Inverse Linking without LF-Movement: A Dependent Type Account

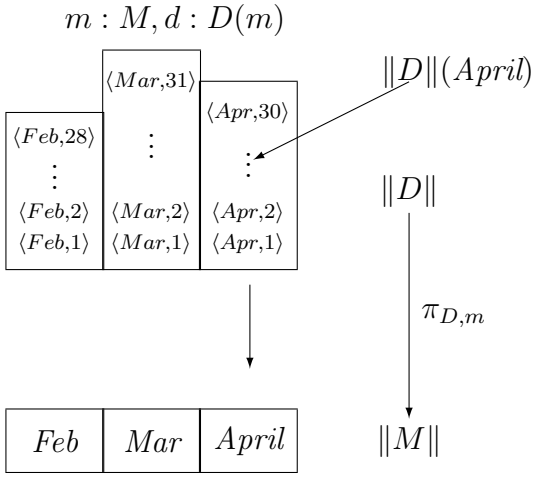
Justyna Grudzińska and Marek Zawadowski

Overview. Inverse linking constructions (ILCs) refer to complex DPs that contain quantified NPs (QPs), as illustrated in (1):

(1) A representative of every country missed a meeting.

ILCs like (1) have been known to be ambiguous between a surface scope reading and an inverse scope reading. On the surface reading, (1) is understood to mean that there is some one specific representative who represents every country and who missed a meeting. On the inverse reading, (1) is understood to mean that a different representative of each country missed a potentially different meeting in each case. Standard analyses of ILCs involve LF-movement ([10], [11], [5]) and have been claimed problematic on several grounds (for the discussion, see Zimmermann in [13], [14]). In this paper, following Zimmermann, we adopt the position that ILCs are structurally ambiguous at surface structure: the two readings of ILCs derive from the two (string identical) surface structures distinguished in [13] and [14]. But whereas the surface structure corresponding to the inverse reading has been interpreted using a non-fully compositional procedure in [13] and [14], we will show that it can be interpreted in a non-ad hoc fully compositional way in our semantic framework with dependent types.

Dependent type semantics. At the heart of our analysis is a dependent type theoretical approach ([8], [9], [7]). The two key features of our approach are: many-sorted (many-typed) analysis and type dependency. Our analysis is many-sorted in the sense that it includes many basic types (e.g. type *M(an)*, type *W(oman)*, ...). The variables of our semantic system are always typed. We write $m : M$ to denote that the variable m is of type M. Types are interpreted as sets. We write the interpretation of the type M as $\|M\|$. In a system with many types, types can depend on the variables of other types. One example of such a dependence of types is that if m is a variable of the type of months M, there is a type $D(m)$ of the days in that month



If we interpret type M as a set $\|M\|$ of months, then we can interpret type D as a set of the days of the months in $\|M\|$, i.e. as a set of pairs

$$\|D\| = \{\langle a, k\rangle : k \text{ is (the number of) a day in month } a\}$$

equipped with the projection $\pi_{D,m} : \|D\| \to \|M\|$. The particular sets $\|D\|(a)$ of the days of the month a can be recovered as the *fibers* of this projection (the preimages of $\{a\}$ under $\pi_{D,m}$)

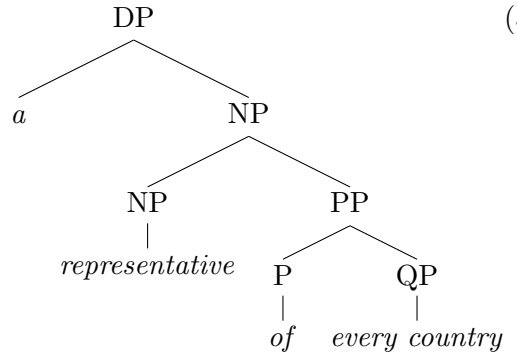
$$\|D\|(a) = \{d \in \|D\| : \pi_{D,m}(d) = a\}.$$

Our semantic system makes no use of assignment functions: variables serve to determine dependencies and act as an auxiliary syntactic tool to determine how the operations combining interpretations of QPs and predicates are to be applied. Our proposal belongs with the group of modern type-theoretic approaches ([12], [4], [6], [3]). The main novelty of our proposal is in combining generalized quantifiers with dependent types and thus introducing quantification over fibers (e.g. quantification over the fiber of the days of April, as in *most days of April*).

