Dowty 1994

The Role of Negative Polarity and Concord Marking in Natural Language Reasoning
SALT IV, Cornell, Ithaca, NY.

starts by explaining Sánchez' work more lucidly than Sánchez himself

presents a simpler alternative:

> I will at this point present an alternative formulation, which I believe is almost certainly equivalent to Sanchez' (though I do not have a proof of this at present). The goal is to "collapse" the independent steps of Monotonicity Marking and Polarity Determination into the syntactic derivation itself, so that words and constituents are generated with the markings already in place that they would receive in Sanchez' polarity summaries. The symbols "+" and "-" will be used, unambiguously, only to indicate the (final) logical polarity.

goes on to the main topic, NPIs and concord marking, a path we don't follow here. Gerald Penn and Frank Richter have a course on this topic M-Th 10:30-12.

The recent work by Larry Moss has Dowty 1994 as its starting point.

Dowty's types

PN*(= type e), S (= type t), and CN (= type (e,t)) are (primitive) categories.

(Dowty's (e,t) is the same as Sánchez' (e→t).)

If A and B are any categories, so is A/B.

If A/B is a category, so are A^+/B^+, A^+/B^-, A^-/B^+, and A^-/B^-.

Parallel definitions to be given for left-leaning-slash categories B\A (functor combining with B to yield A).

("Result on Top" version of CG notation, same as Sánchez'.)

* Actually, in the paper Dowty has NP (= type e) but because we have used NP for the type raised proper names ((e,t), t) I have systematically replaced Dowty's NP by PN in the following slides.

We will in addition need to invoke polarity marking on complex categories themselves, e.g. (PN\S)+ vs. (PN\S)-.

It turns out, however, that we do not really need to define these separately as categories rather, it suffices to let the +/– value of the result-category of the functor indicate the +/– of the functor as a whole; thus we can use the following as a notational abbreviation:

$$(A/B)^{+} =_{def} (A^{+}/B)$$

$$(A/B)^{-} =_{def} (A^{-}/B)$$

Dual Assignments

Since one and the same word (or constituent) can appear with positive polarity in one derivation and negative polarity in another, most lexical items will, in this formulation, be entered in two categories, a "+"-marked category and its "–"-marked counterpart (e.g. *catch* $\in (PN^{+}\backslash S^{+})/PN^{+}$ and *catch* $\in (PN^{-}\backslash S^{-})/PN^{-}$), though with the same semantic interpretation in each case.

↑M and ↓M functors also appear in two categories. but now the terms "preserving" and "reversing" are more appropriate:

Lexical items in general appear in both a "+"-marked and a "–"-marked category though with the same interpretation.

↑M functors (= MONOTONICITY PRESERVING FUNCTORS) appear in a pair of categories of the forms A^{+}/B^{+} and A^{-}/B^{-}.

↓M functors (= MONOTONICITY REVERSING FUNCTORS) appear in a pair of categories of the forms A^{+}/B^{-} and A^{-}/B^{+}.

One might want to adopt a notation for category schemas of the preserving and reversing categories, insofar as the same expressions appear in both members of such pairs:

$$A/_{P}B \;=_{def}\; \{A^{+}/B^{+},\, A^{-}/B^{-}\}$$

$$A/_{R}B \;=_{def}\; \{A^{+}/B^{-},\, A^{-}/B^{+}\}$$

The categorial Slash-Elimination rules (or "Functional Application" Rules) must appropriately respect +/– marking:

Polarity-Preserving /-Elimination

$$\frac{A^{+}/B^{+} \quad B^{+}}{A^{+}}\ /E$$

$$\frac{A^{-}/B^{-} \quad B^{-}}{A^{-}}\ /E$$

Polarity-Reversing /-Elimination

$$\frac{A^{+}/B^{-} \quad B^{-}}{A^{+}}\ /E$$

$$\frac{A^{-}/B^{+} \quad B^{+}}{A^{-}}\ /E$$

Rather that literally specify the four separate rules indicated above however, we might regard "+" and "-" as syntactic features, as features are treated elsewhere in linguistics (but here with deductive significance), and these four rules would be simply instances of a single slash-elimination schema, where A and B are variables for complexes of syntactic features:

$$\frac{A/B \quad B}{A}\ /E$$

Here are the category assignments we would make for determiners in this system: ("VP" is used as an abbreviation for PN\S (= type (e,t)).)

