Types for linguistic typologies. A case study: Polarity Items

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Abstract

This paper describes how in categorial type logics (CTL) derivability patterns among types give a precise way to (i) gain a deeper understanding of the typological classifications proposed in the literature of formal linguistics, (ii) carry out cross-linguistic comparisons, (iii) clarify the consequences predicted by the typologies opening the way to further investigations, and (iv) establish new dependency between linguistic phenomena. In particular, the base logic studied in [2] ($\mathsf{NL}(\diamond, \cdot^{\mathbf{0}})$) is used to elucidate the typology of Greek polarity items discussed in [3] and compare it with Italian data and types. The picture obtained predicts the existence of (i) non veridical contexts which do not license polarity items of the classes considered so far and which could license other sort of polarity items instead; and of (ii) contexts shared by 'negative' and positive polarity items. Finally, it sheds light on a connection between dynamic Montague grammar (DMG) and CTL giving new intuitions about the interpretations of the unary operators of $\mathsf{NL}(\diamond, \cdot^{\mathbf{0}})$.

1 Derivability relations in categorial type logic

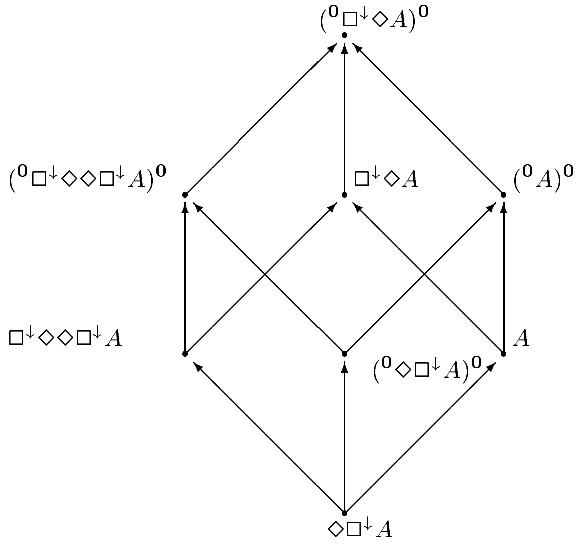
In formal linguistic literature, one finds examples of theories based on classifications of items which belong to the same syntactic category but which differ in some respect. For example, generalized quantifiers have been classified considering the different ways of distributing with respect to negation [1]; a typology of wh-phrases can be given considering their sensitivity to different weak-islands strength [6]; adverbs differ in their order relations [5]; similarly, polarity items have been distinguished by the sort of licensors they require for grammaticality [7, 3].

Our aim is to show how categorial type logic can contribute to the study of linguistic typologies. In particular, we employ $\mathsf{NL}(\diamond, \cdot^{\mathbf{0}})$ to account for the classification of polarity items based on the distinction between veridical and non-veridical expressions proposed in [3]. In this paper we concentrate on the linguistic applications and present only the essential ingredients of the logic system. The reader interested in the logic details of $\mathsf{NL}(\diamond, \cdot^{\mathbf{0}})$ is referred to [2].

Besides functional and compositional connectives ($\backslash, \bullet, /$), $\mathsf{NL}(\diamond, \cdot^{\mathbf{0}})$ has unary operators ($\diamond, \Box^{\downarrow}, {}^{\mathbf{0}}\cdot, \cdot^{\mathbf{0}}$), which can be used to encode the different (semantic) features which characterize items of the same (syntactic) category, e.g. non-veridicality vs. veridicality. Let us introduce this logic briefly. $\mathsf{NL}(\diamond, \cdot^{\mathbf{0}})$ is the base logic characterized by two simple algebraic principles closely connected, i.e. its (unary and binary) operators form either a residuated or a Galois pair. In particular, $\diamond, \Box^{\downarrow}$ form a residuated pair of functions, whereas the other ones ${}^{\mathbf{0}}\cdot, \cdot^{\mathbf{0}}$ are Galois connected operators. More specifically, the former are order-preserving with respect to derivability ($\longrightarrow$), whereas the latter are order-reversing and they are governed by the relations below:

(a_1)	$\diamond\Box^{\downarrow}A \longrightarrow A$	(b_1)	$A \longrightarrow ({}^{\mathbf{0}}A)^{\mathbf{0}}$
(a_2)	$A \longrightarrow \Box^{\downarrow}\diamond A$	(b_2)	$A \longrightarrow {}^{\mathbf{0}}(A^{\mathbf{0}})$

From these simple relations an interesting net of derivability patterns can be derived. The ones we have explored so far are summarized in the picture below which can be extended with a third level applying (b_2) as well.



