Maciej Piasecki

The Multidimensional Approach to Quantification and Reference in the Noun Phrase

1 Introduction

Quantification and reference have been a topic of research since a long time approached from many points of view: linguistic, logical, computational (i.e. Artificial Intelligence), etc. Thus the proposed solutions are often: specific phenomena oriented, too partial, too formal (or informal), to become a base for natural language processing applications. The main goal of this paper is to outline a 'unifying theory' combining: quantification, reference and presupposition into one formal model. Obviously, the model is in large extent an eclectic synthesis of existing solutions.

As it was written earlier, the problem of quantification and reference received a lot of attention. Quantification introduced into logic by Frege with works of Montague (Dowty et. al. 1981) and his *PTQ* logic become able to represent properly multi-quantifier structures. The important problem of richness of quantification in natural language seemed to be overcome with works of Barwise and Cooper (Barwise and Cooper 1981) and further development of *Generalised Quantifier Theory* (GQT), e.g. (van der Does 1996).

In linguistics the main concern is devoted to *reference* as the primary notion. Traditionally, reference is even seen as one of the forms of quantification (see the following section). Obviously the inspirations behind this two notions are different:

- quantification deals with relations between sets, relations concerning only numbers of elements and their configurations,
- reference is concerning the relation of linguistic expressions, used in some discourse, to objects (sometimes abstract) known by the hearer.

Many authors argued (e.g. Hess 1989) that it is impossible to model all the meanings of a sentence using only different configurations of quantifiers e.g. «*referential indefinite*» (Hess 1989, 80). In the opposite direction conclusions are even more visible.

The paper begins with a review of the quantification and reference in Polish NP (the author is a native Polish speaker). Then, some fundamental assumptions will be introduced. Finally, a unifying model of the problem illustrated by some examples will be presented.

2 Reference and Quantification in Polish

In English reference and quantification is primarily connected with *determiner*. The notion of determiners is not used in the Polish linguistic literature. Traditionally, 'the determiners' do not even form a unique syntactic category in Polish. However, there is some evidence supporting the informal definition of determiners.

In the elaborated grammar of Polish (Topolińska 1984) (written partially from semantic point of view) *Noun Phrase* (NP) receives the following structure:

[*lexical markers of reference and quantity judgement*] followed by [*kernel phrase*]

where kernel phrase is further subdivided into:

[*predicative and argumentative expressions used as attributive expressions*] followed by [*constitutive constituent*]

The division is made between constituents conveying referential and quantitative information, distinguished by lexical markers, and the kernel phrases conveying the main descriptive content of NP e.g. *tych dwóch nadzwyczaj młodych chłopców*, (*these two extremely*

young boys) where *tych* signals the reference use of NP, *dwóch* is a numeral conveying information concerning quantity (a quantifying word), *nadzwyczaj młodych* is a part of a kernel phrase playing the role of attributive expressions enriching the basic descriptive content introduced by *chłopców* - the constitutive element - around which the NP is built.
The order of elements in the kernel phrase is not restricted, in contrast to the first constituent - where the order: [*reference marker*] - [*quantity judgement marker*] - [*unit name*],
is always preserved and the second position can be filled by more than one word only in case of compound numerals (unit name is used only for mass terms).
Summarising, Topolińska identifies distinct constituents conveying the quantificational and referential aspects of NP meaning, but she does not state explicitly that these two aspects of meaning are separate in their nature.
Grzegorczykowa in book on Polish semantics treats reference and quantification as synonyms (Grzegorczykowa 1995, 120). She presents a complicated but exhaustive semantic classification of different types of NP. which (slightly revised) is presented below:

- used non-referentially e.g. *Jan jest dobrym nauczycielem.* (*John is a good teacher.*)
- used referentially, further subdivided into:

1 concrete - an object is concrete - precisely identified or indefinite
  - 1.1 crypto-definite - subjectively definite
    e.g. *Powiedział mi o tym pewien pan. (A man has told me about it.)*
  - 1.2 indefinite (*jakiś pan – a man*)
  - 1.3 limited definite
  - 1.4 referring to any element of a specified class
  - 1.5 referring to part of a class (minor part) - partial quantification
  - 1.6 logically quantifying - not connecting the predicate with a concrete object but ascribing some object properties denoted by the predicate
    e.g. *Jakiś człowiek w tej chwili umiera. (A man is dying now.)*

2 general - a predicate is referred to the whole class or each instance of a class
  - 2.1 collectively quantifying
  - 2.2 distributively quantifying
  - 2.3 generic

3 intermediate (between the above two) - concrete set.

