Quantification in Natural Language.
Review article*

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The project

Quantification is a major module in almost all languages. But what means are available to express it? In English, there are several: determiners (1a), adverbs (1b), 'floating' quantifiers (1c), tense and aspect (1d), among others.

(1) a. All dogs bark.
　　 b. Dogs always bark.
　　 c. The dogs all barked.
　　 d. Dogs bark/barked.

All these examples share the semantic structure in figure . In particular, for
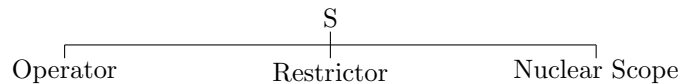
the sentences in (1) the restrictor comes from the noun 'dogs' and the nuclear scope from the verb 'bark'. The quantificational force comes from the operator, which in (1a) is given by the determiner 'all'; in (1b) by the adverb 'always'; in (1c) by the floating quantifier 'all'; and in (1d) by tense or aspect.

It is important to note that in the examples the quantificational elements work on expressions of different type; accordingly the domains of quantification may be quite different. That this is so is especially clear for the transitive sentences (2a,b).

(2) a. A man usually loves a woman
　　　　 $\mathbf{A} : |M \times W \cap L| > |M \times W - L|$
　　 b. Most men love a woman
　　　　 $\mathbf{D} : |M \cap LaW| > |M - LaW|$

In (2a), *usually* operates on the verb *to love*. Depending on one's view on verbs, the corresponding domain of quantification may be cases, events, intervals, or

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other kinds of indices. In (2a) we use Lewisian cases; man-woman pairs to be precise. By contrast, the determiners *most* operates on the noun *men*, and quantification is now over whatever the nominal element denotes (here individuals, with 'LaW' the objects loving a woman). In the book, these forms of quantification are respectively called A- and D-quantification.

Barwise and Cooper (1981) hypothesized that D-quantification is universal.

(3) Every natural language has syntactic constituents (called 'noun phrases') whose semantic function is to express generalized quantifiers over the domain of discourse.

Since generalized quantifier may be obtained from lower level objects like individuals (proper names) or sets (definites), the quantifiers in (3) should be strengthened to those which are 'essentially' set of sets (Thijsse 1983). In this form (3) may look a good candidate, but several papers in the collection *Quantification in Natural Languages* argue that (3) should be rejected. As it happens, quite a few languages only have A-quantification, while D-quantification appears to be scarce.

The book under review grew out of the NSF-project 'Cross-Linguistic Quantification', which started in 1987 at the University of Massachusetts (Amherst). The main concern of the project was to develop 'a broader typological basis for research in semantics and a better integration of descriptive and theoretical work in the area of quantification in particular' (p. vii). In this area of research, there are many interesting questions; for example:

1. Which quantificational resources does a natural language have, and how are they expressed?

2. If a language has different such resources, how are they related?

3. Are there any quantificational universals across natural languages?

The papers in the book try to answer these questions with special emphasis on the third, more typological question. Indeed, most articles concentrate on linguistic issues. The logical aspect of the project's aim to integrate descriptive and theoretical work has remained open.

The papers

We now give a more detailed impression of what the articles in this collection have to offer. Due to limitations of space, we limit ourselves to a selection mostly based on our personal preferences.

EMMON BACH: **A note on quantification and blankets in Haisla**

In this short note Bach sheds some light on how quantification is expressed in polysynthetic languages like Haisla. He holds that Haisla associates A-quantification with affixes, and D-quantification with roots and stems. In general, affix-meanings are adjunctive or functional, but are never argument to such (non-type-shifted?) meanings. An array of Haisla words for *blanket* sustains the claim for A-quantification. These words all end in *aulh*, which Bach translates as: 'completely', 'always', 'all the time', 'all over'.

