Inverse linking and telescoping as polyadic quantification[1]

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Abstract. The paper discusses two constellations in which one quantifier is embedded inside another but where the embedded quantifier seems to outscope its embedder: inverse linking and telescoping. Four phenomena are mentioned that support that idea that the two quantifiers behave neither like the higher nor like the lower quantifier bur rather display a unit-like behavior. This motivates a polyadic analysis, which will be expressed in *Lexical Resource Semantics*. Interesting predictions for so far unnoticed data on negative polarity items follow from this treatment.

Keywords: inverse linking, telescoping, polyadic quantifier, negative polarity items, underspecified semantics

1. Introduction

I will consider two constellations in which one quantifier is embedded inside another but where the embedded quantifier seems to outscope its embedder. This is the case for inverse linking (IL, (1-a)) and telescoping (TS, (1-b)). In telescoping the embedded quantifier must even take scope outside the clause in which it is contained.

(1) a. [A representative from [every city]] supported the proposal. (**Every** > **Some**)
    b. [The picture of his$_i$ mother [that every$_i$ soldier kept wrapped in a sock]] was not much use to him$_i$. (quoted from Sternefeld (t.a.))

Rather than assuming a wide scope for the embedded quantifier, I propose a polyadic analysis, in which the two quantifiers form one unit. I present evidence for IL, based on previous literature, and construct analogous evidence for TS. The polyadic account makes interesting predictions that are confirmed by the data and not compatible with previous approaches.

2. Phenomena: Inverse linking and telescoping

2.1. Inverse linking

I reinterpret four observations from the literature to support the idea that the quantifiers involved in an IL reading form a semantic unit rather than a sequence of quantifiers. I will first argue that the combination of the two quantifiers neither behaves like the syntactically higher one nor like the semantically higher, syntactically embedded one.

[1] I am grateful for discussion and comments to the audiences of *Sinn und Bedeutung*, Göttingen, and of the *2nd European Workshop on HPSG*, Paris. All errors are mine.

Moltmann (1995) discusses the basic properties of *except*-phrases. Such phrases usually attach to universally quantified expressions, as in (2-a). They typically are not compatible with singular definites, see (2-b). Moltmann shows with the example in (2-c) that if a singular definite contains a universal quantifier in an IL reading, an *except*-phrase is possible. This shows, that the overall NP behaves like the syntactically embedded quantifier.

(2) a. Every president except Carter hated peanuts.
b. *The wife except Hllary has no political ambitions.
c. [The wife of [every president]] except Hillary has no political ambitions.

An analogous observation can be made for existential *there*-clauses. Such clauses show definiteness effects, i.e., definites are banned from the post verbal position, see (3). Woisetschlaeger (1983) shows with examples like (3-c) that definite NPs that embed an indefinite NP can occur in existential *there*-clauses. So, again, the overall NP behaves like the syntactically embedded NP.

(3) a. There is [a difficult theorem] on page 433.
b. *There is [the proof] on page 433.
c. There is [the proof of [a difficult theorem]] on page 433.

While the data on *except*-phrases and *there*-sentences suggest that the overall NP behaves like the embedded one, Champollion and Sauerland (2011) present data that show that the overall NP does not fully behave like the embedded NP either. They refer to the kind of data as *Haddock's puzzle*. They discuss the example in (4). The sentence is true in a scenario with, for example, two squares, where only one contains a circle. So, the embedded definite NP *the square* does not have a uniqueness presupposition.

(4) [The circle in [the square]] is white.

Other data on IL show a similar effect. The correct interpretation of (5-a) is not achieved by simply saying that the syntactically embedded quantifier takes scope over the higher determiner. This reading is given in (5-b). This reading is only true if each basket contains an apple.

(5) a. [An apple in [every basket]] is rotten.
b. $\forall y(\textbf{basket}(y) \rightarrow \exists x(\textbf{apple}(x) \wedge \textbf{in}(y,x) \wedge \textbf{rotten}(x)))$

However, intuitively, the sentence is true in a scenario with various baskets, only some of which containing apples and it requires only of the apple-containing baskets that they also have a rotten apple. So, the universal quantifier is not just restricted to baskets but to baskets with apples.

