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Telescoping by Continuations

1 Overview

The term “telescoping” has first been used in Roberts (1989) to describe cases like (1) in which the pronoun in (1b) seems to be bindable by a universal quantifier occuring in the preceding clause (1a):

(1) a. Each degree candidate walked to the stage

b. He took his diploma from the Dean and returned to his seat

These cases are not handled by standard theories of dynamic binding (cf. Groenendijk & Stokhof 1991), although the conditions on binding can be relaxed (and assimilated to the conditions for indefinites) so that at least in principle the required kind of binding becomes feasible.

Unfortunately, the exact conditions that enable anaphoric relations by telescoping have not been sufficiently explored, and this paper does not contribute much to the issue. Instead, I want to draw attention to another type of telescoping that seems even more intriguing than the original one, namely the possible binding relations in (2):

(2) The picture of his$_i$ mother that every soldier$_i$ kept wrapped in a sock was not much use to him$_i$

Here, the potential binder is embedded in a relative clause, but nonetheless the universal quantifier inside that clause seems to be capable of binding the specifier of the DP *his mother*. As these relations are far from local, an analysis along the usual lines of dynamic binding seems out of reach. However, it will be shown in this paper that a certain variant of dynamic binding — one which may be called “delayed binding” — together with continuation theory as proposed by Barker (2002) can be combined in such a way as to make an *in situ* analysis of (2) at least feasible.

Before putting forth such an analysis we have to investigate the syntactic structure of (2), in particular the relation between the relative clause and its head. This immediately relates to the topic of the volume, namely so-called “internally headed relative clauses”, and the question of whether assumptions entertained

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in connection with the semantics of such clauses could provide for an (at least partial) solution of the problem. We will show that this is not the case and then develop a solution of our own.

2 Introducing internally headed relative clauses

Turning first to the syntax of relative clauses, let me remark that the current success of minimalist syntactic theories seems to be proportional to their degree of abstractness and the resulting number of wrong predictions. A case in point is relative clauses in Kayne's Antisymmetric Syntax, cf. Kayne (1994). Consider the structures in (3), with "RC" short for the relative CP:

(3) a. $[_{DP}$ D $[_{NP}$ NP RC]]
 b. $[_{DP}$ $[_{DP}$ D NP] RC]
 c. $[_{DP}$ $[_{D'}$ D NP] RC]

None of these configurations, which have been proposed in the literature, would be compatible with Kayne's Linear Correspondance Axiom LCA. Kayne therefore resurrects Vergnaud's (1974) raising analysis by assuming that the head of the RC is positioned in the specifier of a CP and has been moved there from inside the RC, as illustrated in (4):

(4) a. $[_{DP}$ D $[_{CP}$ NP$_i$ $[_{C'}$ ... t$_i$ ...]]]
 b. $[_{DP}$ the $[_{CP}$ man$_i$ $[_{C'}$ (that) $[_{IP}$ I saw t$_i$]]]]

That way, the RC becomes a C′ with the effect that now, with no adjunction to the right being involved, the structure is consistent with the LCA. This analysis has become known as the internal head analysis of RCs and the construction itself is called an internally headed RC.

Empirical motivation for this analysis has been derived from diverse domains including data from binding theory as in (5);

(5) the interest in *each other* $[_{C'}$ that *John and Mary* showed t]

data involving bound variables as in (6);

(6) The relative of *his*$_i$ $[_{C'}$ that *everybody*$_i$ likes t] lives far away

data involving idiom reconstruction as in (7);

(7) the *headway* $[_{C'}$ that we *made* t] was satisfactory

and many others. In each case it would seem that the data can easily be explained by the raising analysis because the head of the RC (i.e. the item moved to SpecCP) can be interpreted at the position of its trace.

However, the theory has to face a number of serious objections. One is the obvious fact that the morphology of the head noun does not match that of the trace. For example, in a language like German, the head noun could be nominative while the trace is accusative. Moreover, a raising analysis would have to stipulate otherwise unattested movement operations, as illustrated in (8):

(8) [$_{DP}$ der [$_{CP}$ [$_{PP}$ Tag$_i$ [$_{P'}$ an [$_{DP}$ dem t$_i$]]]$_j$ [er t$_j$ ankam]]]
the day on which he arrived

In (8), one first has to move the PP *an dem Tag* into the SpecC position, but this is not sufficient because word order is still incorrect. Therefore subsequent movement of the NP *Tag* to SpecPP must apply. However, this movement is otherwise unmotivated and it appears to induce an island violation, cf.

(9) * Tag$_i$ komme ich [an dem t$_i$]
day come I on that

These and many additional problems are discussed in Webelhuth, Bargmann & Götze (this volume).