As mentioned before, the hierarchy above is built on the assumption that reference and quantification are two different names for the same phenomena of natural language. But is this fundamental assumption really true?
From the mathematical point of view, a quantifier is a relation on sets (GQT) presenting:

- independence from the features of the elements of the sets and their orders,
- scope dependencies - the order of quantifiers affects the meaning of the formula.

These two important properties are very often violated by NPs if we do not distinguish between quantification and reference e.g. *Każdy chłopiec kochał się w tej nauczycielce*. (*Every boy was in love with that mistress.*). Any order of NPs in this sentence gives the same meaning: only one women, explicitly referred to, for every boy. There are no scope dependencies between two NPs expressing quantification in their meaning. One can argue that ‘mathematical quantification’ and ‘linguistic quantification’ are two different notions. Then, why do we need to introduce ‘quantification’ as a synonym to ‘reference’ if we cannot use mathematical quantification to describe it formally?

Concluding, there are many cases in which the purely quantificational point of view fails - in many cases the behaviour of NPs cannot be explained within GQT. However, the same is with 'purely referential' approach (e.g. 2.1-2.3). It seems that what we need is to split the notion of 'reference-equal-to-quantification' into reference and (mathematical) quantification as two independent factors of NP meaning.

3 Unified Approach to Reference and Quantification

As it was mentioned it is impossible to explain all phenomena of NP meaning on only the base 'quantificational' or 'referential' approach to natural language semantics. This observation has lead to a unifying approach proposed by Hess (Hess 1989). Hess gives a detailed review of related works and proposes his own "unifying" model for NPs semantics. The work of Hess is based on some assumptions where the most important is the following one:

#"What we seem to need (*M.P. : to deal with attributive/referential distinction*) is a concept which takes into account that natural language is used not to make *true statements about the world* without further purpose, but to communicate information from speaker to hearer, and the information is used by the hearer to *build up a mental model of the world* in his or her head which corresponds to the model in the speaker's head." (Hess 1989,97)#

The main aim of the Hess'es work is to develop a formal model for NP meaning covering all observed uses of NPs. Hess comes to a list of several different functions of NPs (entirely independent of each other), characterised by a set of features:

1. *Dependence*: (Dependent vs. Independent NPs)

- expresses the relation of *cardinality dependency* visible in sentences with more than one quantifying NP, traditionally modelled by the structural embedding of quantifiers.

2. *Set Relationships*: (Set Inclusion or Set Intersection)

From the point of view of GQT, dependence should be distinguished from other set relations possibly expressed by the configuration of NPs e.g. in a sentence: *Some humans are mortal*. - *some* members of a given set belong also to the second.

3. *Specificity*: Specific vs. Non-specific Uses of NPs

This notion receives many different interpretations in the literature. In Hess own definition:

#"It is yet another, and entirely different, function of noun phrases to express whether an object is real or (potentially) imaginary. This distinction can be made in sentences with higher order verbs and sentential complements." (Hess 1989:130)#

The «imaginary objects» means that the object referred to or described by NP must be interpreted in its possible existence and ascribed features according to the speaker. The hearer, on the base of his knowledge about the speaker, can more or less adequately perform this analysis. The non-specific NP must be interpreted in *'subcontext*' connected to the speaker. Objects from a subcontext can not be inferred to exist in reality.

In case of «real object» the analysis is performed according to the knowledge about the world (and to some extent about the language), presumably common for the hearer and the speaker. This distinction is similar to the *de re* vs. *de dicto* distinction found e.g. in Montague (Dowty et. al., 1981). However, Hess argues that specificity is independent from the other features: specificity and referentially (Hess 1989, 85), and specificity and dependency (modelled by structural embedding) (Hess 1989, 87).

4. *Referentiality*: Referential and Attributive Uses of NPs

Referential use of NP indicates that the speaker is able (in declarative, assertive sentences) or the hearer is expected (in questions) to identify the referent. Both definite and indefinite NPs (Hess 1989,80) can be used referentially or attributively. The referential indefinite NP shows that the speaker is able to identify the referent object but the hearer could have not enough knowledge to do this. Attributive NPs speak about features, expressed by the descriptive content of NP and introduce into discourse potentially existing objects.

