Treating Polarity Sensitivity by Lexical Underspecification: Motivation from Semantic Scope

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1 Introduction[1]

Polarity Sensitive Items (PSIs) come in two flavors, namely *Negative Polarity Items* (NPIs) and *Positive Polarity Items* (PPIs). 1) exemplifies the NPIs *a red cent* and *ever* and 2) presents the PPIs *rather* and *pretty*.

1) a. Chris didn't win *a red cent.*
   b. *Chris won *a red cent.*
   c. Sandy hasn't *ever* eaten cheese cake.
   d. *Sandy has *ever* eaten cheese cake.

2) a. *Chris isn't *rather* boring.
   b. Chris is *rather* boring.
   c. *Sandy isn't *pretty* clever.
   d. Sandy is *pretty* clever.

Whereas NPIs may occur in negated propositions as in 1a) and 1c), they are not available in the positive propositions 1b) and d). PPIs, on the other hand, occur in positive propositions like 2b) and d. but are ungrammatical in the negated counterparts 2a) and c). In 1) and 2), the presence of negation constrains whether the environment is suitable for the particular PSI. In general, PSIs are sensitive to various environments: 3) presents several environments in which NPIs may occur some of which are restricted for PPIs.[2] Further such environments are indirect questions, conditionals, comparatives and certain adverbs like, e.g., *rarely* (see Ladusaw 1979 for an overview).

3) a. I doubt that Chris will win *a red cent.* (adversative *doubt*).
   b. Sandy payed the bill without *ever* finishing her drink. (preposition *without*)
   c. Every person who *ever* walked this earth is guilty. (determiner *every*)
   d. Did Sandy *ever* read the newspaper? (question mode)

Analyses of the natural language phenomenon *Polarity Sensitivity* (PS) should provide intuitive answers to the following two problems around which the phenomenon centers, namely the Sensitivity Problem – *Why are PSIs sensitive to their context?* – and the Licensing Problem – *Which environments allow PSIs to occur and how do they do so?* In this paper, after introducing an underspecified approach to semantic scope (§2), I present PSIs as presuppositional elements in §3, and formalize intuitive answers to the Sensitivity and the Licensing Problem in an underspecified semantics. In §4, evidence for the interplay of structural and semantic licensing as formalized in

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[2] I return to the distribution of PPIs and NPIs in §3.

§3 is presented. Also, further motivation for the underspecified treatment of PS is provided by the interaction of PS and semantic scope. §5 concludes the paper.

2 Underspecification and Scope Ambiguities

Consider the proposition in 4) which is ambiguous due to the two possible scope relations of the two quantified noun phrases.

4) Every woodpecker claims a tree.

5) formalizes the two possible readings in Predicate Logic: there either is a specific tree which every woodpecker claims a) or every woodpecker claims some tree which is not necessarily the same as the others claim b).

5) a. $\exists$ x (tree(x) $\wedge$ $\forall$ y (woodpecker(y) $\rightarrow$ claim(y,x)))
b. $\forall$ y (woodpecker(y) $\rightarrow$ $\exists$ x (tree(x) $\wedge$ claim(y,x)))

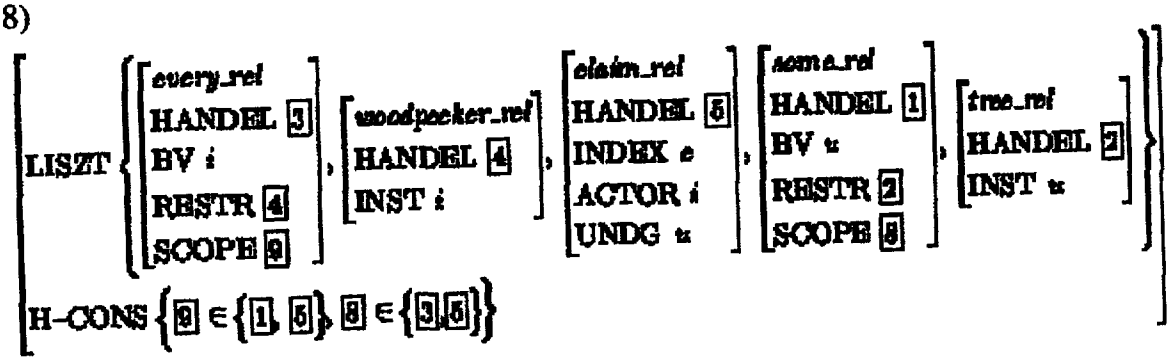
The intended reading of 4) is determined by context. Until sufficient context is provided for, further computations operate on compact, scopally underspecified representations. An underspecified semantics identifies semantic relations by labels. Certain labels may be left underspecified to represent various readings until context resolves the intended one. As an example, the underspecified representation for 4) is given in 6): here, the labels of the scope positions of the two quantifiers are left underspecified. The two possible instantiations in 7a) and b) correspond to the readings in 5a) and b), respectively.