As a way to overcome these difficulties a modification of the raising analysis has been proposed, the idea being that there is no movement into the head position but a kind of matching between the head and some invisible material in the SpecC position — a "matching" that must explicitly be allowed to ignore morphological mismatches or island conditions, as shown in (10):

(10) [$_{DP}$ der$_{nom}$ [$_{NP}$ Tag$_{i,nom}$ [$_{RC}$ [$_{PP}$ an [$_{DP}$ dem$_{dative}$ ~~Tag$_{i,dative}$~~]]$_j$ [$_{IP}$ er t$_j$ ankam]]]]

The details of the new theory need not concern us here, since the matching analysis still assumes that the relevant copy for interpretation is the lower one at the trace position t$_j$. There still remain an impressive number of counterarguments against both theories; we cannot go into the details here (cf. again Webelhuth, Bargmann & Götze this volume). Let me just mention Martin Salzmann's dissertation and the work by Caroline Heycock (this volume), where it is shown that the potential reconstruction site (the trace t$_j$) does not exhibit any condition C effects:

(11) That is the [only picture of *Kahlo*$_i$]$_j$ that they say *she*$_i$ was ever willing to look at t$_j$

(12) die [Nachforschungen über *Peter*$_i$]$_j$ die *er*$_i$ mir lieber t$_j$ verschwiegen
the investigations about Peter which he me prefer concealed
hätte
had
'the investigations about Peter$_i$ that he$_i$ would have rather concealed from me'

In both examples we would expect a condition C violation if the solution to the above problems is reconstruction (or a copy) at LF. But at LF — the only level of representation for structural conditions in a minimalist theory — no such effect can be observed: the sentences are fully grammatical. It seems, therefore, that the reconstruction site is irrelevant for Binding Theory and that the observed Principle A effects should be handled along the lines of Reinhart & Reuland (1993), i.e. as either logophoric (for *picture*-nouns) or in a semantically driven way that takes into account the argument structure of nouns like *interest*, as proposed in the early days of Binding Theory (cf. Ross 1967).

As concerns idiom reconstruction, it has been observed by Gazdar et al. (1985: 238) that the second conjuncts in (13) still carry an idiomatic meaning:

(13) a. My goose is cooked, but *yours* isn't
b. We had expected that excellent care would be taken of the orphans, and *it* was taken
c. I said close tabs would be kept on Sandy, but *they* weren't
d. We thought the bottom would fall out of the housing market, but *it* didn't.

Here, ordinary pronouns seem to "pick up" idiomatic expressions in an environment where movement or reconstruction of the idiomatic material into the position of the pronoun is impossible. But if ordinary pronouns can anaphorically point to (or copy) idiomatic material, relative pronouns can as well. Hence idioms provide no argument for syntactic reconstruction. In sum, I conclude that the traditional analysis is correct and that there is no reason to assume that the head of the RC has a syntactic copy in the trace position of the relative pronoun.

One of the things most often overlooked in the discussion of internally headed RCs is the fact that the proposed analysis for examples like (14)

(14) The picture of himself that everybody sent in annoyed the teacher

would imply that there is only one picture that depicts everybody (or only one person that is the relative of everybody in examples like (6)). But (14) also has a reading with the uniqueness presupposition embedded under *everybody*. In other words, there is a different picture for each person. The obvious conclusion must be that the internal head analysis is insufficient because the quantifier has to gain wide scope w.r.t. the determiner.

Another fact has been overlooked in the discussion of (2). The original example was (15) without an index on *him*:

(15) The picture of his$_i$ mother that every soldier$_i$ kept t wrapped in a sock was not much use to him

(15) is taken from Safir (1999: 613), who attributes it to Bianchi and Åfarli, and it is also discussed in Salzmann (2006). None of these authors, however, seemed to be aware of the following crucial problems:

- *every soldier* must have scope over the entire subject phrase
- *every soldier* might be able to bind *him* in the matrix clause

To me it is intuitively clear that some sort of back reference of *him* to *every soldier* is possible. If this reading exists, the pronoun *him* cannot be interpreted as an E-type pronoun of sorts; rather, it must be interpreted as a genuine bound variable. This seems to be an important observation, because it shows that Kayne's theory alone cannot adequately handle the data, and at the same time it corroborates a proposal by Hulsey & Sauerland (2006) who assume QRing of *every soldier* into the root node of the matrix clause.