Det	Type
a	$(S^{+}/VP^{+})/CN^{+}$ $(S^{-}/VP^{-})/CN^{-}$
every	$(S^{+}/VP^{+})/CN^{-}$ $(S^{-}/VP^{-})/CN^{+}$
no	$(S^{+}/VP^{-})/CN^{-}$ $(S^{-}/VP^{+})/CN^{+}$

As direct object quantificational noun phrases are treated here as functions from transitive verbs (category (PN\S)/PN, abbreviated VP/PN or simply TV) to VP), each determiner in category $(S^{\alpha}/VP^{\beta})/CN^{\gamma}$ above is assumed to have an object-noun phrase counterpart in $(TV^{\beta}\backslash VP^{\alpha})/CN^{\gamma}$.

Applying Divison to Determiners

Det	Type	Extended with Division ("Geach") rule
a	$(S^+/VP^+)/CN^+$ $(S^-/VP^-)/CN^-$	$(TV^+\backslash VP^+)/CN^+$ $(TV^-\backslash VP^-)/CN^-$
every	$(S^+/VP^+)/CN^-$ $(S^-/VP^-)/CN^+$	$(TV^+\backslash VP^+)/CN^-$ $(TV^-\backslash VP^-)/CN^+$
no	$(S^+/VP^-)/CN^-$ $(S^-/VP^+)/CN^+$	$(TV^-\backslash VP^+)/CN^-$ $(TV^+\backslash VP^-)/CN^+$

Examples

$$
\begin{array}{cccc}
 & & \text{every} & \text{armadillo} \\
 & \text{caught} & (TV^{+}\backslash VP^{+})/CN^{-} & CN^{-} \\
\cline{3-4}
\text{Sue} & VP^{+}/PN^{+} & \multicolumn{2}{c}{TV^{+}\backslash VP^{+}} \\
\cline{2-4}
S^{+}/VP^{+} & \multicolumn{3}{c}{VP^{+}} \\
\hline
\multicolumn{4}{c}{S^{+}}
\end{array}
$$

$TV^{+} = VP^{+}/PN^{+} = (PN^{+}\backslash S^{+})/PN^{+}$

Recall the rule of Division ("Geach Rule"):

In addition to having the type S/VP (= t/(e\t)), noun phrases also have the type TV\VP (= ((e\t)/e)\(e\t)). Sánchez derives S/VP ⇒ TV\VP as a theorem.

$$\dfrac{\begin{array}{c}\text{Sam}\\ S^+/VP^+\end{array} \quad \dfrac{\begin{array}{c}\text{didn't}\\ VP^+/VP^-\end{array} \quad \dfrac{\begin{array}{c}\text{catch}\\ VP^-/PN^-\end{array} \quad \dfrac{\begin{array}{c}\text{every}\\ (TV^-\backslash VP^-)/CN^+\end{array} \quad \begin{array}{c}\text{armadillo}\\ CN^+\end{array}}{TV^-\backslash VP^-}}{VP^-}}{VP^+}}{S^+}$$

Question:

If every lexical item has two possible type signatures, does it make parsing inefficient?

Dowty:

If a sentence is well-formed, it must be derivable in category S^+ , so we can use an informal procedure analogous to Genzen-Sequent Parsing (cf. Moortgat 1991) to determine what polarity marking must appear on each category.

Deducing Polarities

every armadillo

$(TV \backslash VP)/CN$ $\quad CN$

caught

VP/PN $\quad TV \backslash VP$

Sue

S/VP $\quad VP$

S^{+}

Sue is the main functor, and as it is polarity-preserving, it will appear only in the categories S^{+}/VP^{+} and S^{-}/VP^{-}. Of these, only the former could result in an S^{+}, so that is the category for Sue. This implies in turn that the VP is marked VP^{+}, else it could not combine with S^{+}/VP^{+}.