6) *l1*:exists(x,*l2*,*l8*), *l2*:tree(x), *l3*:every(y,*l4*,*l9*), *l4*:woodpecker(y), *l5*:claim(e,y,x)
7) a. *l8*=*l3* and *l9*=*l5*: *l1*:exists(x,*l2*,*l3*), *l2*:tree(x), *l3*:every(y,*l4*,*l5*), *l4*:woodpecker(y), *l5*:claim(e,y,x)
b. *l8*=*l5* and *l9*=*l1*: *l1*:exists(x,*l2*,*l5*), *l2*:tree(x), *l3*:every(y,*l4*,*l1*), *l4*:woodpecker(y), *l5*:claim(e,y,x)

The underspecified semantic formalism used in this paper is Minimal Recursion Semantics (MRS, see Copestake et al. 1997), a variant of the just presented Underspecified DRT (UDRT, see Reyle 1993). MRS represents semantic relations as feature structures and therefore is easily compatible with Head-driven Phrase Structure Grammar (HPSG, see Pollard & Sag 1994), the grammar framework in which the grammar of PS formalized here is presented (see also Tonhauser 1999). The underspecified representation in MRS corresponding to 6) is given in 8).[3] The H-CONS (handle constraints) feature encodes lexical and contextual constraints on possible resolutions of the underspecified structure. H-CONS in 8) encodes the constraints introduced by the quantifiers as in 7a) and b).

[3] The feature LISZT encodes the list of semantic relations, HANDEL labels a semantic relation, the remaining feature names should be self-explanatory.

8)



3 Polarity Sensitivity and Lexical Underspecification

Lexical semantic approaches to PS (see, e.g., Kadmon & Landmann 1993, Tovena 1996, Israel 1996) identify properties of (single or classes of) PSIs which are argued to provide for important insights to the sensitivity and distribution of PSIs. In this paper, I follow up on the analysis presented in Tonhauser (1999) in which the property *scale referring* is identified to account for the sensitivity and distribtion of PSIs: *PSIs refer to a point or range on a contextually specified scale.*[4] Consider 9) and 10), where the NPI *a red cent* and the PPI *rather* refer to a low point on a scale of winning and a high point on a scale of cleverness, respectively.

9) Chris didn't win *a red cent.*
10) Sandy is *rather* clever.

The scale to which a PSI refers is created by certain lexical items in the clause as well as contextual information. The idea of PSIs referring to a scale and certain environments evoking a scale isn't new (see, e.g., Fauconnier 1975; Ladusaw 1979) but has not yet been formally exploited to account for the sensitivity and distribution of PSIs.

Now what if the context doesn't provide for a scale? In this case, the PSI can't be interpreted because the property *scale referring* is not supported. In this analysis, I argue that PSIs are sensitive to the context because they require a scale in the context in order to be interpreted. This provides for an answer to the Sensitivity Problem. Formally, PSIs lexically impose a constraint on the context checking whether a scale is available. If a proposition fulfills the constraint imposed on it by the PSI, the proposition allows for the PSI to be interpreted.