Mark C. Baker: **On the absence of certain quantifiers in Mohawk**

Baker's main point is that Mohawk does not have a category of quantified NPs as in English. Whatever quantified NPs are—Baker does not explain that— one property they have according to him is that they are non-referential. This makes it possible for Baker to expel *akwéku*, the Mohawk counterpart of the English *all*, from the expressions that have quantificational force: it refers to a set taken together as a group and it does not obey weak-over constraints of the type *His mother loves every child* where the variable involved in *child* may not bind the variable associated with *his*. The same applies to possible Mohawk counterparts of negative quantifying NPs like nobody, nowhere, etc.: there are no such NPs, because the negation element occurs independently. The non-occurrence of quantifying NPs is according to Baker due to the fact that Mohawk is a nonconfigurational language (word order very free, free argument dropping, discontinuous expressions allowed). This freedom is based on a rich and obligatory system of agreement, encoding information about the person, number and gender of the verbal arguments. In short, Mohawk is a pronominal argument language. Baker argues that in English and Italian Left Dislocation structures exclude quantifiers: the pronouns are not variables. Coindexing a dislocated quantifier with a pronoun is excluded for the same reason why coreference in *Everybody$_i$ has a gun. He$_i$ will shoot* is excluded, *he* not being in an argument position. An exception is to be made for wh-NPs in Mohawk: they are quantificational. This also is argued to follow from Mohawk's property of being a pronominal argument language.

Maria Bittner: **Quantification in Eskimo**

Bittner's contribution is on A- and D-quantification in Eskimo. A-quantification is expressed in two ways: (i) by a suffix on the verb, or (ii) discontinuously by an optional adverb of quantification and a obligatory verbal suffix *-tar* (cf. the analogous function of 'if' and 'when' in English). Here, the adverb gives the force of the quantification while the suffix constraints its scope. By default, the suffix on its own has universal, perhaps even generic force. D-quantification may be expressed (i) by phrases, (ii) by verbal suffixes, or (iii) by the discontinuous antipassive construction. The antipassive consists of an optional noun phrase giving the quantificational force and an obligatory verbal suffix to constrain scope. The default force of the suffix is existential.

Despite the great differences in surface structure, there are important similarities between A- and D-quantification in Eskimo and in English. In both languages the corresponding D- and A-quantifiers mainly differ in the kinds of object quantified over (individuals vs. something like Lewisian cases). Also, they both determine the domain of D-quantification by the same mechanisms: context, nominal constituents, relative clauses, or topicalized phrases. Bittner stresses that the heavily polysynthetic Eskimo is a great challenge to compositionality: its exotic surface structure is quite different from the intended semantic representation.

Maria Bittner and Ken Hale: **Remarks on definiteness in Warlpiri**

The literature on the (in-)definiteness effect in the eighties and early nineties focussed primarily on Germanic languages, which have three major lexical categories (N,V,A) and many other lexical categories and subcategories among which determiners, numerals, demonstratives, proper names. Bittner and Hale describe a language having just two lexical categories: Noun and Verb. There is no determiner category: the Warlpiri counterparts of cardinals, *many*, *which ones*, etc. belong to the same category as nouns like *child* do, having the same kind of distributional properties. So, what about (in-)definiteness? Bittner and Hale argue that the source of (in-)definiteness must be semantic rather than be expressed by morphological encodings. They propose to call each noun triply ambiguous, each expressing a definite, indefinite and predicative reading: a Mohawk sentence with the noun *child* as the argument of a verbal group expressing 'I see' may be glossed as (a) 'I see a child' (indefinite); (b) 'I see the child' (definite); and (c) 'I see him/her$_1$m who$_1$ is a child' (predicative). Bittner and Hale think in terms of type-shifting operators bringing about the effect of e.g. definiteness in the case of a definite interpretation. Like so many generativists they stick to first order logical forms and related forms such as Godehard Link's mereological sigma-operator.

Gennaro Chierchia: **The Variability of Impersonal Subjects**

Chierchia analyses the quantificational and anaphoric properties of impersonal *si*-constructions in Italian, see (4) for an example.

(4) *In Italia si beve   molto vino.*
     In Italy si drinks a   lot   of wine.
     'In Italy people drink a lot of wine.'

Here, *si* expresses a non-specific, plural human subject.