$TV^{+} = VP^{+}/PN^{+}$

$TV^{-} = VP^{-}/PN^{-}$

$$
\dfrac{\underset{S^{+}/VP^{+}}{\text{Sue}} \quad \dfrac{\underset{VP/PN}{\text{caught}} \quad \dfrac{\underset{(TV\backslash VP)/CN}{\text{every}} \quad \underset{CN}{\text{armadillo}}}{TV\backslash VP}}{VP^{+}}}{S^{+}}
$$

The verb *catch* is a monotonicity-preserving function, and if it had a simple PN object, we could deduce it must be marked VP^{+}/PN^{+} by parallel reasoning. Instead, it is the argument of a TV\VP functor. Because *every armadillo* is monotone-preserving we have either $TV^{+}\backslash VP^{+}$ or $TV^{-}\backslash VP^{-}$, but again only the former could result in VP^{+} after combining with an argument, so this determines both the category of the object noun phrase and of the verb.

every $(TV \backslash VP)/CN$ armadillo CN

caught VP^{+}/PN^{+} ——— $TV^{+} \backslash VP^{+}$

Sue S^{+}/VP^{+} ——— VP^{+}

——— S^{+}

Given the lexical choices for object *every*, $(TV^{+} \backslash VP^{+})/CN^{-}$ and $(TV^{-} \backslash VP^{-})/CN^{+}$, only the former gives the needed result category, thus fixing the polarity for it and also determining that the CN argument of every appears in CN^{-}.

every $\quad$ armadillo

$$\dfrac{(TV^{+}\backslash VP^{+})/CN^{-} \qquad CN^{-}}{TV^{+}\backslash VP^{+}}$$

caught

$$\dfrac{VP^{+}/PN^{+} \qquad TV^{+}\backslash VP^{+}}{VP^{+}}$$

Sue

$$\dfrac{S^{+}/VP^{+} \qquad VP^{+}}{S^{+}}$$

Thus there is a unique polarity assignment possible for this example, marked straightforwardly in the derivation tree, and it is in fact the same as the one determined by Sánchez' method.

Another deduction

every (TV \VP)/CN armadillo CN

catch VP /PN — TV \VP

didn't VP /VP — VP

Sam S /VP — VP

S+

every armadillo

$(TV \backslash VP)/CN$ CN

catch

VP/PN $TV \backslash VP$

didn't

VP^{+}/VP^{-} VP^{-}

Sam

S^{+}/VP^{+} VP^{+}

S^{+}

every (TV \VP)/CN armadillo CN

$TV^{-}\backslash VP^{-}$

catch VP^{-}/PN^{-}

VP^{-}

didn't VP^{+}/VP^{-}

VP^{+}

Sam S^{+}/VP^{+}

S^{+}

Division ("Geach Rule") for NPs

S/VP ⇒ TV\VP

How does it apply here?

$TV^{-} = VP^{-}/PN^{-}$

$$\dfrac{\overset{\text{Sam}}{S^{+}/VP^{+}} \quad \dfrac{\overset{\text{didn't}}{VP^{+}/VP^{-}} \quad \dfrac{\overset{\text{catch}}{VP^{-}/PN^{-}} \quad \dfrac{\overset{\text{every}}{(TV^{-}\backslash VP^{-})/CN^{+}} \quad \overset{\text{armadillo}}{CN^{+}}}{TV^{-}\backslash VP^{-}}}{VP^{-}}}{VP^{+}}}{S^{+}}$$

One more deduction

no (TV \VP)/CN

armadillos CN

TV \VP

caught VP /PN

VP

Sue S /VP

S+

no armadillos

$(TV\backslash VP)/CN \quad CN$

$TV\backslash VP$

caught

$VP/PN \quad TV\backslash VP$

VP^{+}

Sue

$S^{+}/VP^{+} \quad VP^{+}$

S^{+}

If *caught* is VP^{-}/PN^{-} then *no armadillos* must be $TV^{-}\backslash VP^{-}$ or $TV^{-}\backslash VP^{+}$
If *caught* is VP^{+}/PN^{+} then *no armadillos* must be $TV^{+}\backslash VP^{+}$ or $TV^{+}\backslash VP^{-}$
Because the resulting category must be VP^{+}, the choices are $TV^{-}\backslash VP^{+}$ and $TV^{+}\backslash VP^{+}$. The categories for *no armadillos* resulting from Division ("Geach Rule") are $TV^{-}\backslash VP^{+}$ and $TV^{+}\backslash VP^{-}$. The right choice is $TV^{-}\backslash VP^{+}$.