So what are the appropriate scales for a particular PSI? Ladusaw (1979) presents a semantic approach to licensing which characterizes the environments suitable for NPIs by the semantic notion of *downward-entailingness*. PPIs under his approach are available in *upward-entailing* environments or downward-entailing ones without overt negation. Zwarts' (1993) findings further refine Ladusaw's analysis: some downward-entailing environments are also *anti-additive* and some are even *anti-mor-*

[4] The property *scale referring* also characterizes other elements like, e.g., *very*. The lexical property uniquely singling out PSIs is yet to be found.

phic (the three types of environments stand in the subset relation). PSIs are found to be sensitive to the various strengths of environments, not only to downward- or upward-entailingness. See Table 1 for the mathematical definitions of the environments, the various kinds of PSIs and examples of both. The answer to the Licensing Problem under this analysis is the following: PSIs are licensed by operators which provide for an environment suitable for the particular PSI.

Summarizing, PSIs are identified as presuppositional items: they impose a constraint on the context which needs to ensure the availability of an appropriate (as defined by the particular PSI) scale for the PSI. Table 2 summarizes these lexical constraints. The remaining sections of §3 formalize the analysis of Polarity Sensitivity in HPSG/MRS.

operator f	example	(available) PSIs	example
1a. downward-entailing (weak) $\alpha \leq \beta \rightarrow f(\beta) \leq f(\alpha)$	*at most n*	weak NPI weak PPI	*any* *rather*
1b. anti-additive (strong) $f(\beta \vee \alpha) \leftrightarrow f(\beta) \wedge f(\alpha)$	*no one*	weak NPI strong NPI	*any* *yet*
1c. anti-morphic (superstrong) $f(\beta \vee \alpha) \leftrightarrow f(\beta) \wedge f(\alpha)$ and $f(\beta \wedge \alpha) \leftrightarrow f(\beta) \vee f(\alpha)$	*not*	weak NPI strong NPI superstrong NPI	*any* *yet* *a bit*
2. upward-entailing $\alpha \leq \beta \rightarrow f(\alpha) \leq f(\beta)$		weak PPI strict PPI	*rather* *some*

Table 1: Environments and PSIs

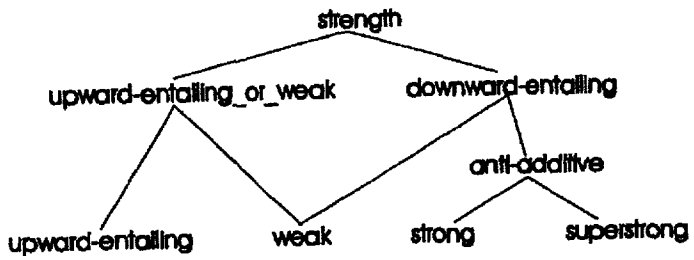
PSI	constraint on context
weak NPI	at least downward-entailing environment
strong NPI	at least anti-additive environment
superstrong NPI	anti-morphic environment
weak PPI	at most downward-entailing environment
strict PPI	only upward-entailing environments

Table 2: Contextual Constraints of PSIs

3.1 Lexical Entries

The type hierarchy in 11) encodes the possible strengths of the operators. It models the subset relation of the environments (cf. Table 1) and thereby allows PSIs to lexically express their minimal requirement on the strength of the environment (cf. Table 2).

11)



12a) presents the relevant part of a lexical entry of a PSI (here, NPI *ever*) and 12b) presents the relevant part of the operator *every* creating a superstrong environment.

12)

a. $\left[\begin{array}{l}\text{LISZT}\left\{\left[\begin{array}{l}\textit{ever\_rel}\\ \text{HANDEL } \boxed{1}\end{array}\right]\right\}\\ \text{H-CONS}\left\{\left[\begin{array}{l}<_{PS}\\ \text{LIC } \textit{handle}\\ \text{PSI } \boxed{1}\\ \text{STR } \textit{downward-entailing}\end{array}\right]\right\}\end{array}\right]$

b. $\left[\text{LISZT}\left\{\left[\begin{array}{l}\textit{every\_rel}\\ \text{HANDEL } \boxed{1}\\ \text{BV } i\\ \text{RESTR } \boxed{2}\\ \text{SCOPE } \boxed{3}\\ \text{LCR}\left[\begin{array}{l}\text{DOM } \boxed{2}\\ \text{STR } \textit{superstrong}\end{array}\right]\end{array}\right]\right\}\right]$