The data in (4) and (5) show that, even though the syntactically embedded quantifier takes wide scope, its restrictor incorporates part of the semantic material of the syntactically higher quantifier—we only consider squares with circle and baskets with apples.

The final observation is attributed to Larson (1985). He observes that no quantifier may take intermediate scope between the two quantifiers that appear inside one NP, i.e., sentence (6) does not have a reading in which **Two** takes scope between **Some** and **Every**, though the relative scope of the other two may vary in principle. This, again, supports an approach that takes the two NP-internal quantifiers as a unit.

(6) Two policemen spy on someone from every city. (Larson 1985)

The four observations together show that the combination of the two quantifiers neither behaves like the syntactically higher quantifier nor like the syntactically lower one. In addition we find a unit-like behavior. This supports the idea, also articulated in Moltmann (1995), that the two quantifiers inside the NP behave as one unit and should be treated as a polyadic quantifier.

2.2. Telescoping

TS is characterized by a strong quantifier that takes scope in a higher clause. Since Rodman (1976) it had been a standard assumption that strong quantifiers cannot take scope outside their local clause. This view has been challenged recently, for example in Barker (2012). Konietzko et al. (t.a.) provide experimental evidence for the existence of TS readings in German. This wide scope can be seen if the higher clause contains a pronoun bound by the embedded quantifier, a diagnostics systematically used in Barker (2012). For ease of reference, I repeat the example from (1-b) in (7). Here the quantifier *every* is contained in a relative clause. Nonetheless the matrix clause contains a pronoun, *him*, that is bound by the universal quantifier.

(7) [The picture [that every$_i$ soldier kept]] didn't bring him$_i$ much luck.

In this section I will show that TS behaves just like IL with respect to the four environments discussed in section 2.1. I will primarily use German data for TS. The English translations of the sentences are not assigned grammaticality judgments.

Except-phrases in German are restricted to universals, just as in English, see (8). The definite singular is only possible under a generic reading. However, an *except* phrase can attach to a singular, non-generic definite NP in a TS-constellation. This is shown in (9).

(8) Jede/ *Die Präsidentenfrau außer Hillary hat keine eigenen politischen Ambitionen.
every/ the wife of a president except Hillary has no own political ambitions

(9) [Die Frau, [die jeder$_i$ Präsident geheiratet hat]], außer Hillary, unterstützt ihn$_i$ ohne
the woman that every president married has except Hillary supports him without
eigene politische Ambitionen.
own political ambitions
'[The woman [that every$_i$ president married]], except Hilllary, supports him$_i$ without own political ambitions.'

When we look at existential sentences, the German equivalent of *once upon a time*-statements can be used. It shows the same definiteness effects we find for English *there* sentences, which is illustrated in (10). Just as we saw for IL, if the definite NP syntactically contains a wide-scope indefinite, even within a relative clause, the sentence is considerably better. All speakers that I consulted see a clear contrast between the version of (11) with an embedded indefinite and the version with an embedded definite—though, admittedly, some of them find the version with the embedded indefinite not completely acceptable.

(10) Es war einmal [eine/ *die Königin].
there was once a/ the queen
'Once upon a time there was a/the queen.'

(11) Es war einmal [die Königin, [die über ein/ *das großes Reich herrschte]].
there was once the queen who over a/ the big empire reigned
'Once upon a time there was the queen [that reigned a/the big empire].'

We can also present TS data analogous to the *Haddock's puzzle* data. To do this, we embed the lower definite NP inside a relative clause. Champollion and Sauerland (2011) have actually done this in an empirical study. Subjects saw a picture and were asked to choose whether a sentence with an embedded indefinite or an embedded definite NP would be a more natural description of the picture. Their sentences looked as in (12).

(12) a. [The circle in [the/a square]] is white. [85.5% chose *the*]
b. [The circle [that is in the/a square]] is white. [76.2% chose *the*]

Champollion and Sauerland (2011) found that even for the version in which the critical NP is embedded inside a relative clause, the definite determiner is strongly preferred over the indefinite. This shows that even if the definite NP occurs inside a relative clause, its uniqueness presupposition is not determined simply on the basis of clause-internal material but uniqueness is only presupposed for circle-containing squares.