$$
\dfrac{\begin{matrix}\text{Sue} \\ S^{+}/VP^{+}\end{matrix} \qquad \dfrac{\begin{matrix}\text{caught} \\ VP^{-}/PN^{-}\end{matrix} \qquad \dfrac{\begin{matrix}\text{no} \\ (TV^{-}\backslash VP^{+})/CN\end{matrix} \qquad \begin{matrix}\text{armadillos} \\ CN\end{matrix}}{TV^{-}\backslash VP^{+}}}{VP^{+}}}{S^{+}}
$$

Now we know the polarity of CN because *no* is either $(S^{+}/VP^{-})/CN^{-}$ or $(S^{-}/VP^{+})/CN^{+}$, or $(TV^{+}/VP^{-})/CN^{+}$ or $(TV^{-}/VP^{+})/CN^{-}$ with Division.

$$\dfrac{\begin{array}{c}\text{Sue}\\ S^{+}/VP^{+}\end{array} \qquad \dfrac{\begin{array}{c}\text{caught}\\ VP^{-}/PN^{-}\end{array} \qquad \dfrac{\begin{array}{c}\text{no}\\ (TV^{-}\backslash VP^{+})/CN^{-}\end{array} \qquad \begin{array}{c}\text{armadillos}\\ CN^{-}\end{array}}{TV^{-}\backslash VP^{+}}}{VP^{+}}}{S^{+}}$$

Van Benthem examples

no

$(S^+/VP^-)/CN^-$

$(S^-/VP^+)/CN^+$

$TV^- = VP^-/PN$

every with Division

$(TV^+\backslash VP^+)/CN^-$

$(TV^-\backslash VP^-)/CN^+$

$$\dfrac{\dfrac{\overset{\text{no}}{(S^+/VP^-)/CN^-} \quad \overset{\text{man}}{CN^-}}{S^+/VP^-} \qquad \dfrac{\dfrac{\overset{\text{can}}{VP^-/VP^-} \quad \overset{\text{slay}}{TV^-}}{TV^-}\,\mathbf{B} \qquad \dfrac{\overset{\text{every}}{(TV^-\backslash VP^-)/CN^+} \quad \overset{\text{dragon}}{CN^+}}{TV^-\backslash VP^-}}{VP^-}}{S^+}$$

(no man$^-$)(((can slay$^-$))(every(dragon$^+$)))

no

$(S^{+}/VP^{-})/CN^{-}$

$(S^{-}/VP^{+})/CN^{+}$

no $(S^{+}/VP^{-})/CN^{-}$ man CN^{-}

S^{+}/VP^{-}

can VP^{-}/VP^{-}

B

S^{+}/VP^{-}

slay TV^{-}

B

S^{+}/VP^{-}

every $(S^{+}/VP^{+})/CN^{-}$ dragon CN^{-}

S^{+}/VP^{+}

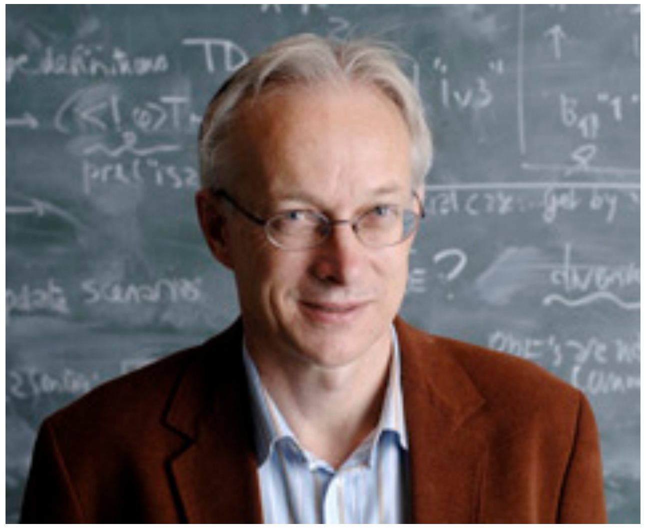
VP^{-}

TV^{+}

S^{+}

(no man^{-})(((can slay^{-}))(every(dragon^{-})))

Personages



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