    What are the truth conditions for such constructions? Chierchia argues that these truth condition have to comply with six constraints, which have to do with quantificational variability in generic and episodic sentences; quantificational variability in *if/when* clauses; anaphoric behaviour; among other things. At first blush, the constraints suggest that *si* could be interpreted using Krifka's 'generic' extension of DRT, but this not unproblematic. Firstly, DRT's tripartite structures do not comply with linguistically common binary branching. Instead, Chierchia suggests the use of structures such as (5)

(5) [$_{IP}$ [$_{CP}$ Se si$_{arb}$ è alti][$_{IP}$ [$_{ac}$ sempre$_{arb}$][$_{IP}$ si$_{arb}$ è ancje biondi]]]
     'If one is tall, one is also always blond'.

These structures have the virtue of indicating that the material c-commanded by the adverbial quantifier *sempre* occurs within its semantical scope, while all other material remains outside its scope. Secondly, instead of using DRT's novelty condition and existential closure, Chierchia opts for Dekker's existential disclosure. Disclosure has the virtue of applying only to the restriction and scope of adverbs of quantification, rather than to arbitrary environments (as in case of closure). These principles are combined with the simple semantics

$$\text{SI}(P) \equiv \exists x_{arb}[P(x_{arb})]$$

which existential closes the subject argument, and comes with an implicit restriction. In the final section, Chierchia shows that the resulting system explains the behaviour of *si* as delimited by the six constraints.

ILEANA COMOROVSKI: **On Quantifier Strength and Partitive Noun Phrases**

The main thesis argued for in this paper is that definiteness is not a unitary phenomenon: it should be split up in terms of a distinction between the existential use of *there*-sentences and their presentational use. This difference is to be considered as a genuine semantic, i.e. truth-conditional distinction. There is no structural ambiguity: the two interpretations are based on the structure $[_S[_{NP}$ there$][_{VP}$ be NP$_i$ XP$_i$]], but they are subjected to different semantic rules. On the existential interpretation *there* and *be* are grouped together and the postcopular elements are taken together as an NP analogous to a predication rule proposed by Bach and Cooper, which brings the XP under the heading of the postcopular NP. On the presentational interpretation the verb *be* is combined with the XP to form a semantic unit, say YP, having the syntactic form of a discontinuous predicate (which is united by Bach's well-known wrapping rule). YP is thematically dependent on the postcopular NP. On this use of the sentence the *there* is semantically empty. The presentational force of the interpretation requires that the postcopular NP is novel and never anaphoric.

LEONARD M. FALTZ: **Towards a Typology of Natural Logic**

Is there a logical structure appropriate to describe all natural languages? According to Montague Grammar the answer is 'yes': it is the function-argument structure suggested by Frege, and formalised in terms of Intensional Type Theory. However, this apparatus is mainly developed to give the semantics of SVO languages, such as English. Can it also be sustained for non-configurational languages, or pronominal-argument (pro-arg) languages? To this end, Faltz studies the pro-arg languages Lakhota and Navajo. In these languages, there are (almost) no NPs occurring as argument to a verb phrase. Instead, the verb comes with pronominal elements with which Proper Names and the like are coindexed. For example, (6a) means (6b), which indicates that *John* is not an argument to *to play*.

(6)   a.   John śkate (Lakhota); John naané (Navajo)
       b.   John, he played.

Observations like these, besides more complex ones, raise intriguing questions concerning the categorial status of pro-arg languages. Faltz poses the following with respect to Lakhota and Navajo: How should verbs be interpreted (as n-place relations, as propositions)?; Are there any NPs in these languages, and if so, do they denote generalised quantifiers?; If NPs do not denote generalised quantifiers, how is this kind of infromation expressed, if at all? The picture

which emerges is that NP-like configurations do occur, mostly of a demonstrative nature, and that all other quantificational elements are 'floating'. Perhaps the most important point made by Faltz is that the categorial glue suggested by these languages is different from the 'Montagovian' one; it seems that the function-argument structure studied in λ-calculus should be replaced by identification-of-arguments, as in unification systems.