Hulsey and Sauerland also discuss a similar example, namely

(16) The picture of himself$_i$ everybody$_i$ sent in annoyed his$_i$ mother

They observe that *his* is problematic in having a bound reading. "But in [(16), their ex. (70), W. St.], *his* can be analyzed as an E-type pronoun *the person on x*, where *x* is bound by the DP *the picture of himself*." (p. 135) I do not see, however, how such a move could solve the problem, because the antecedent DP itself contains a variable that must in some way be interpreted in the scope of *everybody*. I therefore see no gain in assuming an E-type analysis but instead take (16) at face value by assuming that both *himself* and *his* are to be analyzed as bound variables.

A QR-analysis for examples like these seems to have first been suggested by Doron (1982) but has widely been rejected on the grounds that QR should normally be clause-bound. In the present paper, I will propose a semantic account for the relevant binding data that does without QR. It combines two ingredients: Barker's continuation theory as developed for inverse linking, and my own theory of delayed binding (cf. Barker 2002, Sternefeld 2001, and Klein & Sternefeld 2013).

There are a number of reasons why such an in situ theory is preferable to QR, most of which follow from Heycock's contribution to this volume; in particular the restrictions on reconstruction seem to be semantic rather than syntactic in nature. On the other hand, the semantic framework I will suggest in this paper is more or less unrestricted and rather general. E.g., it does not, in and of itself, obey clause boundedness; rather, the appropriate (island) conditions still need to be built in additionally, much as in the theory of Barker (2002).

As a starting point, note that Barker's theory nicely accounts for inverse linking illustrated in (17):

(17) $[_{DP}$ $[_{DP}$ the rose $][_{PP}$ in every vase $]]$

Given the structure in (17), the PP can be interpreted as the so-called continuation of the predicate *rose* and thus as a further restriction of the determiner *the*; this yields the linear reading.

Or it can also be interpreted by giving wide scope to the PP and its quantifier, which means that *the rose* is merely an argument of *in* and the main quantifier now becomes *every vase*; this yields the inverse linking reading. The technical details will be developed in section 4; the important points for now are these: (1.) no movement is involved in the analysis of the two readings and (2.) the wide scope analysis of *every vase* not only works for PPs but also for RCs as in (18):

(18) die Rose, die in jedem Knopfloch steckt
the rose which in every buttonhole sticks

However, Barker's theory does not automatically guarantee that wide quantifier scope also implies the potential for the binding of pronouns. This is so because quantifiers are still Fregean relations, not real quantifiers. In the present framework, as in the classical one, quantifier expressions will take a restriction and a scope, but in contrast with Generalized Quantifier Theory will additionally be real binders. That is, they behave like expressions $(\forall x)$ or $(\exists y)$ in being capable of binding variables (namely x and y respectively). In addition, we assume a compositional semantics for these expressions along the lines of Henkin & Tarski (1961). For details I refer the reader to Sternefeld (2001) and Klein & Sternefeld (2013). For now, the important thing to note is that binding of a pronoun does not require QR — everything works *in situ*.

The structure in (17) and the parallel structure $[_{DP}$ DP RC $]$ for RCs are not the ones we find in textbooks; nonetheless there is reason to believe that they are correct. A well-known argument in favor of $[_{DP}$ DP RC $]$ comes from data called *hydras* (cf. Link 1984):

(19) $[[_{DP}$ the man and the woman $][_{RC}$ who hate each other $]]$

The head of the RC must be a plural phrase, which can only be formed by the conjunction of two DPs. The RC must therefore be attached to the conjoined DP (or conjoined D$'$s) as a whole.

Quite different evidence showing that the RC interacts closely with the determiner rather than with the NP is provided by data like (20):

(20) a. Alle Kinder haben den Arm, der dreckert war, gehoben
all children have the arm that dirty was raised

b. * Alle Kinder ham'n Arm, der dreckert war, gehoben
all children have-the arm that dirty was raised

(German)

Prinzhorn (2005) has shown that there cannot be phonological reduction of the definite article *der* (*the*) in the presence of a RC. Without such a RC, the contraction *ham'n* is fully okay. It seems that the RC requires some further accent or stress on the definite determiner. This points to a close relation between D and the RC, which can be implemented as a semantic relation between D and a further restriction of D (cf. Sternefeld 2006). Likewise, we find determiners like *derjenige* in German, that obligatorily require a relative clause as a complement (unless they are used as anaphoric DPs without any extensions):

(21) derjenige (Mann) *([$_{RC}$ der kam])
that-one (man) who came

The conclusion is that the RC is not attached to the NP but to a projection of D.