In 12a), the NPI *ever* lexically introduces a constraint on the context in the H-CONS feature. The constraint specifies that the PSI identifed by the handle □ needs to stand in the $<_{PS}$-relation to the handle of some LIC(enser) which is underspecified in the lexical entry. (The $<_{PS}$-relation between handles and the resulting PS-chain are introduced in §3.2.) The constraint models the property *scale referring* of PSIs. *ever* also requires the strength (STR) of the licenser to be at least downward-entailing. The feature LCR in 12b) marks the lexical item *every* as a licensing operator which introduces a superstrong environment in its restriction. The domain feature DOM encodes semantic restrictions on licensing applying to, e.g., determiners and conditionals (see §4). In the formalization, PPIs impose a negative constraint on the context: strict (weak) PPIs impose a constraint on the context ensuring that no downward-entailing (anti-additive) environment is present.

3.2 Constructing the PS-chain

The PS-chain captures the relation in which PSIs and operators stand to each other in the proposition. The PS-chain of the representation of a proposition is the top level value of the feature PS which encodes the $<_{PS}$-relation. PSIs and operators are identifed by the type *ps* which requires them to introduce their relevant handle to the $<_{PS}$-relation 13): PSIs introduce their handle a) whereas operators introduce the DOM handle b).

13)

a. $ps \longrightarrow \left[\begin{array}{l}\text{LISZT}\left\{\left[\begin{array}{l}psi\_rel\\ \text{HANDEL } \boxed{1}\end{array}\right]\right\}\\ \text{H CONS}|\text{PS}\{\boxed{1}\}\end{array}\right]$ b. $ps \longrightarrow \left[\begin{array}{l}\text{LISZT}\left\{\left[\begin{array}{l}ps\_operator\_rel\\ \text{LCR}|\text{DOM } \boxed{1}\end{array}\right]\right\}\\ \text{H CONS}|\text{PS}\{\boxed{1}\}\end{array}\right]$

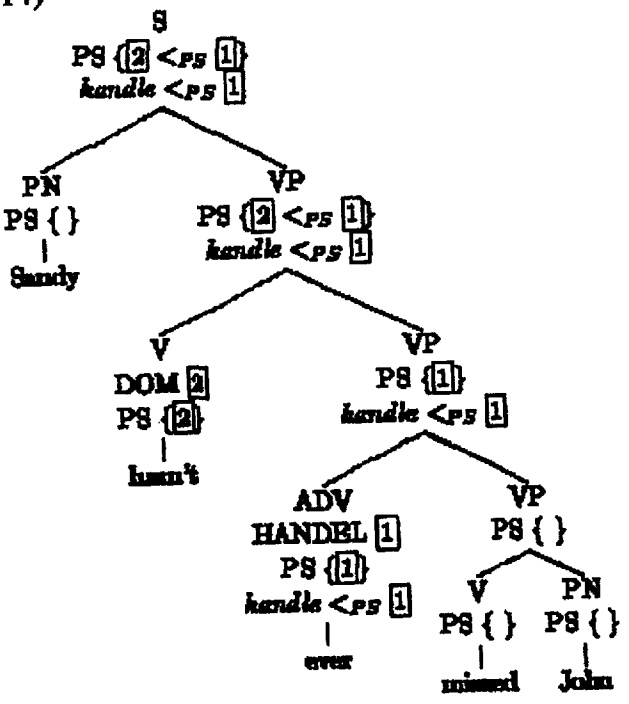
The $<_{PS}$-relation and thereby the PS-chain for a proposition is created by the following rule: The PS-value of a mother is the $<_{PS}$-relation holding between the PS-value of the head daughter and the PS-value of the complement daughter.