Not only NPs with articles show the attributive/referential distinction but every other NP can also be classified as preferring of the values e.g. *each*, *every*, *all* - the first is referential, the last is strictly attributive and *every* is ambiguous (Hess 1989,93).

The possible configurations of values of specificity and referentiality are shown in Tab 1. Hess supports all positions with appropriate examples. Thus, it seems that these two independent features form some kind of two dimensional domain of NP meanings.

	specific	non-specific
referential	(a) strongly referential (b) strictly extensional (*each*)	(a) identificational (b) strictly intensional (*bare plural*)
attributive	(a) weakly referential (b) extensional (*every*)	(a) strictly non-referential (b) intensional (*all*)

Tab. 1. Examples of existing relations between referentaillity and specificity.

where (a) point describes different uses of NPs in declarative sentences and (b) questions.

5. *Absolutness*: Absolute vs. Relative NPs

The last two features, originates from GQT. The absoluteness is know in GQT as a distinction between *weak* and *strong quantifiers* (van der Does 1996). Hess relates this distinction to the notion of presupposition (unfortunately undefined in his model):

«Relative noun phrases presuppose the existence of a base set while absolute ones have no such requirement» (Hess 1989, 131)

6. *Totality*: Total vs. Partial NPs

This distinction is based on the observation that the following expression:

$X = \{ x \mid (x \in \mathbf{women}) \wedge (x \in \mathbf{red\_haired}) \}$, where **women**, **red_haired** are appropriate sets, by definition, in GQT always denotes the maximum set of all entities meeting the criteria. Instead, Hess argues that in English the default interpretation for NP: *seven boys* is partial: it denotes any set of seven boys. He continues that the only lexicalised marker to form a total description is the article *the*, e.g. *the dogs* covers all instances of dogs of some context.

In Hess's model each feature 'works' independently for a particular NP. They form a multidimensional space of possible meanings. For two of the features, it is shown in Tab. 1. Nevertheless, in contrast to this 'partial view', not all value configurations are generally allowed. Hess's model is accompanied by its 'computational' version defined in means of logic programming constructions (written in Prolog). However, it appears that not all linguistic ideas could be expressed in the logic programming model. Unfortunately, the very important notions of specific/non-specific use of NP and generic meaning are between them. The definition and role of presupposition in the model is very unclear.

4 Multidimensional Domain of NPs Meanings

The model proposed here preserves the main ideas of Hess. However, it is trying to avoid some drawbacks mentioned earlier. Due to the assumed earlier dynamic approach to the meaning, the meaning of each part of the utterance is identified with the change introduced by it to the knowledge of the hearer. To model this change it seems plausible to introduce Semantic Representation Structures (SRS), similar to structures in DRT (Kamp and Reyle 1993). However, it must be emphasised, that it is not proposed to assume existence of such structures in somebodys mind. SRS models the information communicated by a given utterance but can not be identified with the knowledge possessed by the hearer. Furthermore, SRS must be *embedded* (Kamp and Reyle 1993), i.e. interpreted according to general knowledge possessed by the hearer, to get the final meaning. Further, we will concentrate on changes introduced to SRS by NPs.

Each NP introduces to SRS information conveyed by its descriptive content and creates a *reference marker* (Kamp and Reyle 1993) which is interpreted according to the referentiality of NP. In case of referential NP *a link* between reference marker and an object in *general knowledge model* (GKM) must be created. GKM contains description of (presumably) common knowledge (including objects the hearer is personally acquainted with) and *subcontexts* - models of the knowledge of the speaker(s). Links established with objects in subcontexts allows for modelling referential non-specific NPs. A hearer trusting his speaker can assume existence of objects described by speaker and create their descriptions in his GKM. Concluding, SRS helps us to model different types of relations between referentiality and specificity.

For further investigations, a simplified structure of NP is assumed:

NP = Det + CNP, where **Det** is a determiner (or a combination of determiners), and **CNP** is a kernel phrase (see 2 section) denoting the descriptive content of **NP**. Both constituents plays the different roles in the construction of SRS:

- **CNP** - introduces *a class* – a pattern describing properties of some set of *objects*;
- **Det** – introduces to SRS a semantic operator (DetSO) of a complicated structure, fulfilling different tasks, taking the class introduced by **CN** as its main argument; transforming it to the element representing an entity, a set of entities or the class itself; the exact effect of **Det** is determined by values of the features defined (see below) in Hess like style.