Before going into technical details, I would like to stress again that the semantics to be developed in this paper is meant to provide a general framework for telescoping rather than a linguistic theory. Its status is that of an abstraction like X-bar theory in syntax. Every such system overgenerates; we would not expect the X-bar scheme to be instantiated for all possible values of the variables in $[_{X^i}\ X^{i-1}\ Y^{max}]$. Likewise we do not expect that the full expressive power of our formal system is put to use in natural language semantics; some restrictions still have to be imposed on the semantic composition rules; I refer the reader to Barker (2002).

When considering data like (2) or (15) linguists tend to ask a number of questions that will not necessarily be answered by the formal system as such. For example, observing that there are two bound variables involved we may well ask whether there is an interaction between cataphoric and anaphoric anaphora. As far as I can see, the semantic theory proposed below does make a specific prediction, namely that forward anaphora is possible only if the cataphoric reading is. In terms of semantic processing one might then ask whether there is a difference between (21) and (22):

(22) The picture of Peter's mother that every soldier$_i$ kept t wrapped in a sock was not much use to him$_i$

In (22), the wide scope reading is not enforced by the possessive, is it therefore more difficult to get?

Another case in point is the difference between subject and object quantifiers. The syntactic reconstruction theories make a clear prediction: If reconstruction is involved, (23) should be bad on the intended reading, because the accusative object cannot have scope over the (trace of) the subject:

(23) Seine$_i$ Dozentin, die jeden$_{acc}$ Studenten$_i$ faszinierte, las seinen$_i$ Text
His lecturer who every student fascinated read his text
Korrektur
proof
'the lecturer who fascinated every student proofread his text'

If QR is involved, the picture is reversed: we would expect an LF asymmetry between subjects and objects along the lines of the ECP. Such a theory would predict that (24) is ungrammatical:

(24) Seine$_i$ Dozentin, die jeder$_{nom}$ Student$_i$ anhimmelte, las seinen$_i$ Text
His lecturer who every student adored read his text
Korrektur
proof
'the lecturer who every student adored proofread his text'

A purely semantic theory would be unable to differentiate between the two constructions. In our theory both construals would be possible, and it seems to me that intuitively this is the correct conclusion.

There are many other questions we cannot discuss here, one being the nature of the quantifiers that permit telescoping. Recently we got a panic-stricken email from our colleague Gisbert Fanselow who was horrified to find that in his introductory semantics course 50% of the students accepted a bound reading for sentences like (25):

(25) der Sohn von keiner Frau liebt ihre Schwester
the son of no woman$_i$ loves her$_i$ sister

This was not too surprising for us, because in a questionaire concerning the readings of

(26) Die Dozentin, die keinen Studenten$_i$ faszinierte, las seinen$_i$ Text
the lecturer who no student$_{acc}$ fascinated read his text
Korrektur
proof
'the lecturer who fascinated no student, proofread his text'

we also found a 50% availability of the bound reading. Again, we would like to stress that the system we propose is neutral in this respect, it may allow continuations with negative quantifiers, or it may exclude them.

Are there any grammatical restrictions and if so, what is their nature? Is the telescoping phenomenon real, or can we disregard it and explain it as a side effect of something else still to be explained? These questions call for an empirical investigation; I refer the reader to the contribution of Radó et al. in this volume.

3 Introducing continuations

We are now entering the technical part of the paper and I will briefly introduce the idea of a continuation. A continuation is basically a placeholder for material that will be supplied only at a later stage in the processing of a sentence. Every category, whether phrasal or lexical, may come with a continuation. In Dynamic Montague Grammar (cf. Groenendijk & Stokhof 1990), a sentence like *A man is walking* is represented rougly as $\lambda p \exists x(\mathbf{man}(x) \wedge \mathbf{walk}(x) \wedge p)$, where p stands in for the following sentence, this is what we call a continuation. In continuation semantics, this idea is generalized; not only propositions but any constituent can have a continuation.

In more technical terms, a continuation of a category X is a property of X; in particular, a continuation of a proposition is a property of that proposition. In this paper, we will only consider continuations of (possibly open) propositions. A sentence like *A man is walking* can, at least in principle, be represented in three different ways, depending on the position of the placeholder for the continuation:

(27) a. $\lambda c.c(\exists x(\mathbf{man}(x) \wedge \mathbf{walk}(x)))$
b. $\lambda c.\exists x(\mathbf{man}(x) \wedge c(\mathbf{walk}(x)))$
c. $\lambda c.\exists x(c(\mathbf{man}(x)) \wedge \mathbf{walk}(x))$

In all three cases, c is of type $\langle t, t\rangle$ in an extensional system; for the purposes at hand we can ignore intensionality. In (27a), we consider the possibility that the existential quantifier is in the scope of some other expression to be added later, this is the case of inversed linking discussed below. (27b) is a case where something is added to the scope of a quantifier; this would be a continuation like *He whistles* in Dynamic Montague Grammar. In (27c) something is added to the restriction of a quantifier; this could be an extraposed relative clause, e.g. *who whistles*.