As an example, consider the proposition *Sandy hasn't ever missed John* represented in 14). The NPI *ever* introduces an underspecified constraint on the context (*handle* $<_{PS}$ □) which is propagated up to the top of the representation. Negation as well as the NPI introduce themselves to the PS-chain which at the top level is □ $<_{PS}$ □. The resolution component finally needs to check whether the underspecified constraint can be resolved based on the relation encoded in the PS-chain. In 14), the underspecified handle in the constraint of *ever* can be unified with □, the handle of *not*, which stands to *ever* in the $<_{PS}$-relation as indicated by the PS-chain and lexically suits the requirements of *ever* by creating an at least downward-entailing scale. Additionally, resolution needs to adhere to the following constraint:

Constraint PS: Resolved PS-constraints and resolved scope constraints may not express contradicting relations between handles.

The interplay of structural and semantic licensing as formalized here by the PS-chain together with Constraint PS is empirically supported in §4. Furthermore, employing the resolution component in a treatment of PS is motivated by accounting for the interaction of PS and semantic scope.

14)



4 Polarity Sensitivity and Semantic Scope

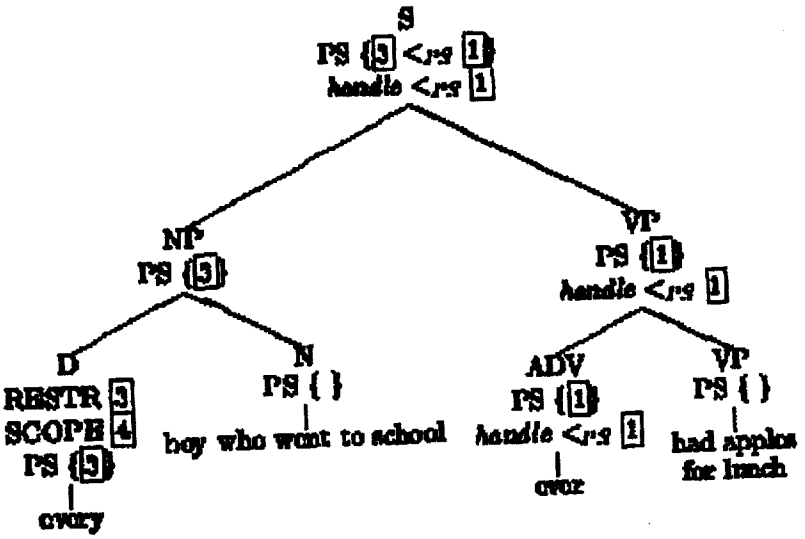
The grammaticality judgements of the examples in 15) with the NPI *ever* are accounted for by *every* only being a licenser in its restriction which is easily captured in the lexicalist, semantic approach to PS by the lexical entry of *every* as given in 12) b.

15) a. *Every boy who went to school *ever* had apples for lunch.
b. Every boy who *ever* went to school had apples for lunch.

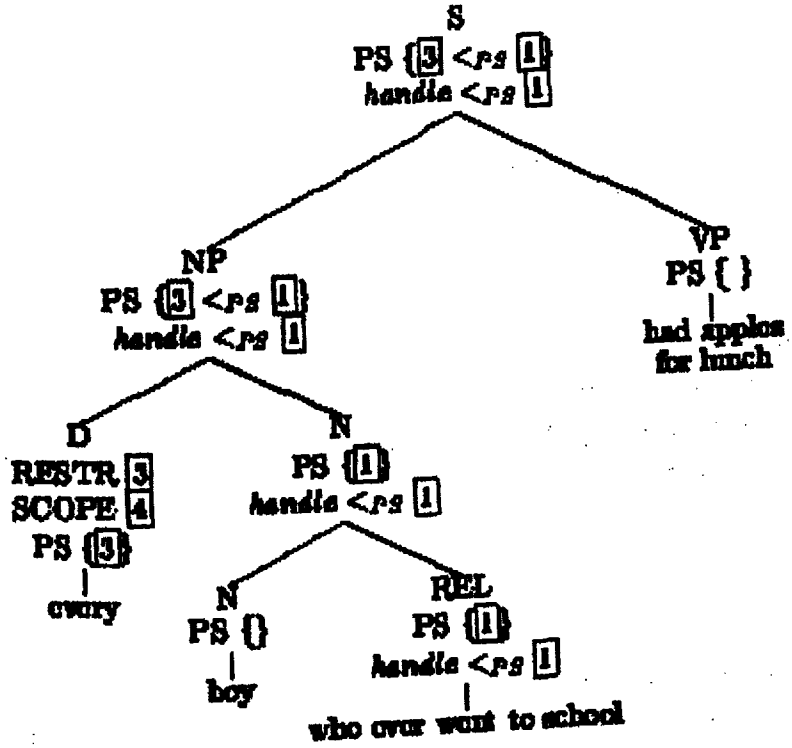
15 a) and b) are analyzed as given in 16a) and b), respectively.