Moreover, the following equivalences hold. Let (f_1, f_2) be either the residuated or the Galois pair above, $f_1 f_2 f_1 A \longleftrightarrow f_1 A$, and similarly $f_2 f_1 f_2 A \longleftrightarrow f_2 A$. For example,

$$\Diamond\Box^{\downarrow}\Diamond A \longleftrightarrow \Diamond A \quad \text{and} \quad \Box^{\downarrow}\Diamond\Box^{\downarrow}A \longleftrightarrow \Box^{\downarrow}A.$$

Let $F \in \{\Box^{\downarrow}\Diamond\cdot, ({}^{0}\cdot)^{0}, {}^{0}(\cdot^{0})\}$, $FA \longleftrightarrow FFA$, viz. F is a closure operation. For example,

$$\Box^{\downarrow}\Diamond A \longleftrightarrow \Box^{\downarrow}\Diamond\Box^{\downarrow}\Diamond A \quad \text{and} \quad ({}^{0}A)^{0} \longleftrightarrow ({}^{0}(({}^{0}A)^{0}))^{0}.$$

Before going to look at the linguistic applications of this system few comments are in order. Categorial type logic (CTL) fremowork provides a modular architecture to study constants and cross-linguistic variations of grammatical composition, viz. the former are accounted for in the base logic and the latter by means of the structural module. The logic we employ, $\mathsf{NL}(\Diamond, \cdot^{0})$, is the base logic where no extra structural postulates are considered. In the next section we are going to show how its derivability relations displayed in the cube above give the right expressivity to account for the typology of polarity items (PIs) described in [3]. Note that in this case cross-linguistic differences between Greek and Italian PIs distribution are accounted for simply by means of lexical type assignments. A question which stays open is whether the logical type equivalences we have just shown will play a role when extending the fragment of the linguistic items we have considered so far.

2 Typology of Polarity Items

When speaking of PIs a classical reference is the work by Ladusaw [4] where negative polarity items (NPIs) are characterized as expressions requiring to be in the scope of a downward monotonic context (DM). In [7] it is shown

	Veridical	**Non-veridical**	**Anti-veridical**
$f_{(t,t)}$	now/yesterday	perhaps/usually	It is not the case
$f_{(t,(e,t))}$	weak int. vp	too-clauses	
$f_{((e,t),(e,t))}$		will/can	doesn't/without
$f_{((a,t),((c,t),t))}$: 1^{st} ar.	a	no/every	
$f_{((a,t),((c,t),t)}$: 2^{nd} ar.	a		no
$f_{(a,(a,a))}$: 1^{st} ar.	and	or/if	neither ... nor
$f_{(a,(a,a))}$: 2^{nd} ar.	and	or/if	neither ... nor
$f_{(a,(t,t))}$: 1^{st} ar.	before/without		
$f_{(a,(t,t))}$: 2^{nd} ar.	after	before	without

Table 1: (Non-)veridical contexts.

that downward monotonic functions can be classified into subclasses and this classification is reflected on the NPIs which differ in the class of licensor they require. In [3] Giannakidou shows that this classification based on a hierarchy of downward monotonic functions, though on the right track, is not general enough and proposes to enlarge the focus of the lens used to classify the licensors.