For example, we simply want to add a new proposition, e.g. $\mathbf{whistle}(x)$; this addition can be interpreted as conjunction so that the combinatory rule that adds $\mathbf{whistle}(x)$ (= z) to (27) (= α) would be (28):

(28) $\alpha(\lambda r(r \wedge z))$

Thus, applying (27) to $\lambda r(r \wedge \mathbf{whistle}(x))$ yields three different outputs:

(29) a. $(\exists x(\mathbf{man}(x) \wedge \mathbf{walk}(x)) \wedge \mathbf{whistle}(x))$
b. $\exists x(\mathbf{man}(x) \wedge (\mathbf{walk}(x) \wedge \mathbf{whistle}(x)))$
c. $\exists x((\mathbf{man}(x) \wedge \mathbf{whistle}(x)) \wedge \mathbf{walk}(x))$

In Dynamic Semantics, all formulas are equivalent and could be expressed by either (30a), (30b), or (30c):

(30) a. A man is walking. He whistles.
b. A man is walking and whistling.
c. A man who is whistling is walking.

Of course, what we really want in a general theory of continuations is a recursive system where the resulting formulae in (29) themselves are capable of having continuations, i.e. are formulae beginning with λc. We will present such a system further below. The system will not use rules like (28) but instead will combine the scopal possibilities in (27) in a unified system with unambiguous lexical entries, using more complicated functions that combine via functional composition.

Barker supposes that quantifiers and determiners are grammatical signs of continuations themselves. This feature of his analysis is not really important for us. However, a crucial assumption of our analysis will be that the restriction and the scope of a quantifier may come with their own continuations and these continuations can be projected up to the DP. We thus have to assume that a determiner like *every* comes along with two possibilities of recursive continuations: first we can add and pile up continuations as restrictions (in classical theory, only one restriction is possible, here we assume a recursive process of adding restrictions) and only after this process is finished can we continue with the scope of the quantifier and recursive continuations of its scope. This forces us to combine (27b) and (27c) as will become clear below.

Before formalizing these ideas, let me explain another assumption that will become relevant below for variable binding. I will assume that every predicate P is encoded as an open proposition; for a one-place predicate P this could be the proposition $P(x)$, with the choice of the variable being immaterial (cf. Klein & Sternefeld 2017). Under this assumption, (31) below very roughly sketches different steps of a compositional derivation of the (dispreferred) linear analysis of *the rose in every vase*, whereas (32) sketches the preferred inverse linking analysis. We still assume (28) as a combinatory rule. Another simplification in (31) concerns the assumption that we exploit continuations only at one point, throughout (31) there is only one continuation concerning the expression *the rose* (= (31d)), which is assumed to have a continuation generated by the determiner's restriction. As can be seen in (31a), *every vase* in this derivation has no continuation at all. Likewise, no other lexical expression is assumed to have a continuation in the present (preliminary) derivation. A third simplification concerns the assumption that beta reduction is “unsual” in the sense that the usual restrictions for free and bound variables do no apply:

(31) the rose in every vase

a. every vase = $\lambda p \forall x(\mathbf{vase}(x) \rightarrow p)$

b. in = $\mathbf{in}(y, x)$

c. in every vase = $\forall x(\mathbf{vase}(x) \rightarrow \mathbf{in}(y, x))$

d. the rose = $\lambda c \lambda q\ \textsc{the}_y(c(\mathbf{rose}(y)), q)$

e. the rose in every vase = $\lambda q.\textsc{the}_y(\mathbf{rose}(y) \wedge \forall x(\mathbf{vase}(x) \rightarrow \mathbf{in}(y, x)), q)$

The notation $\textsc{the}_y(p, q)$ abbreviates the Russellian quantificational paraphrase $\exists y(\forall x(p \leftrightarrow x = y) \wedge q)$. (31a) and (31b) combine via β-reduction of the unusual kind that will be commented upon below. The resulting (31c) combines with (31d) to yield (31e) by applying (28) and the same kind of unorthodox β-reduction.