In section 2.1 I showed that the restrictor of an embedded universal quantifier is also influenced by material from the embedding NP. Similar data can be found for TS. In (13) the universal quantifier occurs inside a relative clause and binds a pronoun in the matrix clause. The sentence can be truthfully uttered in a scenario where there are presidents that are not married to a woman. This shows, that the sentence does not mean: For each president, there is a unique woman that he has married and that supports him. A good paraphrase would rather be: For each president that is married to a woman, the woman that he has married supports him.

(13) [Die Frau, [die jeder$_i$ Präsident geheiratet hat]], unterstützt ihn$_i$.
the woman that every president married has supports him

Finally, let us consider data analogous to (6). In (14) there is an embedded quantifier, *jeder Popstar* ('every pop star') that binds a matrix pronoun. The matrix clause contains an additional quantificational element, *mindestens zweimal am Tag* ('at least twice a day').

(14) [Die meisten Fans, [die jeder$_i$ Popstar hat]], hören mindestens zweimal am Tag
most fans that every pop star has listen-to at least twice a day
seinen$_i$ aktuellen Hit.
his current hit
'Most of the fans that every$_i$ pop star has, listen to his$_i$ current hit at least twice a day.'
a. Natural reading: **Every** > **Most** > **Two**
b. No reading: # **Every** > **Two** > **Most**

The most natural reading for the sentence is the one sketched in (14-a). In (14-b) I sketch a reading in which the additional quantifier takes scope between the embedded universal and the embedding quantifier, *most*. A scenario that supports this reading is quite reasonable: For each pop star there are two occasions a day during which the majority of their fans listen to their current hit. Such a reading is, however, not available for (14). This shows that for TS just as for IL, no quantifier may take intermediate scope between the telescoping quantifier and the one containing it.

The discussion so far shows that all the observations presented for IL carry over the TS. Before concluding this section, I would like to point out a restriction of TS that, as far as I know, has not been explicitly stated in the literature. While TS is possible for a quantifier that occurs inside a relative clause, it seems to be excluded for quantifiers from clauses that depend on verbs. Barker (2012) provided the example in (15), where quantifier is inside a subject clause.

(15) *[That Mary seems to know every$_i$ boy] surprised his$_i$ mother.

For German my informants reject TS from inside a subject clause, as in (16-a), and from a complement clause, see (16-b). If these initial observations can be systematically confirmed, the availability of a TS reading is restricted to quantifiers from inside NPs.

(16) a. *[Dass jeder$_i$ Student die Püfung bestanden hat], überrascht seine$_i$ Dozenten.
'[That every$_i$ student passed the exam] surprises his$_i$ teachers.'
b. *[Dass jeder$_i$ Student die Prüfung bestanden hat], teilte ihm$_i$ die Dekanin mit.
'[That every$_i$ student passed the exam], the dean told him$_i$.'

I argued in this section that TS readings exist but that they require the presence of a combination of two quantifiers: a syntactically embedding determiner and an embedded one. Given this constellation, TS readings show a strong relation between the embedded and the embedding quantifier.

3. Previous non-polyadic approaches

In this section I will briefly summarize relevant aspects of and challenges for previous approaches to IL and TS. I will look at approaches based on Quantifier Raising (QR), the analysis in Champollion and Sauerland (2011), and on continuation-based approaches.

QR is an operation that moves a quantified NP to the S-node where it takes scope (May 1977). QR is usually assumed to be clause-bounded. For IL, there are two alternatives: Either the embedded quantified NP attaches by QR to the embedding NP or it attaches to an S-node. If it attaches to the S-node, it is hard to capture the observations that show that the complex NP behaves like the embedding quantifier (*except*-phrases and *there*-sentences). The inseparability of quantifiers is also hard to derive if all quantifiers in a sentence simply attach to S.

The alternative would be to move the embedded quantifier to a high position inside the embedding NP, so called NP- (or DP-)internal QR. Heim and Kratzer (1998) reject this type of analysis based on pronoun binding. As shown in May (1985), the syntactically embedded NP can bind a pronoun in the rest of the sentence. An example of this is given in (17).