In particular, she gives evidence for a typology of PIs described in terms of sensitivity to (non-)veridicality – where quite intuitively a non-veridical expression (NV) is such that it does not entail the truth of the proposition it takes in its scope. The set of non-veridical functions contains as subset the one formed by anti-veridical expressions (AV) which are negation-like operators. We will refer to these two sets as NV and AV, respectevely. Notice that Ginnakidou's analysis does not refuse the previous proposals since in [8] it is proved that downward monotonic functions form a proper subset of the non-verdical ones.

Before going to present the typology of PIs and their account into categorial type logic, let us give a closer look to the classification of the NV which determines the one of PIs. In [8] non-veridicality is defined for expressions denoted by monadic and dyadic functions. Having assumed a categorial type logic perspective offers a deeper understanding of the typological classifications proposed in the literature. It gives a way to extend this definition to n-adic functions and prove the inclusion relation $\mathsf{DM} \subseteq \mathsf{NV}$ considering such extension. For reasons of space, we cannot go into the detail of such aspect and we limit ourselves to give a classification of some (non-)veridical contexts with the corresponding typed functions (Table 1). Note that since a subset relation holds between anti-veridical and non-verdical contexts, all the items which occur in the rightmost column should be repeated in the middle one as well. We can now move to see how PIs interact with these contexts.

2.1 PIs and non-veridical contexts

A first distinction among PIs is given by considering whether they can or cannot occur in veridical contexts (V). The ones which are felicitous in such contexts are considered positive polarity items (PPIs); the ones which are not, are named affective polarity items (APIs). Among the latter a further classification can be made by distinguishing the items which require to be in the scope of an anti-verdical expression, the label of negative polarity items (NPIs) is reserved for them.

An important aspect of this theory is that when an item is sensitive to a certain property `A` and this property is found to be in a subset relation with a more specific one `B` (i.e. $\mathtt{B} \subseteq \mathtt{A}$), the item will then be expected to occur in contexts characterized by `A` as well as by `B`. This is the case of APIs which are felicitous both in non-veridical and anti-veridical contexts. On the other hand, since NPIs are sensitive to anti-verdicality and AV is a subset of NV, NPIs will not be grammatical in non-veridical contexts.

Finally, the relations between an item and the semantic property it depends on can be of different nature. This opens the way to a further classification of expressions belonging to the same sort of sensitivity dependency besides the one given by the set-relation holding between properties we have just considered. Giannakidou defines two possible relations which can be summarized as below[1]. Let SET be either NV, or AV, or V (or any set defined by a semantic property)

1. An item A is *licensed* by an expression $B \in \mathsf{SET}$ iff $\forall C \in \mathsf{SET}$, A is grammatical in the (immediate) scope of C.
2. An item A is *anti-licensend* by an expression $B \in \mathsf{SET}$, if A is ungrammatical in the (immediate) scope of B.

This distinction creates the possibility of having for example PIs which are ungrammatical in veridical contexts, but which do not have to be felicitous in all non-veridical ones. A case in point is *any* which is in an anti-licensing relation with veridicality. If we consider the non-veridical contexts introduced in Figure 1, we see that *any* though forbidden in the veridical contexts is not grammatical, for example, in the scope of perhaps-clause **Perhaps Paul talked to anybody*, whereas it is in most of the other non-veridical contexts.

2.2 Categorial typle logic analysis

In categorial type logic (CTL) the assembly of linguistic expressions corresponds to functional application and therefore to type-matching. In particular, due to the logic property of the functional connectives a structure of type A/B (or $B\backslash A$) will compose with a structure of type B or of any other type C such that $C \longrightarrow B$. This will be the main property we are going to exploit in our analysis of polarity items.