For the more plausible inverse linking reading we need a continuation of the predicate *in* and a different rule for combining (32a) and (32b):

(32) a. every vase = $\lambda p \forall x(\mathbf{vase}(x) \rightarrow p)$

b. in = $\lambda c.c(\mathbf{in}(y, x))$

The rule is functional composition:

(33) $\lambda c\ [\![\text{ every vase }]\!]([\![\text{ in }]\!](c))$

(34) a. in every vase = $\lambda c \forall x(\mathbf{vase}(x) \rightarrow c(\mathbf{in}(y, x)))$

b. the rose = $\lambda c \lambda q\ \textsc{the}_y(c(\mathbf{rose}(y)), q)$

c. the rose in every vase = $\lambda q \forall x(\mathbf{vase}(x) \rightarrow \textsc{the}_y(\mathbf{rose}(y) \wedge \mathbf{in}(y, x), q))$

The rule that combines (34a) and (34b) could be something like (35):

(35) $\lambda q\ [\![\text{ in every vase }]\!](\lambda r\ [\![\text{ the rose }]\!](\lambda p.p \wedge r)(q))$

Obviously, these rules are *ad hoc* and will be replaced by only one uniform rule (namely functional composition) to which we will come back further below.

The unorthodox machinery necessitated by the above derivations concerns the binding of variables. Note that the free variable x in (32b) must end up bound in the scope of the binder $\forall x$ in (34a), and likewise when going from (34a) and (34b) to (34c), the variable y, which is free in (34a), ends up bound in the scope of the binder $\textsc{the}_y$. We therefore need a theory where semantic composition via λ-abstraction is fully compatible with unrestricted β-reduction. In other words, we need a theory where the following equivalence holds:

(36) $\lambda p \forall x(P(x) \rightarrow p)(Q(x)) = \forall x(P(x) \rightarrow Q(x))$

But β-reduction of this sort is strictly forbidden in standard semantics: we cannot interpret a free variable (the last occurence of x on the left of =) as if it were in the scope of a binder.

Logical theory notwithstanding, we as linguists need such a new framework for independent reasons, e.g. one might want to account for data like (37) in a semantics that is fully compositional and avoids syntactic reconstruction:

(37) a. Sich selber$_i$ hasst$_j$ niemand$_i$ t$_i$ t$_j$
him self hates nobody
'nobody hates himself'

b. Seinen$_i$ Bruder hasst$_j$ niemand$_i$ t$_i$ t$_j$
his brother hates noone
'noone$_i$ hates his$_i$ brother'

It is at this point that a theory of semantic reconstruction is called for that allows for delayed interpretation of variable binding.

I have sketched such a theory in much previous work, but a general theory has been developed only recently in joint work with Udo Klein; cf. Klein & Sternefeld (2013). I refer the reader to this article, which explains a general semantics that minimally differs from the standard semantics in that it allows for beta reduction in an unrestriced way, so that the equivalence in (36) is provably valid.

4 Restricted quantifiers and continuations

As said above, each (open) proposition p that enters the computation may come along with its continuation. But in many cases, these continuations will not be exploited in actual derivations. To account for this in a uniform way we will assume that such continuations are initially generated but semantic composition can always kill or plug a continuation by "lowering", i.e., by applying $\lambda c \ldots$ to the identity function $\lambda p.p$. Up to now we have always used lexical entries without continuations in case the potential continuation are not needed and would be plugged later. From now on we will include all possible continuations but will also make all plugging operations explicit.

Let us next go into a more detailed analysis of our practice examples, namely the linear and inverse construals of *an apple in every basket*. Having derived these, we will finally analyze the telescoping example (2)/(15).

We assume that all categories are indexed in syntax, where indexing encodes the identity of variables to be bound or coordinated (see Klein & Sternefeld 2017 for the coordination of variables). In general, syntactic merge will require identity of indices, i.e. coordination of variables. Moreover, relations like *in* will be represented as open propositions $\mathbf{in}(x_i, x_j)$ whose variables will eventually be bound by appropriate binders. In order to identify the correct indices, we assume that the preposition is indexed by $\langle i, j\rangle$, the general convention being that the first argument encountered in syntax binds the last argument in this list.

This much said, we have to develop a general format of lexical entries which combines the possibilities for an item to have wide or narrow scope by using one continuation variable, here c, for continuations that will have scope over the lexical entry, and another variable, here p, which simply adds further material, possibly within the dynamic scope of the entry in question (cf. Bott & Sternefeld 2017 for an elaboration of the theory and for numerous applications). According to this scheme, a two-place relation like *in* is represented as follows:

(38) $[\![\text{ in }]\!]_{i,j} = \lambda c \lambda p.c(\mathbf{in}(x_i, x_j) \wedge p)$

Simple nouns like *vase* or *rose* are one-place relations, hence have the format in (39):

(39) $[\![\text{ N }]\!]_i = \lambda c \lambda p.c(\mathbf{N}(x_i) \wedge p)$

Turning finally to determiners, their lexical entry must provide for a continuation of both its scope and its restriction. In particular, having parsed the DP *a rose*, continuing with a PP or a relative clause will further add to the restriction *rose* (in the linear reading). Accordingly, the determiners are doubly continualized:

(40) a. $[\![\text{ every }]\!]_i = \lambda c \lambda p \lambda c' \lambda p' \forall x_i [c(p) \rightarrow c'(p')]$
b. $[\![\text{ a }]\!]_i = \lambda c \lambda p \lambda c' \lambda p' \exists x_i [c(p) \wedge c'(p')]$

The only mode of combining A and B is functional composition:

(41) a. $\lambda c A(B(c))$ (linear)
b. $\lambda c B(A(c))$ (inverse)

Let us now analyze the two readings of *an apple in every basket (is rotten).*

Functional composition of noun and determiner indexed by i and j yields (42):

(42) $[\![\text{ an apple }]\!]_i = \lambda c [\![\text{ an }]\!]_i ([\![\text{ apple }]\!]_i (c)) =$
$\lambda c \lambda p \lambda c' \lambda p' \exists x_i [c(\mathbf{apple}(x_i) \wedge p) \wedge c'(p')]$

And likewise for *every basket*:

(43) $[\![\text{ every basket }]\!]_j = \lambda c [\![\text{ every }]\!]_j ([\![\text{ basket }]\!]_j)(c) =$
$\lambda c \lambda p \lambda c' \lambda p' \forall x_j [c(\mathbf{basket}(x_j) \wedge p) \rightarrow c'(p')]$

The next step is to combine *in* with *every basket*. We assume that *every basket* is a complete DP, hence its restriction cannot have further continuations. This means that we have to plug the restriction by applying *every basket* first to the identity function $\lambda p.p$ of type $\langle t,t\rangle$ and then to the propositional constant T (= truth). The result is given in (44):

(44) $\lambda c'\lambda p'\forall x_j[\mathbf{basket}(x_j) \to c'(p')]$

This will then be applied to *in* as shown in (45):

(45) $[\![\text{ in every basket }]\!]_i = \lambda c [\![\text{ every basket }]\!]_j ([\![\text{ in }]\!]_{\langle i,j\rangle}(c)) =$
$\lambda c\lambda p'\forall x_j[\mathbf{basket}(x_j) \to c(\mathbf{in}(x_i, x_j) \wedge p')]$

Now adding this to *an apple* in the linear mode means that *in every basket* restricts the restriction of *an apple*, hence we can straightforwardly combine the two:

(46) $[\![\text{ an apple in every basket }]\!]_i = \lambda c [\![\text{ an apple }]\!]_i ([\![\text{ in every basket }]\!](c)) =$
$\lambda c\lambda p\lambda c'\lambda p'\exists x_i[\mathbf{apple}(x_i) \wedge \forall x_j[\mathbf{basket}(x_j) \to c(\mathbf{in}(x_i, x_j) \wedge p)] \wedge c'(p')]$

Assuming that this DP is complete and followed by the sentence predicate enforces plugging of the restriction's continuation, resulting in:

(47) $\lambda c'\lambda p'\exists x_i[\mathbf{apple}(x_i) \wedge \forall x_j[\mathbf{basket}(x_j) \to \mathbf{in}(x_i, x_j)] \wedge c'(p')]$

Adding a one-place predicate like *is rotten*$_i$ yields:

(48) $\lambda c\lambda p'\exists x_i[\mathbf{apple}(x_i) \wedge \forall x_j[\mathbf{basket}(x_j) \to \mathbf{in}(x_i, x_j)] \wedge c(\mathbf{rotten}(x_i) \wedge p')]$

If we assume that this is the end of a text, we plug the continuations in the usual way:

(49) $\exists x_i[\mathbf{apple}(x_i) \wedge \forall x_j[\mathbf{basket}(x_j) \to \mathbf{in}(x_i, x_j)] \wedge \mathbf{rotten}(x_i)]$

In the more natural inverse linking reading, *in every basket* takes wide scope over *an apple*. This presupposes that *an apple* is complete and thus has no continuations of its restriction.

(50) $[\![\text{ an apple }]\!]_i = \lambda c\lambda p\exists x_i[\mathbf{apple}(x_i) \wedge c(p)]$

We then apply *in every basket* to *an apple*:

(51) $\lambda c\,(45)((50)(c)) =$
$\lambda c\lambda p\forall x_j[\mathbf{basket}(x_j) \to \exists x_i[\mathbf{apple}(x_i) \wedge c(\mathbf{in}(x_i, x_j) \wedge p)]]$

Adding *is rotten*$_i$ and plugging the continuation gives the desired truth conditions:

(52) $\forall x_j[\mathbf{basket}(x_j) \to \exists x_i[\mathbf{apple}(x_i) \wedge (\mathbf{in}(x_i, x_j) \wedge \mathbf{rotten}(x_i))]]$

This paves the way for our analysis of telescoping.

