

Standard definition of **description denotation**:

Definition (description denotation)

For each signature Σ, for each Σ interpretation $\mathsf{I} = \langle \mathsf{U}, \mathsf{r}, \mathsf{S}, \mathsf{A}, \mathsf{R} \rangle$, the description denotation function D_I is the total function from D_0^Σ to the power set of U such that $\mathsf{D}_\mathsf{I}(\delta) = \left\{ u \in \mathsf{U} \,\middle|\, \text{for each } g \in \mathsf{G}_\mathsf{I},\ u \in \mathsf{D}_\mathsf{I}^g(\delta) \right\}$.

Solution: Technicalities 12

So far we know that $\mathring{r}$ **points at a distinguished model element** r.

We want to make sure that r **is the root**...

- $\forall \boxed{1}$ component($\boxed{1}$, $\mathring{r}$) i.e.: $\exists \boxed{0}$ ($\boxed{0} \approx \mathring{r} \wedge \forall \boxed{1}$ component($\boxed{1}$, $\boxed{0}$))

... **of an utterance**:

- $\mathring{r}$ SYNSEM NONLOCAL SLASH $\sim$ *eset*
- $\mathring{r}$ SYNSEM LOCAL CAT VAL SUBJ $\sim$ *elist* $\wedge$
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- etc.

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Solution: Comparisons and summary

Rooted models – not an original idea:

- discussed **in modal logic** (*rooted* or *point generated* models; Blackburn *et al.* 2010: 56),
- these are exactly **Pollard's (1999: §6) singly generated** models.

Here, we **additionally**:

- require that such rooted models correspond to **utterances**,
- allow terms to **refer to the root** directly.

This view is **ontologically agnostic**; model objects may be:

- **utterance tokens and their parts** (King 1999),
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Yatabe 2004 on unlike category coordination

Yatabe 2004 deals with **unlike category coordination**, e.g. (Bayer 1996):

- We emphasized [[Mr. Colson's many qualifications]$_{NP}$ and [that he had worked at the White House]$_{CP}$].
- We emphasized [[that Mr. Colson had worked at the White House]$_{CP}$ and [his many other qualifications]$_{NP}$].

His **lexical entry for *emphasized***:

- $$\begin{bmatrix} \text{PHON } \langle \textit{emphasized} \rangle \\ \text{...VALENCE} \begin{bmatrix} \text{SUBJ } \left\langle \left[\text{...HEAD } c\left(\begin{bmatrix} \textit{noun} \\ \text{CASE } \textit{nom} \end{bmatrix} \right) \right] \right\rangle \\ \text{COMPS } \langle [\text{...HEAD } c(\textit{noun} \vee \textit{comp})] \rangle \end{bmatrix} \end{bmatrix}$$

The key idea is the use of the **distributive functor,** c:

- $$\boxed{1} : c(\alpha) \equiv \boxed{1} : \alpha \vee (\boxed{1} : [\text{ARGS } \langle \boxed{a_1}, \ldots, \boxed{a_n} \rangle] \wedge \boxed{a_1} : \alpha \wedge \ldots \wedge \boxed{a_n} : \alpha)$$

The value of ARGS is the list of (heads of) conjuncts in coordination.

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The key idea is the use of the **distributive functor,** c:

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Reformulation in second-order RSRL

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What would it require?

- signatures **specify types of arguments of relation symbols** (each either e or et);
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  - instead of the general relation $\mathsf{c}(\boxed{0}, \alpha)$ taking a second-order argument α
  - define a standard relation $\mathsf{c}_{\alpha}(\boxed{0})$ for each $\mathsf{c}(\boxed{0}, \alpha)$ actually needed in the grammar.

Instead of conclusion

Solutions:

- **"Höhle's problem"**:
  - **General Identity Principle** (GIP; Sailer 2003: 116),
  - modified to exempt some structures (e.g., of sort *ref*) from its scope;
- **exhaustive models** (twin structures, stranded structures, ontological problems):
  - **modification of RSRL**,
  - each model corresponds to an **utterance**,
  - and has a distinguished element – the **root**;
- **unlike category coordination** (Yatabe 2004):
  - **extension of RSRL**,
  - values of variables – **arguments of relations** – may be objects or **properties of objects**,
  - i.e., second-order RSRL.

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Thank you for your attention!

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