David Gil: **Universal Quantifiers and Distributivity**

Gil focusses on the difference between *all* and *every*, arguing that *all* and its counterpart in other languages is basic in its expression of universal force, whereas *every* is rather idiosyncratic in its behaviour. The unmarked nature of *all* shows up in its possibility to express individual or collective action whereas *every* is marked for its restriction to individual action only. There are five reasons to call distributivity of *every* and its counterparts in other languages when occurring in the external argument position marked: (i) distributivity is a marked phenomenon in general; (ii) *every* occurs in more restricted environments; (iii) *all*, *many*, *few*, *three* require plural agreement, plural anaphoric reference, etc. as opposed to *every*; (iv) in some languages counterparts of *every* are morphologically derived from the counterparts of *all*, but never reversely; (v) cross-linguistically counterparts of *every* are less frequent than the counterparts of *all*. It is time for a general critical remark about the collection of papers exemplified by Gil. He assumes a distinction between distributive key and distributive share without taking the trouble to explain it (It is Partee who explains it on page 564). Obviously the distinction is well-known in the Amherstian environment, but it would be wise for people to evade the impression of writing only for their fellow Amherstians. This is not just one incident but it extends to the citation culture emanating from such a closed shop attitude.

James Higginbotham: **Mass and Count Quantifiers**

This article, familiar to the readers of *Linguistics and Philosophy*, starts the development of a theory of mass quantification as general as that for count quantification. Here, two question come to the fore: (i) in what sense are mass nouns like predicates, and in what sense are they like names?; and (ii) what determines the class of quantifiers that can appear with mass nouns? After sketching the semantic elements, Higginbotham makes the first steps toward a theory of mass quantification; this theory is then applied to LF syntax and other semantic issues.

Higginbotham's theory is based on ordered Boolean algebras with predication formalised as inclusion. He shows how simple generic, conditional, and existential sentences can be interpreted in such structures, as can the predicative use of mass terms. Next, he considers Lønning's homogeneity condition, which states that mass terms can only cooccur with homogeneous predicates (i.e., predicates which are both closed under the part-of relation and closed under finite joins). According to Higginbotham HC is nearly but not entirely universal; a fact which he explains by means of a nominalization operator Σ, which only makes sense for homogeneous arguments.

Following up on these basics, Higginbotham starts to develop a theory of mass quantification. As has been done by others, Higginbotham introduces of

relative sizes to generalise the notion of cardinality available in the count case. He does so in two ways. Firstly, he introduces the notion of a *covering*; i.e., the transitive, symmetric closure of the part-of relation, meaning something like: at least as big as. Secondly, he introduces the notion of a measure μ from elements of the Boolean algebra to the interval of real numbers $[0, \infty)$. The most prominent mass quantifiers are defined within the resulting system. On the more logical side, Higginbotham argues that invariance under isomorphisms in the count case, should be replaced by invariance under Boolean isomorphism that preserve μ in the mass case.

Finally, the formal system developed is applied to LF syntax, articles, and amounts.

HELEN DE HOOP: **On the Characterization of the Weak-Strong Distinction**

Helen de Hoop tackles or enlarges the problem concerning the weak-strong distinction. The latter part of the disjunction concerns the conceptual problem of understanding what it means for a distinction to be made with regard to the determiner of a NP after which it is also applied to the NP itself, dependent on its syntactic environment. The weak-strong distinction at the determiner level is well-known from the literature on generalized quantification every since Barwise and Cooper proposed it. The general picture is that strong determiners may not occur in the position of the dots in *There is/are ... in the X*. However, investigation into the ways in which NPs are to be interpreted shows that interpretation may vary dependent on the position of the NP in a sentential structure. In Dutch sentences of the form (i) [NP$_1$ Aux Adv NP$_2$ V] the weak NP$_2$ may have an interpretation different from the one in (ii) [NP$_1$ Aux Adv NP$_2$ V]; in the latter but not in the former case it may have a strong interpretation. So, there is an interaction between the scope of an adverbial and the interpretation of a quantifying NP. De Hoop describes this phenomenon in some detail. Returning to the opening sentence of this paragraph, we think that De Hoop has discussed and ordered intriguing phenomena adequately, but on the other hand we feel some doubt as to her choice to apply the semantic distinction between determiners to a distinction between NPs. Maybe it is inevitable to see weak and strong as positional properties rather than as inherent properties, but perhaps a new set of terms should be coined in order to keep the two sets of oppositions apart.