(17) [Someone [from every$_i$ city]] despises it$_i$. (May 1985, p. 68)

In addition to this, Champollion and Sauerland (2011) show that a classical interpretation of QR leads to the wrong readings for *Haddock's puzzle* as in (5) above.

If we assume clause-boundedness of QR, TS readings cannot be derived in principle. If clause-boundedness is not imposed, there will be overgeneration, as it might then be difficult to block QR from subject and complement clauses.

Champollion and Sauerland (2011) assume that the embedded quantified NP is moved by QR to an S node. They address *Haddock's puzzle* by assuming an intermediate accommodation of the restrictor of the syntactically embedded quantifier. This means for the examples discussed above, (4) and (5), that the uniqueness presupposition of *the square* in *the circle in the square* only applies to squares with circles and that the quantificational domain of *every basket* in *an apple in every basket* is restricted in such a way that the baskets under consideration are all apple-containing. The strength of this proposal is that it uses standard mechanisms in both syntax and semantics.

There are, however, a number of challenges for this approach. By its very outset, it runs into the problems mentioned above for approaches with QR to S, i.e., it cannot account for the observations on *except*-phrases and *there*-sentences and it is not clear how Larson's ban on intermediate scope of NP-external quantifiers should be derived. It is an open question how Champollion and Sauerland would restrict QR to extraction from relative clauses and ban it from V-dependent clauses.

Barker (2012) and Sternefeld (t.a.) present a different type of approach. They are among those who assert the importance of TS data. They use *continuations*, i.e., a mechanism to extend the scope domain of an element beyond its c-command domain. This is done in Barker (2012) by type shifting operations and in Sternefeld (ta) by *unrestrained β-reduction*.

Since these systems are set up in such a way that semantic scope is not tied to syntactic c-command, IL and TS readings follow directly from the standard combinatorial mechanisms. They straightforwardly account for pronoun binding in IL and TS as well. Barker (2002) shows that the inseparability of quantifiers in IL is a consequence of the way the type shifting operations work.

The approach nonetheless faces some problems. First, it is unclear how the data on *except*-phrases and *there*-sentences will be captured. Second, the quantifier restrictor interdependence, discussed here as *Haddock's puzzle*, is not addressed. Third, the type shifting operations that are required to allow for TS from relative clauses can also be used to derive TS readings from V-dependent clauses, which I have argued to be not available.

The brief literature overview in this section shows that non-polyadic analyses face problems when confronted with the strong correlation that the two quantifiers have in IL and TS. I will show in the next section that a polyadic analysis can solve these problems.

4. Analysis

In this section I will present polyadic semantic representations that for IL and TS and then discuss a syntax-semantics interface that allows the construction of the required polyadic representations.

4.1. Semantic representation

Polyadic quantification is a well-established notion in formal semantics. Keenan and Stavi (1986) and Keenan and Westerståhl (1997) provide the basic notions and examples and discuss some formal properties of polyadic quantifiers. While a monadic generalized quantifier binds one variable and has a restrictor and a scope, a polyadic quantifier typically binds more variables, may have more than one restrictor, and has a scope. The adjectives *same* and *different* are usually listed as examples of natural language expressions that require polyadic quantification for an adequate semantics. May (1985, 1989) proposes a polyadic analysis for every sentence in which more than one quantifier occurrs. Moltmann (1995) argues that the data on *except*-phrases motivate a polyadic analysis. More recently de Swart and Sag (2002), Iordăchioaia (2009), and Iordăchioaia and Richter (2014) provide polyadic analyses for *Negative Concord*, i.e., for cases where several negative indefinites occur in a sentence, but the sentence receives a single-negation interpretation.

I will only look at the kind of polyadic quantifiers needed for the present purpose. Example (5) will be used for illustration. In (18) the polyadic representation is given. In this representation the two logical determiners are given in a list notation, followed by the variables they bind. Then we have a list of the respective restrictors and, finally, the scope of the polyadic quantifier.