16)

a.



b.

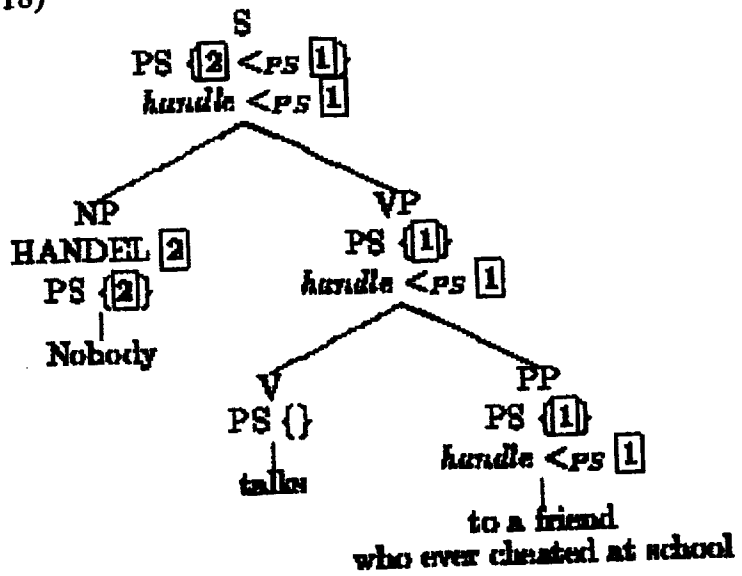


For both propositions, *ever* introduces an underspecified constraint and the PS-chain is [3] <PS [1]. However, 16) a. violates Constraint PS since semantically *ever* is in the scope of *every* and therefore 16) a. is ruled out. The interplay of structural and semantic licensing formalized here overcomes the problems these licensing proposals exhibit in isolation. The final examples in 17) concern the disambiguation of semantic scope by PS constraints.

17) a. Nobody talks to a friend who cheated at school.
b. Nobody talks to a friend who *ever* cheated at school.

Whereas 17 a) is ambiguous between a specific and a non-specific reading for *a friend*, only the non-specific reading is available for b) due to the NPI *ever*. However, for both propositions, the constraints on quantifier scope allow either (i) *nobody* < *a friend* or (ii) *a friend* < *nobody* (notice that for 17b), *ever* always is in the restriction of *a friend*). In the analysis of 17b), given in 18), *ever* additionally introduces the constraint *handle* <PS [1].

18)



Based on the PS-chain, the underspecified constraint can be resolved by the handle of *nobody*. Due to Constraint PS, this is only possible under scope solution (i) thereby singling out the correct reading for 17b). The contextual constraint on resolution introduced by the NPI disambiguates 17b). This variant of interaction between PS and semantic scope, too, is accounted for by the formalization employing underspecification and resolution as presented here.

5 Conclusions

In this paper, I present the presuppositional nature of PSIs in an underspecified semantics. The grammar of Polarity Sensitivity formalizes the empirically motivated

interplay between structural and semantic licensing and accounts for the interaction of Polarity Sensitivity and semantic scope. The interaction provides further motivation for the underspecified treatment of Polarity Sensitivity. Future research might integrate the lexical semantics of individual PSIs to this formalization as presented in, e.g., Kadmon & Landmann (1993) and Tovena (1996) and investigate further on the deiambiguating nature of PSIs.

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