In this light, Giannakidou' s anlysis of NPIs and APIs interaction with NV contexts can be summarized as below, where $\circ$ is the composition operator, Δ[X] means that X is in the structure Δ, and * marks ungrammatical composition.

$$\begin{array}{cc} \mathrm{AV} \circ \Delta[\mathrm{NPI}] & {}^*\mathrm{NV} \circ \Delta[\mathrm{NPI}], \\ \mathrm{AV} \circ \Delta[\mathrm{API}] & \mathrm{NV} \circ \Delta[\mathrm{API}], \\ {}^*\mathrm{V} \circ \Delta[\mathrm{NPI}] & {}^*\mathrm{V} \circ \Delta[\mathrm{API}]. \end{array}$$

Since the polarity must be in the immediate scope of its licensor, we can consider Δ[NPI] to be of type *npi*, viz. the NPI has scope over the whole structure and determines its type, and similarly Δ[API] is of type *api*. Combining this and the observation about functional composition it follows that (i) the type assigned

[1] Besides the licensing vs. anti-licensing condition, Giannakidou distinguishes some items which are licensed indirectly due to the negative implicature given rise by the sentence in which they occur. However, this third case is not relevant for our investigation which mainly concerns the relation between the types of an overt licensor and the sensitive item.

by APIs to Δ[API] derives the one assigned by NPIs to Δ[NPI], (ii) AVs have *npi* as argument, whereas NVs have *api*, and (iii) neither *npi* nor *api* derives the argument type of veridical expressions. Summing up,

$$\text{AV} \in A/npi \quad \text{NV} \in A/api, \quad \text{V} \in A/ppi$$

$$api \longrightarrow npi \qquad npi \not\longrightarrow ppi \qquad api \not\longrightarrow ppi.$$

We leave a general formula A on the value of the licesors'type, since it is not relevant for the understanding of the main idea. Notice that the inclusion relation $\mathsf{AV} \subseteq \mathsf{NV}$ at the heart of the linguistic theory, follows as a consequence from these types, viz. $A/npi \longrightarrow A/api$. Let's make things more concrete by means of an example. In Table 1 we have seen that *yesterday*, *usually* and *it is not the case* are all denoted in the domain $D_t^{D_t}$, hence their (syntatic) category is s/s. In order to account for PIs distribution we need to differentiate these types as explained. In Section 1 we have seen that unary operators give us the right expressivity to account for such distinction. For example, we can consider npi, api and ppi as ${}^{\mathbf{0}}(\Diamond\Box^{\downarrow}s))^{\mathbf{0}}, ({}^{\mathbf{0}}s)^{\mathbf{0}}$ and $\Box^{\downarrow}\Diamond s$, respectevely. Consequentely, *it is not the case* $\in s/({}^{\mathbf{0}}s)^{\mathbf{0}}$, *usually* $\in s/({}^{\mathbf{0}}(\Diamond\Box^{\downarrow}s))^{\mathbf{0}}$ and *yesterday* $\in s/\Box^{\downarrow}\Diamond s$. In this way, the derivability relations stipulated above follow from the logical properties of the unary operators. These types will correctly block a structure contaning a NPI or API (having wide scope) to compose with the verdical expression *yesterday* (see 1(a)-(b) below), and will predict the difference between NPIs and APIs with respect to NV contexts, like *usually* (2(a) vs. 2(b)).

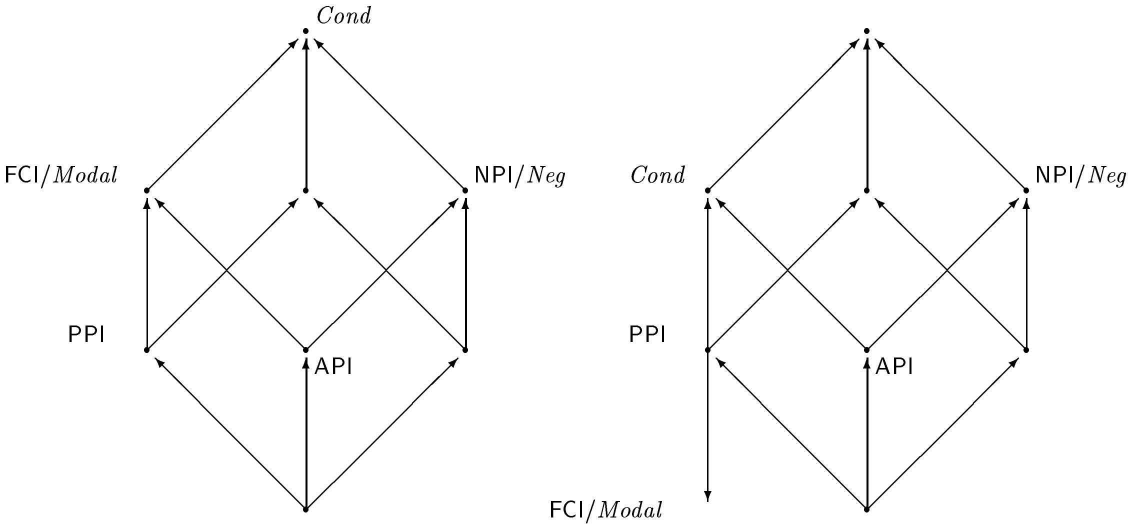
1. (a) *Yesterday I spoke with *anybody* I met.
   (b) *Yesterday I said *a word*.
2. (a) Usually I speak with *anybody* I meet.
   (b) *Usually I say *a word*.