(18) [An apple in [every basket]] is rotten.
$\langle \mathbf{Every}, \mathbf{Some}\rangle \langle y, x\rangle \langle \mathbf{basket}(y), (\mathbf{apple}(x) \wedge \mathbf{in}(y, x)\rangle (\mathbf{rotten}(x))$

I assume the truth conditions of the formula in (18) to be the same as those of the formula in (19). The interpretation is such that we first interpret the first determiner from the list of determiners and this takes the second determiner in its scope. What is special is that the material from the second restrictor ($\mathbf{apple}(x) \wedge \mathbf{in}(y, x)$) is incorporated under an existential quantification into the restrictor of the universal quantifier. This leads to truth conditions that are the similar to those in Champollion and Sauerland (2011).

(19) $\mathbf{Every}\ y[\mathbf{basket}(y) \wedge \exists x(\mathbf{apple}(x) \wedge \mathbf{in}(y, x))]\ (\mathbf{Some}\ x[\mathbf{apple}(x) \wedge \mathbf{in}(y, x)](\mathbf{rotten}(x)))$

We can generalize from this one example to the general case and extend our semantic representation language (some version of higher-order predicate logic with generalized quantifiers) to include this type of polyadic quantifiers. The necessary definitions are given in (20). First the syntax is introduced. Then, the semantics is given by showing the reduction to monadic quantification.

(20) For determiners $Q_1, \ldots, Q_n$, variables $x_1, \ldots, x_n$, and formulæ $\phi_1, \ldots, \phi_n, \psi$, $\langle Q_1, \ldots Q_n\rangle\langle x_1, \ldots, x_n\rangle\langle \phi_1, \ldots, \phi_n\rangle(\psi)$ is a formula, and

$$\langle Q_1, \ldots Q_n\rangle\langle x_1, \ldots, x_n\rangle\langle \phi_1, \ldots, \phi_n\rangle(\psi)$$
$$\equiv Q_1 x_1[\phi_1 \wedge \exists x_2 \ldots \exists x_n(\phi_2 \wedge \ldots \wedge \phi_n)]$$
$$(Q_2 x_2[\phi_2 \wedge \exists x_3 \ldots \exists x_n(\phi_3 \wedge \ldots \wedge \phi_n)]\ (\ldots (Q_n[\phi_n](\psi) \ldots))$$

The important aspect of the semantics of the polyadic quantifiers defined in (20) is that every quantifier is restricted to the existence of elements in the restrictor of the scopally lower quantifiers. The definition in (20) shows that the particular kind of polyadic quantifier needed for IL and TS is reducible to monadic quantification. Therefore, a polyadic analysis is not strictly logically necessary, but it is well motivated from the point of view of the syntax-semantics interface.

Given the semantic analysis of the sentence, we can now derive the empirical observations from section 2. There is no need to mention the *Haddock's puzzle* data again. The semantics of our polyadic quantifiers is explicitly defined in such a way as to include the restrictor of the semantically lower quantifiers in that of the scopally higher ones.

I start with *except*-phrases. *Except*-phrases can only occur with universally quantified NPs. I state the semantic representation of a sentence containing the NP *the wife of every president* in (21), together with its monadic equivalent. The monadic formula shows that the resulting quantifier has the interpretation of a universal. Thus, we correctly predict that it is compatible with *except*-phrases.

(21) [The wife [of every president]] is popular.

$$\langle \textbf{Every}, \textbf{The}\rangle\langle x, y\rangle\langle \textbf{president}(x), \textbf{wife}(y, x)\rangle(\textbf{be-popular}(y))$$
$$\equiv \textbf{Every}\ x[\textbf{president}(x) \wedge \exists y(\textbf{wife}(y, x))](\textbf{The}\ y[\textbf{wife}(y, x)](\textbf{be-popular}(y)))$$

The argumentation for *there*-sentences is analogous. I provide a *there*-sentence together with its polyadic representation and the monadic equivalent in (22). There are various explanation for the definiteness effects in the literature. I will pick the one from Zucchi (1995) for illustration. According to Zucchi an existential sentence is non-presuppositional, i.e., it does not presuppose the existence of the post-verbal subject. The monadic formula can be used to show that this condition is met here. The higher quantifier, **Some**, is restricted to a theorem which has a prove. The existential presupposition of the definite NP *the proof of a theorem* can then be locally accommodated. Consequently, there is no global presupposition of the post-verbal subject NP.