The notion of *class* can be defined informally as *a pattern of objects*. Leaving the question of its proper formalisation open we can postulate several features that it should have:

- *similarity and inheritance relations* allowing gathering many similar classes under the common name (every **CNP** is a label for many *subclasses* differing in minor details);
- description of static features of any object of a given class (e.g. shape, colour, etc.);
- description of rules associated with objects of the given class (e.g. objects behaviour on any stimulus – if any, how to use or apply an object etc.).

An object is a model of some entity (real or abstract), possessing some features, consistent with some classes. The features determining the work of DetSO (meaning of the determiner) are independent of each other and can defined as follow:

1) *Referentiality*: referential vs. attributive,
2) *Specificity:* specific vs. non-specific,
3) *Generality*: type vs. instance (strongly connected to genericness notion),
4) *Quantificational characteristic*:

- collective / distributive/ cumulative, (van der Does 1996)
- cardinality dependence

5) *Presuppositional characteristic - quantifier induced presupposition* (Zuber 1998)
   - typical existential presuppositions,
   - absolute/relative, (Hess 1989) in case of quantifying NPs.

The first two points follow exactly the original proposition of Hess. Quantificational characteristic is based on well developed GQT, only the points 3 and 5 need explanation.
Traditionally, *presupposition of a sentence* (*triggered* by a sentence) (Beaver 1997) is identified with propositions entailed by both: the sentence and its negation. There are many different types of presupposition among them the most interesting for us is *existential presupposition*. Sometimes presupposition is called *the feasibility condition* which must be fulfilled to make the evaluation of the logical value of a sentence possible. Following this idea, presupposition appears to be some kind of *precondition* which must be fulfilled before SRS of the discourse will be modify with the meaning of a sentence. In case of *presupposition failure* some actions must be undertaken to cope with it (e.g. accommodation of presupposition). (Beaver 1997) Recently, Zuber argued that presupposition can be ascribed to determiners ("quantifiers" in his own terms), as well - *quantifier induced presupposition* (Zuber 1998). Preconditions imposed by DetSO are determined by its presupposional characteristic. Mostly they have existential character: existence of an object or set must be assured.
The value of generality is instance when NP introduces objects into discourse e.g. all referential uses in classification of Grzegorczykowa. However, in case of so called "*attributive sentences*" e.g. *Jan jest dobrym nauczycielem.* (*John is a good teacher.*), or typical generic sentences e.g. *Wieloryb jest ssakiem* (*A whale is a mammal*) we are in situation where the underlined NPs denotes classes of entities, representing set of features.

5 Three Layers Model of Determiners Meaning

DetSO can be perceived as an operator performing its tasks on three subsequent levels (or phases of acting): *Reference Level*, *Presupposition Level*, and finally *Quantification Level*. The primary argument of DetSO is *a class* delivered as a meaning of **CNP**.

1. Reference Level

On the reference level DetSO consist of *reference operator*:
ref_op(type/instance, class, context, E_D + E_R) -> set of objects/classes
taking as arguments: type/instance 'switch', a class, a context of utterance and sets of objects from SRS (E_D) and objects from GKM (E_R). The operator returns a set of objects **S** of the given class or a set of classes – subclasses of the given class. The operator 'is looking for' classes when the switch is set to type (generic and descriptive uses) and for objects when the switch is set to instance. In some cases of genericness (e.g. English generic use of *the – the dog*) the set of classes contains exactly one class – the class delivered as the argument. In case of referential NP the operator searches for objects according to context, in case of attributive it returns a set of all objects of the given class. In anaphoric uses, the returned set of objects contains objects found in SRS.

2. Presupposition Level

On this level preconditions defined as a part of DetSO are applied to the set S created earlier. In most cases, the cardinality of the set is checked, and typically it must be one. When

a determiner does not produce quantifier induced presupposition the precondition is just an empty condition (e.g. S=S). As the effect of this level, a logical value is produced. In case of *false* some actions must be performed to enable the further interpretation of an utterance.

3. Quantification Level

Finally, the prepared earlier set **S** becomes one of the arguments of the generalised quantifier (GQ) which models DetOS on this level. The difference between *collective*, *distributive* and *cumulative* uses can also be modelled with the help of GQ, see (van der Does 1994). Moreover, because a quantifier is a relation on sets, the quantifier of the given DetSO taking as one of its arguments the set S, connects it to the second argument created by the other NP and 'delivered' with help of a verb.

