# Deriving polarity effects

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## Abstract

*Polarity Items are linguistic expressions known for being a 'lexically controlled' phenomenon. In this paper we show how their behavior can be implemented in a deductive system. Furthermore, we point out some possible directions to recast the deductive solution into a Tree Adjoining Grammar system. In particular, we suggest to compare the proof system developed for Multimodal Categorial Grammar (Moot & Puite, 1999) with the Partial Proof Trees proposed in (Joshi & Kulick, 1997).*

## Introduction

In this paper we discuss how polarity effects can be derived from controlled lexical items. Polarity Items (PIs) are linguistic expressions which depend on the polarity of their context for grammaticality (Ladusaw, 1979). Moreover, both in the syntactic and semantic traditions their distribution is considered to be 'lexically controlled'. Combining these two claims we can look at PIs as lexical items carrying some sensitivity features from which their restricted distribution derives. Reading out this observation, we can deduce that the needed ingredients to formalize PIs' behavior are: (i) lexically anchored structures, and (ii) operations to compose them. These two points are what is required by the definition of 'lexicalized grammar'. Several are the formalisms which satisfy these properties, among them we distinguish two main groups: Phrase Structure Grammars (e.g. Tree Adjoining Grammars –TAG), and Deductive Grammars (e.g. Multi Modal Categorial Grammar –MMCG). In (Bernardi, 1999) PIs have been studied from a proof theoretical perspective using MMCG as framework.
An interesting question to ask is how the derivations of polarity effects can be recast into Phrase Structure Grammars. Working out a comparison in this sense, will clarify the linguistic meaning of the logical principles at work in the deductive approach, and will open new possibilities of interaction between the two groups. From the one hand, Phrased Structure Grammars are known for being linguistically sensitive formalisms which, however, lack some of the inferential power inherent in the deductive approaches. On the other hand, the latter, are logically well defined, but the formal behavior of its operators might result less intuitive from a linguistic perspective. We believe that a communication between the two families would be productive for both approaches.
In this paper we suggest some possible lines of research which could be worked out to recast the deductive implementation of PIs into TAG. In order to reduce the gap between the two systems we consider the works carried out in (Joshi & Kulick, 1997) and (Joshi *et al.*, 1999), which build a bridge between TAG and MMCG. In the former

paper, categorial grammar proofs are used as building blocks resulting in a 'middle ground' system known as PPTS. In the latter, the comparison is extended to the structural modalities which characterize MMCG.

## 1. Polarity Items

For reasons of space we limit our analysis to Negative Polarity Items (NPIs), i.e. expressions as *yet, at all, anything,* licensed by downward-entailing operators, e.g. *nobody, rarely,* (Ladusaw, 1979). In the examples below NPIs are emphasized and licensers are marked by bold characters.

**Linguistic** data

| | | | |
|---|---|---|---|
| (ia.) | Somebody left. | (iiia.) | Kim **rarely** says *anything at all.* |
| (ib.) | **Nobody** left. | (iiib.) | *Kim says *anything at all.* |
| (iia.) | **Nobody** left *yet.* | (iva.) | **Nobody rarely** says *anything.* |
| (iib.) | *Somebody left *yet.* | (ivb.) | **Nobody** says *anything.* |

These data show that: although NPIs require a negative licenser the converse is not the case (i,ii); the negative context created by a licenser can license more than one NPI within its scope (iii); and NPIs can occur in sentences with more then one licenser (iv). Furthermore, NPIs can occur in more complex structures as well, as shown below:

(va.) **Nobody** thinks Peter did *anything* wrong.
(vb.) *Somebody thinks Peter did *anything* wrong.

(va.) A doctor who knew *anything* about acupuncture was **not available**.
(vb.) *Some doctor who knew *anything* about acupuncture was **not found**.

These example show that NPIs can occur in an embedded sentence while licensed by an expression in the main sentence (v); and that they are felicitous when part of a relative construction which allows to escape the syntactic scope of the licenser, but still force them to be interpreted in its semantic scope (vi). See (de Swart, 1998), where the last example has been proposed and discussed.

## 2. Polarity Items in MMCG

Two well known facts regarding MMCG and PIs are that: MMCG belongs to the family of resource sensitive logic, where the resources are meant as linguistic signs; and PIs are linguistic expressions sensitive to the polarity of their context. We suggest to consider the polarity as a particular feature required by the NPI and produced by the licenser.
This idea has been independently implemented in two different resource logics, namely MMCG (Bernardi, 1999), and Multiplicative Linear Logic (Fry, 1999). In the latter the 'polarity feature' is represented as a proposition $\ell$ assigned to the linguistic categories, of the NPIs and licensers, by means of the tensor operator $\otimes$. The proper function of this operator is to concatenate logical types, or in other words the linguistic resources the logic is reasoning about. When employing it to concatenate the polarity feature to a linguistic category the former is treated as a 'phantom resource'. The language of MMCG is expressive enough to avoid this improper use of the concatenation operator, and of the resource management. A detailed comparison of the two proposals is given in (Bernardi, 2000). In the following we briefly introduce MMCG system and then we show its application to NPI.
Classical Categorial Grammar (CG), has its logical counterparts in the Lambek Calculus (Lambek, 1958). The formal language of this calculus is built on the binary opera-

tors, \, / and •, viz. the directed implication operators and the product one, and a finite set $\mathcal{A}$ of atomic formula, e.g. $\mathcal{A}=\{np, s, n\}$. MMCG is obtained extending this language with unary operators $\Box^{\downarrow}$ and $\Diamond$. We refrain from presenting the logical rules of the whole system which can be found in (Moortgat, 1997) and we comment the logical behavior of the unary operator on which the PIs account is based. Let $\Gamma \vdash A$ stand for the assignment of the category $A$ to the linguistic structure $\Gamma$,