(22) There is [the proof [of a theorem]] on page 423.
$\langle \textbf{Some}, \textbf{The} \rangle \langle x, y \rangle \langle \textbf{theorem}(x), \textbf{proof}(y, x) \rangle (\textbf{bo-on-p423}(y))$
$\equiv \textbf{Some}\ x[\textbf{theorem}(x) \wedge \exists y(\textbf{pr}(y, x))](\textbf{The}\ y[\textbf{pr}(y, x)](\textbf{be-on-p423}(y)))$

Let us briefly comment on Laron's observation on the inseparability of the two quantifiers in IL. Given that the polyadic quantifier is one unit, it follows directly that no quantifier that is not part of the polyadic complex can take intermediate scope between those that are part of the polyadic quantifier. I will come back to this issue in section 6, though.

So far I have only presented representations for IL. The representations for corresponding TS sentences would not be much different. For illustration I sketch the semantic representation of the sentence from (1-b) in (23).

(23) [The picture [that every soldier kept]] didn't bring him much luck.
$\langle \textbf{Every}, \textbf{The} \rangle \langle x, y \rangle \langle \textbf{soldier}(x), (\textbf{pict}(y) \wedge \textbf{keep}(x, y)) \rangle (\textbf{no-luck}(y, x))$

Before closing this subsection, I would like to mention that a polyadic approach is compatible with each of the contributing quantifiers binding individual pronouns in the overall scope. In (24) I show that an unequivocally polyadic quantifier, required by the occurrence of *anderes* ('different') in the sentence, does not block binding of a pronoun.

(24) Jeder$_i$ hat ein anderes Verständnis von seiner$_i$ Umwelt.
'Everyone has a different understanding of his environment.'

In this subsection I have introduced a polyadic semantic representation for IL and TS. I have shown that these representations have the right truth conditions for the phenomena presented in section 2 and that they overcome problems of earlier, non-polyadic approaches. In the next subsection I will present a system of the syntax-semantics interface that allows us to derive polyadic representations in a systematic way.

4.2. Syntax-semantics interface

Probably one of the most important obstacles for using polyadic quantifiers widely in linguistic analyses is that many architectures of the syntax-semantics interface do not have the possibility to derive polyadic representations directly. For example Moltmann (1995) achieves polyadic effects through pragmatic inference but not as a direct part of the compositional semantics. Similarly Champollion and Sauerland (2011) get the same truth conditions as I propose in section 4.1, but they use a pragmatic operation of intermediate accommodation.

In contrast to these systems, there are proposals that explicitly use polyadic quantifiers. May (1985, 1989) introduces quantifier amalgamation: He assumes that all quantifiers that attach to a particular node are interpreted jointly, as a polyadic quantifier. De Swart and Sag (2002) make a very similar proposal. In their system, all dependents of a head can be amalgamated into a polyadic quantifier. Finally, Iordăchioaia (2009) and Iordăchioaia and Richter (2014) build polyadic quantification into a system of underspecified semantics. I will follow this last approach here.

I will use the system of *Lexical Resource Semantics* (LRS, Richter and Sailer 2004). LRS is based on techniques of underspecified semantics, as motivated for example in Pinkal (1996). It is typically combined with a surface-oriented syntactic analysis such as HPSG (Pollard and Sag 1994). The general idea of LRS is that words and phrases constrain the possible semantic representations of the utterance in which they occur. For example, each sentence that contains the word *basket* has as parts of its semantic representation (i) the constant **basket**, (ii) some discourse referent x, and the functional application of **basket** to x, i.e., the expression $\mathbf{basket}(x)$. At the level of an utterance, the overall semantic representation must be a formula that consists exactly of the semantic constants and operators contributed by the words. The syntactic structure and also the words may specify certain additional requirements on these overall representations but typically, these "lexical resources" do not fully specify the resulting representations.

I will illustrate the system with the example in (18). In (25) I indicate the words and phrases of the sentence and, for each of them, the semantic constants and operators as well as the constraints that they contribute. I have already commented on the contribution of the word *basket*, which is given in (25-a). The contribution of *apple* (see (25-f)) is analogous.