PAULINE JACOBSON: **On the Quantificational Force of English Free Relatives**

Jacobson's thesis is that free relatives in English like *I ate what John ordered* should not be analyzed in terms of a *wh*-element as the head of the NP preceding the relative clause RS. Rather she assumes an analysis in which *wh*- and RS form a unit WH of type $\langle e, t \rangle$ which is type-lifted into an NP of type $\langle\langle e, t \rangle, t \rangle$. The aim of the paper is to defend the latter analysis. To that end Jacobson develops a theory of plurality based on Link's mereological approach (although it seems to have Scha-like properties cf. p. 471). She claims that *what John ordered* is vague between atomic entities (he might have ordered something paraphrasable

as a singular definite) and proper plurals (he might have ordered a set of entities paraphrasable as a universal).

ELOISE JELINEK: **Quantification in Straits Salish**

This is one of the volume's core articles. Jelinek argues that Straits Salish has A-quantification but no D-quantification. To do so, she first shows that Straits does not distinguish between nouns and verbs; it has just predicates whose arguments positions can only be satisfied by pronouns and variables (both definite). There is, however, a small closed class of adverbials that express quantificational notions by taking scope over such predicate/argument structures. Their scope could extend over several arguments, so that quantification is polyadic. Also, the adverbials may take scope over each other.

The predicates may occur as lexical heads of a determiner phrase (cf. the restrictor in an English determiner phrase). The class of determiners in Straits is restricted to some pronouns and demonstratives. In particular, it does not contain weak determiners – such as: numbers, *some*, *many*, *few*, ... – or strong quantifiers – such as : *each*, *every*, *most*, *all*, ... Indeed, the function of weak determiners is (partly) taken over by predicates (cf. the predicate *to be many*). Strong quantifiers are expressed by adverbials.

In Straits, determiner phrases do *not* occur as arguments of a predicate. Instead they are adjoined structures which are coindexed with pronominal arguments. E.g., where in English *the two men* appears as an argument of the verb *to work*, as in (7a), Straits would have an adjoined phrase coindexed with the pronominal *they*, as in (7b).

(7) a. The two men worked.

  b. They worked, the two men.

The determiner phrases can both be definite and indefinite (as is also observed in the controbution of Bittner and Hale). (In)definiteness depends on the pronoun they are coindexed with.

All in all, we learn that D-quantification is absent in Straits Salish; quantification is unselective A-quantification.

BARBARA PARTEE: **Quantificational Structures and Compositionality**

Barbara Partee provides a general overview of the issues involved in the analysis of quantification. As observed above the notion of A-quantification has been developed on top of the existing notion of D-quantification. So on the basis of the tripartite structure it turned out to be the case that two ways of quantification are avaialable. So questions like 'Two or more?', 'Can they be reduced to one general possibly more abstract pattern of organizing information?', 'What about Barwise and Cooper's universals?', etc. Partee surveys discussions about different languages (Salish, American Sign Language, Warlpiri) with respect to which these questions are naturally posed. She also pays attention to the variety of structural means available in languages for expressing non-D-quantification by discussing relational quantification such as proportional quantification, distributivity. She develops the notion of a biclausal structure with higher order

predicates or operators expressing quantification. Other quantificational structures are reviewed as well such as those related to focus and topic marking, and quantifiers as morphological operators on verbs. The leading question in this paper is how to observe the principle of compositionality given the many different ways in which quantification can show up structurally without an immediate grammaticalization.

KAREN PETRONIO: **Bare Noun Phrases, Verbs and Quantification in ASL**

This paper is on the interaction of bare plurals (such as *women* in: *women love movies*) with the three classes of verbs available in American Sign Language (ASL). The classes are: plain verbs, agreement verbs, and spatial verbs. Disregarding the generic use of bare plurals, it is shown that the quantificational force of a bare NP varies with the type of verb it is combined with. This part of the short study mainly belongs to descriptive linguistics, and as such it seems valuable. Petronio suggests that for the ASL sentences considered the semantics can be given using familiar techniques: bare plurals are variables varying over a Linkian algebraic domain, which 'receive' quantificational force from Heimian closure.

CRAIGE ROBERTS: **Domain Restriction in Dynamic Semantics**

Roberts studies the issue of domain restriction, which affects several types of operator: quantificational determiners, adverbs of quantification, modals, tenses, focus-sensitive particles. An example with an adverb of quantification is (8).