6 Examples of Model-based Analysis

Most Polish determiners are ambiguous. However, it seems possible to distinguish one configuration of values of features as *the most preferred reading*. The proposed readings are defined on the base of language competence of the author and are not a final solution.

1) *każdy* - an example of a distributive determiner (Topoliñska 1984):

- precondition of existence of a non-empty set (relative determiner), referential,
- distributive quantifier <u>every</u> Q_E X,Y = { <X,Y> | $X \subseteq Y$}, instance oriented ('specific').

e.g. *Każda książka została zapakowana.* (*Each book has been packed.*)

2) *wszyscy* - typically presented as a collective determiner:

- no precondition of existence of the base set (absolute determiner), attributive,
- collective quantifier <u>every</u> Q_E X,Y = { <X,Y> | $X \subseteq Y$}, instance oriented.

e.g. Wszystkie książki zostały zapakowane (All books have been packed.)

but sometimes presents distributed reading, like in a sentence:

e.g. *Wszystkie książki zostały przejrzane* (*Every book has been looked over.*)

3) *pewien*

There are no articles in Polish but there are lexical markers of indefiniteness: *jakiś*, *pewien*, *ktoś*, *coś*. An especially interesting case is the pronoun *pewien*. It reveals similar semantic ambiguity to English *a*(*n*) and is used in similar syntactic positions. However, its most preferred reading seems to be *crypto-definite* reading (Grzegorczykowa 1995):

- without preconditions of existence, referential,
- distributive quantifier <u>some</u> Q_E X,Y = { <X,Y> | $|X \cap Y| > 0$}, instance oriented.

e.g. Każdy chłopiec kocha pewną kobietę (Each boy loves a woman)

but it can be used as a typical lexical marker of indefiniteness:

- no preconditions of existence, attributive,
- distributive quantifier <u>some</u> Q_E X,Y = { <X,Y> | $|X \cap Y| > 0$}, instance oriented.

4) *jakiś* - complementary to the previous, typically used as 'indefinite determiner':

- without preconditions of existence, attributive,
- distributive quantifier <u>some</u> Q_E X,Y = { <X,Y> | $|X \cap Y| > 0$}, instance oriented.

e.g. *Każdy chłopiec kocha jakąś kobietę.* (*Each boy loves a woman.*)

5) *ten* - a typical demonstrative, strongly referential:

- precondition of existence of a unique object, referential,
- distributive quantifier <u>some</u> Q_E X,Y = { <X,Y> | $|X \cap Y| > 0$}, instance oriented.

e.g. *Każdy chłopiec kocha tę kobietę.* (*Each boy loves this woman.*)

It seems to be impossible to use it attributively.

7 Conclusions and Further Research

The presented work is still in progress. Only an outline of the model was presented which is far away from the final shape. Nevertheless, it is already visible that a wide range of linguistic phenomena can be explained on its base. The model needs an extension to the level of the whole discourse. The information encoded by the positions of NPs in syntactic structure should be included into the model as well.

Literature

Hess Michael (1989): Reference and Quantification in Discourse, not published thesis (*Habilitationsschrift*), University of Zurich.
van der Does Jaap (1994): Applied Quantifier Logic, Doctoral dissertation, ILLC, University of Amsterdam, Amsterdam.
Dowty David R., Wall, Robert E., Peters Stanley (1981) "Introduction to Montague Semantics", Dordrecht: D. Reidel.
Grzegorczykowa Renata (1995): Wprowadzenie do semantyki jêzykoznawczej, PWN, Warszawa.
Kamp Hans, Reyle Uwe (1993): From Discourse To Logic, Kluwer, Dordrecht.
Topolinska Zuzanna (1984): Składnia grupy imiennej (w:) Gramatyka współczesnego języka polskiego, t. 1, Składnia, Warszawa.
Barwise Jon, Cooper Robin, Generalized Quantifiers and Natural Language. Linguistics and Philosophy 4:159-219, 1981.
Beaver David (1997): Presupposition, in van Benthem J., ter Meulen A., editors, Handbook of Logic and Language, Elsevier.
van der Does Jaap (1996): Basic Quantifier Theory in van der Does J. And van Eijck J., editors, Quantifiers, Logic and Language, CSLI Publications.
Zuber Richard (1998): Constrained Functions and Semantic Information, in de Rijke M., Ginzburg J., and Moss L., editors, Logic, Language and Information, vol. III, CSLI Publications, Stanford University.