The determiners *every* and *an* make a more complex semantic contribution, see (25-b) and (25-h). They specify that the logical determiner must occur as an element of a possibly polyadic quantifier. The position of the determiner within this quantifier is not specified, indicated as i for *every*. The variable bound by the quantifier has to occur in the corresponding position in the list of bound variables (i.e., x needs to be the i-th variable). The variable bound by the determiner should then occur within the corresponding restrictor as well. When the words *every* and *basket* combine, no additional elements are introduced into the semantic representation, but a constraint that $\mathbf{basket}(x)$ occur in the i-th restrictor. This is shown in (25-c).

Space prevents me from going through each line in (25), but the general idea of words contributing elements of semantic representations and phrases contributing constraints on how these may be combined should be clear.

(25) An apple in every basket is rotten.

a. *basket*: $\mathbf{basket}(x)$

b. *every*: $\left\langle \ldots, \textbf{Every}^i, \ldots \right\rangle \langle \ldots, x^i, \ldots \rangle \langle \ldots, (\ldots x \ldots)^i, \ldots \rangle (\ldots)$
c. *every basket*: $\textbf{basket}(x)$ must be in the i-the restrictor (i.e., in that of *every*)
d. *in*: $(\ldots \wedge \textbf{in}(y, x))$
e. *in every basket*: $\textbf{in}(y, x)$ must not occur in the i-th restrictor
f. *apple*: $\textbf{apple}(y)$
g. *apple PP*: $(\textbf{apple}(y) \wedge \ldots \textbf{in}(y, x) \ldots)$
h. *an*: $\left\langle \ldots, \textbf{Some}^j, \ldots \right\rangle \langle \ldots, y^j, \ldots \rangle \langle \ldots, (\ldots y \ldots)^j, \ldots \rangle (\ldots)$
i. *an apple PP*: $\textbf{apple}(y)$ is in the j-th restrictor (i.e., that of *an*)
j. *is rotten*: $\textbf{rotten}(y)$
k. *NP is rotten*: $\textbf{rotten}(y)$ is in the scope of the quantifier that binds y

No other expression occurs in the semantic representation

Once a sentence is completed, any semantic representation that uses exactly the contributed elements and satisfies all constraints is a potential reading. For our example we have four such readings, given in (26). There are two non-polyadic readings, (26-a) and (26-b). In these readings, **Every** and **Some** are each the only determiners in the list of determiners and i and j are both 1. For these readings, the constraints in (25) do not constraint the relative scope of the quantifiers. Thus, we derive scope ambiguity by underspecification. The formulæ in (26-c) and (26-d) show polyadic readings. Here the two quantifiers unify to form a single quantifier. However, again, the mutual order of the determiners is not specified. The IL reading is derived if **Every** is the first element ($i = 1$), a surface-order reading if **Some** is first ($j = 1$).

(26) a. Non-polyadic: (*There is the same rotten apple in every basket.*)
$\textbf{Some}\ y[\textbf{apple}(y) \wedge \textbf{Every}\ x[\textbf{basket}(x)](\textbf{in}(y, x))](\textbf{rotten}(y)))$
$i = 1$, $j = 1$; non-identical quantifiers

b. Non-polyadic: (*Every basket contains a rotten apple.*)
$\textbf{Every}\ y[\textbf{basket}(y)](\textbf{Some}\ x[\textbf{apple}(y) \wedge \textbf{in}(y, x)](\textbf{rotten}(y)))$
$i = 1$, $j = 1$; non-identical quantifiers

c. Polyadic: (polyadic inverse linking)
$\langle \textbf{Every}, \textbf{Some} \rangle \langle x, y \rangle \langle \textbf{basket}(x), (\textbf{apple}(y) \wedge \textbf{in}(y, x)) \rangle (\textbf{rotten}(y))$
$i = 1, j = 2$; quantifier unification

d. Polyadic: (polyadic surface scope order)
$\langle \textbf{Some}, \textbf{Every} \rangle \langle y, x \rangle \langle (\textbf{apple}(y) \wedge \textbf{in}(y, x)), \textbf{basket}(x) \rangle (\textbf{rotten}(y))$
$i = 2, j = 1$; quantifier unification
x is not bound in the first restrictor!