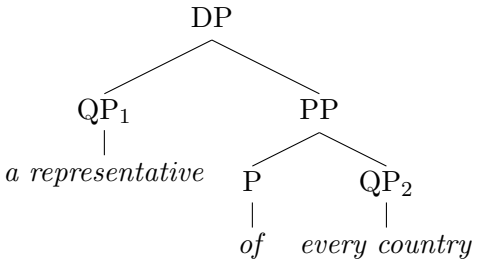
Common nouns (CNs). Two kinds of CNs can be distinguished: sortal and relational. Whereas in the Montagovian setting sortal CNs (e.g. *man*, *woman*) are interpreted as one-place relations (expressions of type $\langle e, t\rangle$), in our dependent type theoretical framework they are treated as types. For example, *man* is interpreted as the type M/set of men. CNs modified by postnominal modifiers, e.g. *man who represents every city*, are also interpreted as types, e.g. as the type/set of men representing every city. In the Montagovian setting relational CNs (e.g. *representative*) are interpreted as two-place relations (expressions of type $\langle e, \langle e, t\rangle\rangle$). Our framework allows us to treat them as dependent types, e.g. *representative* (as in *a representative of a country*) is interpreted as the dependent type $c : C, r : R(c)$/for any element a in the set of countries $\|C\|$, there is a set (fiber) $\|R\|(a)$ of the representatives of that country. Importantly, we propose that relational CNs undergo 'relational-to-sortal' shifts when used with regular postnominal modifiers, as in structure (2) below ('sortal-to-relational' shifts are also possible when sortal CNs are used in structures like (3) below).

Two surface structure analyses of ILCs. The two readings of ILCs derive from the two surface structures (SSs) in (2) and (3) (here we adopt the assumption that indefinites are quantificational expressions but our proposal also can be made to work on the adjectival theory of indefinites).

(2)



(3)



On the surface reading (SS2), the prepositional phrase (PP) stands in the sister position to the head nominal *representative*. The relational CN *representative* undergoes a 'relational-to-sortal' shift when used with a regular postnominal modifier (as in SS2). The complex NP (CN modified by the postnominal PP) *representative of every country* is interpreted as the type/set of representatives of every country and the DET *a* quantifies existentially over this set, yielding the surface ordering of quantifiers. On the inverse reading (SS3), the PP is right-adjoined to the QP consisting of the head nominal. Crucially, the head nominal *representative*

is now interpreted as the dependent type $c : C, r : R(c)$; the preposition *of* signals that *country* is a type on which *representative* depends (our treatment of prepositions is inspired by [1]); *country* is interpreted as type C. By quantifying over $c : C, r : R(c)$, we get the inverse ordering of quantifiers (quantification over fibers is treated on a par with quantification over sets interpreting any other types)

$$\forall_{c:C}\exists_{r:R(c)}$$

(for every country a in the set of countries $\|C\|$, there is at least one representative b in the corresponding set (fiber) $\|R\|(a)$ of the representatives of that country)

By making the type of representatives dependent on the type of countries our analysis forces the inversely linked reading without positing any extra scope mechanisms.

References

[1] Barker, C.: Possessives and relational nouns. In: C. Maienborn, K. von Heusinger and P. Portner (eds). Semantics: An International Handbook of Natural Language Meaning. Berlin: De Gruyter Mouton (2011).

[2] Barker, C., Shan, C.c.: Continuations and Natural Language. Oxford Studies in Theoretical Linguistics (2014).

[3] Bekki, D.: Representing anaphora with dependent types. In: Asher N, Soloviev S (eds). Logical Aspects of Computational Linguistics. Lecture Notes in Computer Science, vol. 8535, Springer, 14-29 (2014).

[4] Cooper, R.: Dynamic generalised quantifiers and hypothetical contexts. In: *Ursus Philosophicus*, a festschrift for Björn Haglund. Department of Philosophy, Göteborg University (2004).

[5] Larson, R. K.: Quantifying into NP. Manuscript (1985).

[6] Luo, Z.: Formal Semantics in Modern Type Theories with Coercive Subtyping. Linguistics & Philosophy 35, 491-513 (2012).

[7] Makkai, M.: First Order Logic with Dependent Sorts, with Applications to Category Theory. Preprtint McGill University (1995).

[8] Martin-Löf, P.: An intuitionstic theory of types. Technical Report. University of Stockholm (1972).

[9] Martin-Löf, P.: Intuitionistic Type Theory. Bibliopolis (1984).

[10] May, R.: The Grammar of Quantification. PhD thesis. MIT (1977).

[11] May, R.: Logical Form: Its Structure and Derivation. MIT Press (1985).

[12] Ranta, A.: Type-Theoretical Grammar. Oxford University Press, Oxford (1994).

[13] Zimmermann, M.: Boys Buying Two Sausages Each — On the Syntax and Semantics of Distance Distributivity. LOT Dissertation Series 62. Utrecht (2002).

[14] Zimmermann, M.: Inverse Linking without LF-movement. In: L. Carmichael, C. -H Huang, V Samiian (eds). Proceedings of WECOL 2001. CSU Fresno, Fresno, California (2003).