The cube of derivability relations given above offers a much richer hierarchy of types which will allow us to make more fine-grained distinctions among polarity items as actually is required by the linguistic data. In the remainder of this section we will present the results given by the application of this CTL analysis to PIs in Greek and Italian showing how it helps carry out cross-linguistic comparisons. Again, for reason of space we summarize (part of) the data in the tables below and the needed types in the two cubes to be compared with the previous one. The items we have considered are (i) NPI:*ipe leksi*, API: *kanenan*, free choice item (FCI): *opjondhipote*, for Greek; and (ii) NPI: *nessuno*, API: *mai*, FCI: *chiunque*, for Italian.

Greek	FCI	API	NPI
Veridical	*	*	*
Negation	*	Yes	Yes
Modal verb	Yes	Yes	*
Conditional	Yes	Yes	Yes

Italian	FCI	API	NPI
Veridical	*	*	*
Negation	*	Yes	Yes
Modal verb	Yes	*	*
Conditional	*	Yes	*

From this comparison the following conclusions can be drawn: (i) both in Greek and Italian, there could be contexts where both PPI and API are felicitous (e.g. conditionals); (ii) in Italian there could be other sorts of polarity items sensitive to non-veridical contexts like modal verb, and ungrammatical in the scope of conditional and negation. Note that the last point shows how the difference between the two levels of non-veridicality given by $({}^{\mathbf{0}}\cdot)^{\mathbf{0}}$ and ${}^{\mathbf{0}}(\cdot^{\mathbf{0}})$ allows us to account for anti-licensing and licensing conditions. The small framgent of items we have considered is intended to give an example of how the type logic perspective helps clarify the consequences predicted by the typologies and open the way to further investigations.



Greek **Italian**

We conclude by pointing out another potential advantage of CTL analysis which could be explored in further research, namely it helps establish dependency between linguistic phenomena and linguistic theories. In particular, our search for the right lexical type assignments suggests a possible connection between non-verdicality and $({}^{0}\cdot, \cdot^{0})$, and veridicality and $(\Box^{\downarrow}, \Diamond)$. Due to the close relation between (non-)veridical contexts and the (anti-)licensing of discourse anaphora the proposed account sheds light on a connections between the operators $\uparrow, \downarrow$ introduced in dynamic Montague grammar (DMG) and the unary operators of $\mathsf{NL}(\Diamond, \cdot^{0})$. If an expression is in the scope of ${}^{0}(\cdot^{0})$ (and $({}^{0}\cdot)^{0}$) it is closed; if it is in the scope of $\Box^{\downarrow}\Diamond\cdot$ anaphoric links are allowed. Which translated into DMG terms means that $\Box^{\downarrow}\Diamond$ corresponds to $\uparrow$ where $\uparrow \phi =_{def} \lambda p.(\phi \wedge {}^{\vee}p)$ and ${}^{0}(\cdot^{0})$ (and $({}^{0}\cdot)^{0}$) to $\downarrow$ where $\downarrow \psi =_{def} \psi({}^{\wedge}\mathsf{true})$.

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