**Logical Rules**

$$\frac{\Delta \vdash \Diamond A \quad \Gamma[\langle A \rangle] \vdash B}{\Gamma[\Delta] \vdash B}[\Diamond E] \qquad \frac{\Gamma \vdash A}{\langle \Gamma \rangle \vdash \Diamond A}[\Diamond I]$$

$$\frac{\Gamma \vdash \Box^{\downarrow} A}{\langle \Gamma \rangle \vdash A}[\Box^{\downarrow} E] \qquad \frac{\langle \Gamma \rangle \vdash A}{\Gamma \vdash \Box^{\downarrow} A}[\Box^{\downarrow} I]$$

Notation: $[*E]$ and $[*I]$ stand for the elimination and introduction of the operator $*$. For our goal the attention should be focused on the introduction rules, which imply that if a structure $\Gamma$ is proved to be of category $A$, then it is of category $\Box^{\downarrow}\Diamond A$ as well, viz. $A \Rightarrow \Box^{\downarrow}\Diamond A$

$$\cfrac{\cfrac{\Gamma \vdash A}{\langle \Gamma \rangle \vdash \Diamond A}[\Diamond I]}{\Gamma \vdash \Box^{\downarrow}\Diamond A}[\Box^{\downarrow} I]$$

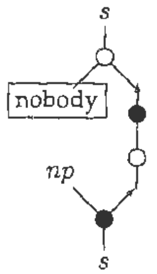
We will profit of this logical property of the system to deal with NPIs. Recolling the information deduced from the linguistic data given above, we know that while a NPI requires a negative licenser, the converse is not true. In our framework this means that the type assigned to the licenser has to derive the type of a lexical item of the same linguistic category but lacking the polarity effect, e.g. if the standard type for general quantifier (GQ) is $s/(np\backslash s)$, then a licenser GQ, as *nobody*, is typed $s/\Box^{\downarrow}\Diamond(np\backslash s)$, this type satisfies the requirement above, namely $s/\Box^{\downarrow}\Diamond(np\backslash s) \Rightarrow s/(np\backslash s)$. The 'polarity feature' is properly represented as a 'property' of the linguistic category by means of $\Box^{\downarrow}\Diamond$. The logical type assigned to NPIs will require to be in a context where this property is provided. Moreover, it will have to account for cases as (iiia), where more then one NPI is licensed by the same licenser. Let us consider the adverb *yet* as an example. The standard adverbial type is $(np\backslash s)\backslash(np\backslash s)$, we enrich it with the the polarity feature obtaining $\Box^{\downarrow}\Diamond(np\backslash s)\backslash\Box^{\downarrow}\Diamond(np\backslash s)$, where the modalities on the goal formula will require the context to be of the right polarity, and the ones on the argument will account for multiple NPIs occurrences.

**Example 2.1** Nobody left yet.

$$\cfrac{\text{nobody} \vdash s/\Box^{\downarrow}\Diamond iv \qquad \cfrac{\cfrac{\cfrac{\text{left} \vdash iv}{\langle\text{left}\rangle \vdash \Diamond iv}[\Diamond I]}{\text{left} \vdash \Box^{\downarrow}\Diamond iv}[\Box^{\downarrow} I] \qquad \text{yet} \vdash \Box^{\downarrow}\Diamond iv\backslash\Box^{\downarrow}\Diamond iv}{\text{left} \circ \text{yet} \vdash \Box^{\downarrow}\Diamond iv}[\backslash E]}{\text{nobody} \circ (\text{left} \circ \text{yet}) \vdash s}[/E]$$

## 3. A possible interaction

In (Joshi & Kulick, 1997) it is acknowledged that the bridge connecting TAG with deductive approaches fails to incorporate the elimination rule for the tensor operator. This might be a problem when trying to recast the way PIs are treated in (Fry, 1999). We have shown that MMCG has the right expressiveness for dealing with this linguistic phenomenon and that the solution is strongly based on the logical properties of the unary modalities. In (Joshi *et al.*, 1999) a translation of the behavior of MMCG modalities into Partial Proof Trees (PPTs) is given and it is claimed that by using PPTs the linguistic phenomena motivating the introduction of these modalities can be handled eliminating them. It could be interesting to see whether this claim hold with respect to the linguistic application here described. A possible way to tackle this question could be to look at the proof nets developed for MMCG and presented in (Moot & Puite, 1999), where they are proved to be sound and complete. In this graph-based proof system, the lexical items are anchored to trees, which are the result of the unfolding of the original types. This remind quite straightforward the idea on which PPTS is based. Below we give the tree assigned to nobody as an example.

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