(8) On sunny days, Ali worked in the garden. Jessie generally ran in the park.

Here, Jessie generally ran in the park *on sunny days*.

The questions are: What kind of phenomenon is domain restriction?; and: How can it be captured formally? According to Roberts the answers are: domain restriction is pragmatic, presuppositional; and it should be captured in terms of Lewisian accomodation using syntactic, semantic, and various kinds of pragmatic information (such as common ground).

To make her point, Roberts first argues *against* an anaphoric approach to domain restriction, as available in The Dynamic Montague Grammar of Groenendijk and Stokhof. Roberts' main argument is that the DMG treatment depends too much on syntactic details of the formalisations chosen. Indeed, a purely structure-driven account seems impossible, since non-structural pragmatic factors play a crucial rôle, too. To argue *in favour of* the position that domain restriction is presuppositional, she gives examples to show that, like the familiar presuppositions, domain restrictions do not always project. For instance, (9a; our example) presupposes the hearer to be familiar with the domain of quantification, while (9b) has no such presupposition.

(9) a. Some prefer communism.
     b. If Chinese vote, some prefer communism.

Similar filtering effects can be detected, be it with more difficulty, in case of focus-sensitive particles such as *only*.

Our opinion

The articles in this book are of high, sometimes even of very high quality. The two volumes offer a wealth of linguistic insights on the quantificational resources of human languages, insights which often work as eye openers. Anybody interested in natural language quantification should study this book, if only to find stimulating ideas to start or continue one's own research.

This is not to say that the collection leaves nothing to be desired. Firstly, at the semantic level there is a strong bias towards a particular kind of explanation: the semantics of D-quantification is mainly explained using the theory in (Barwise and Cooper (1981)); the semantics of A-quantification is often seen as an instance of Lewis/Heim/Kamp-unselective quantification; generic phenomena confirm theories of Carlson, Kratzer, and Krifka. Of course these theories are important in the development of formal semantics, but to use them as a kind of default explanation seem to us a rather unhealthy attitude. Indeed, one rather expects that the often exciting insights into the quantificational structure of natural language would lead to new approaches to formal semantics.

Secondly, sometimes theories are used to 'explain' phenomena which could also have been explained with traditional formalisms. For example, in some of the articles DRT is used as a typical formal language which sustains a pro-arg structure. But it shares this property with most formal languages. Since Lindström (1966) (simple) quantificational formulas are of the form

$$Qx_1 \ldots x_n.\varphi$$

Here, φ is a formula in which the variables occur as arguments to atomic formulas, the quantifier is adjoined to φ and coindexed with the arguments of predicates by means of variables. This is just as a pro-arg language would have it. (A notable exception to this scheme is of course Montague's higher-order language in which quantifiers may truly occur as an argument of the verb.) The most important difference between natural pro-arg languages and formal quantifier languages seems to be that in the first the quantificational element need not have scope over the predicate. In this respect, however, standard DRT is best seen as a formal language on a par with quantificational languages.

Thirdly, the lack of hints at new approaches to semantics may be due to the fact that the stress is almost entirely on non-logical, linguistic work. It would have been helpful if at least some more formal developments were included, say, on the possible ways in which the notion of A-quantification may be formalised. Here, the insights in the semantics and pragmatics of polyadic quantification could be of much help, but this research is ignored almost entirely (cf. Higginbotham and May (1981), Keenan (1987), Keenan (1992), Keenan (1996), Van Benthem (1989), May (1989), Westerståhl (1987), Westerståhl (1994), Sher (1990), Spaan (1996), among others).

All in all we think the present book will challenge people working in congenial areas of semantics, who might want to attempt answering such questions as:

1. Which notion of quantification is needed to formalise the quantificational structure of the languages reported on?

2. How expressive are the resulting quantifier logics?

3. How do the domains associated with restrictor and nuclear scope affect quantification (e.g., quantification over case vs. quantification over other kinds of indices)?

4. Are there any interesting calculi for fragments of the quantificational resources?

This kind of research might keep us occupied for some years to come. But it can only be fruitfully pursued after a thourough studies of *Quantification in Natural Languages*.

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