5 Telescoping with RCs

We are now ready for an analysis of the worst case, namely telescoping out of a RC. The example we mentioned above is repeated in (53):

(53) The picture of HIS$_x$ mother that EVERY$_x$ SOLDIER kept t wrapped in a sock was not much use to HIM$_x$

For simplicity we assume that *his mother* is analyzed with the iota-operator, whereas the definite description is a Russellian quantifier. Moreover, we assume that the restriction's continuation has been plugged. We thus start off with (54):

(54) $[\![$ the$_y$ picture of HIS$_x$ mother $]\!]$ =
$\lambda c \lambda p \exists y \forall u((\mathbf{picture}(u, (\iota v)(\mathbf{mother}(v, x))) \leftrightarrow y = u) \wedge c(p))$

It is now easy to see that the RC plays the same role as the PP in the inverse linking case. The RC thus translates as:

(55) $[\![$ that$_y$ every soldier$_x$ kept wrapped in a sock $]\!]_y$ =
$\lambda c \lambda p \forall x(\mathbf{soldier}(x) \rightarrow \exists z(\mathbf{sock}(z) \wedge c(\mathbf{kept\text{-}wrapped\text{-}in}(x, y, z) \wedge p)))$

It is evident that the index y on *that* is the index of an (invisible) RC operator corresponding to a silent relative pronoun that has been moved to SpecC. This index is needed to properly identify variables in a coordination scheme that identifies the y of the RC with the same variable y of the DP it attaches to.

(56) $\lambda c\ (55)((54)(c))$ =
$\lambda c \lambda p \forall x(\mathbf{soldier}(x) \rightarrow \exists z(\mathbf{sock}(z) \wedge \exists y \forall u((\mathbf{picture}(u, (\iota v)(\mathbf{mother}(v, x))) \leftrightarrow y = u) \wedge c(\mathbf{kept\text{-}wrapped\text{-}in}(x, y, z) \wedge p))))$

Note that due to unusual beta reduction, *HIS* can be bound by the RC. Likewise, the final step, namely continuing with *was not much use to HIM*, involves binding by beta-reduction, as shown in (57):

(57) $\lambda c\ (56)(\lambda c' \lambda p'.c'(\mathbf{not\text{-}of\text{-}much\text{-}use\text{-}to}(y, x) \wedge p')(c))$ =
$\lambda c \lambda p \forall x(\mathbf{soldier}(x) \rightarrow \exists z(\mathbf{sock}(z) \wedge \exists y \forall u((\mathbf{picture}(u, (\iota v)(\mathbf{mother}(v, x))) \leftrightarrow y = u) \wedge c(\mathbf{not\text{-}of\text{-}much\text{-}use\text{-}to}(y, x) \wedge \mathbf{kept\text{-}wrapped\text{-}in}(x, y, z) \wedge p))))$

This completes our discussion of example (2)/(15).

Let us finally return to (25), repeated as (58):

(58) der Sohn von keiner Frau$_y$ liebt ihre$_y$ Schwester
the son of no woman$_y$ loves HER$_y$ sister

Compared to previous examples the predicate *son* is relational. As before, if this implies that the structure of the DP is

(59) $[_{\mathrm{DP}}$ the $[_{\mathrm{NP}}$ son of no woman]]

there is no way to get wide scope for *no woman* in situ. If, on the other hand, the structure is (60) as argued for above,

(60) $[_{\mathrm{DP}}$ $[_{\mathrm{DP}}$ the$_x$ son$_{x,y}$ $]_x$ [of no$_y$ woman$_y$ $]_y$ $]_x$

we get wide scope for *no woman* with respect to the determiner *the* by the same mechanism already applied above. The index x is the argument index of the sentential predicate, as in *x loves Berta*. The index y, by contrast, gets semantically wide scope (as the index of the quantifier *no*) and may serve as a binder by accidental coindexation with a pronoun, as in *x loves HER$_y$ sister*.

The discussion shows that to some degree telescoping is a consequence of wide scope, and this is in accord with other theories like QR. In contrast to these theories, the actual mechanism of scope taking is local and does not require movement at LF.

The acceptance rate for sentences like (25) is not yet captured in the above system. In theory, it would be possible to separate the ability of taking wide scope from that of delayed binding of variables (i.e. unrestrained beta-reduction), perhaps only for negative quantifiers, but given the 50% acceptance rate of such sentences, we have a 50% chance that such a theory would be too restrictive, hence wrong.

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