In (26) I list four readings, non-polyadic and polyadic surface scope and inverse linking readings. The question arises whether we really need the non-polyadic readings. If we allow them, we need an additional constraint to ensure inseparability of the two quantifiers, which was one of the initial motivations for a polyadic analysis. If we exclude them, we need additional possible interpretations for a polyadic quantifier to allow a reading where every basket must contain an apple. In section 6 I will report data that support the existence of the non-polyadic readings.

Given this situation we need an additional constraint to enforce inseparability on quantifiers from the same NP. We can do this with the constraint in (27). The constraint specifies that quantifiers that stem from the same NP may not be separated by quantifiers from outside this NP.

(27) Dominance condition for quantifiers
If a quantified NP n dominates another quantified NP m, then each quantifier that takes intermediate scope between n and m is also dominated by n.

For illustration, consider the hypothetical logical form of the separated reading of (6). The sentence and the relevant, unavailable reading are given in (28).

(28) Two policemen spy on someone from every city. **# Every $>$ Two $>$ Some**

In this reading, the NP *someone from every city* dominates the NP *every city*. Since *two policemen* takes scope between these two, the constraint in (27) requires that this NP be also dominated by *someone from every city*. Since this is not the case, the reading is unavailable.

Before closing this section, we need to express one further constraint. Given the polyadic analysis of TS we can maintain the clause-boundedness constraint on strong quantifiers. This constraint is formulated in (29). The constraint is formulated in such a way that clause-boundedness is ensured for strong quantifiers that occur inside a V-dependent clause.

(29) Clause-boundedness of strong quantifiers
If a clause is a dependent of a verb, then the clause's semantic representation contains all (strong) quantifiers that it dominates.

This constraint correctly excludes TS from subject or complement clauses (see the data in (15) and (16)). It also excludes TS from inside a relative clause if the quantifier in question is further embedded within the relative clause. Due to the complexity of such examples, it might not be easy to determine the grammaticality of such sentences, but sentence (30) does not allow for a bound interpretation of the pronoun in the matrix clause.

(30) *[Die Professorin, [die meint, dass jeder$_i$ Student faul ist] hat Vorurteile über ihn$_i$].
'The professor who thinks that every$_i$ student is lazy has prejudices about him$_i$.'

In this section I have presented a polyadic analysis of IL and TS within the framework of LRS. I first discussed the required semantic representations and showed how the data from section 2 can be accounted for. Then I sketched the constraints introduced by each word and within the sentences. I showed how the polyadic readings can be derived. I also allowed for non-polyadic readings and stipulated a constraint to guarantee inseparability of quantifiers from the same NP even in the non-polyadic readings. Finally I introduced a clause-boundedness constraint for the scope strong quantifiers. Their clause-boundedness is restricted to V-dependent clauses. This still makes TS possible from within an NP, but excludes it from within a subject or complement clause.

5. Additional observation: NPI licensing

The polyadic analysis makes the right predictions also for data on negative polarity items (NPIs) within complex NPs that have not been previously reported in the literature to my knowledge. Classical NPI-licensing contexts include the scope of negation and the restrictor of a universal quantifier. An NPI is, however, not licensed inside a definite NP.

In (31-a) the underlined NPI *je* ('ever') occurs inside an extraposed relative clause that is part of a definite NP. As expected, the NPI is not licensed. In (31-b) the NP contains an additional embedded universal quantifier. The relative clause is clearly attached to the higher noun, *Name* ('name'), as is clear by the gender agreement in German. Nonetheless the NPI is now licensed.

(31) a. *Auf der Liste wurde [der$_i$ Name] vermerkt,
[der$_i$ <u>je</u> im Zusammenhang mit dem Skandal genannt wurde].
'On this list [the$_i$ name] was noted
[that$_i$ had <u>ever</u> been mentioned in connection with the scandal].'

b. Auf der Liste wurde [der$_i$ Name [jeder$_j$ Politikerin] vermerkt,
[der$_i$ <u>je</u> im Zusammenhang mit dem Skandal genannt wurde].
'On this list [the$_i$ name of every$_j$ politician] was noted
[that$_i$ had <u>ever</u> been mentioned in connection with the scandal].'

Under a non-polyadic analysis the NPI does not end up in the restrictor of the universal but in its scope, which is not an NPI-licensing position. In (32) I sketch the semantic representation of (31-b) under the polyadic analysis. Now the NPI's semantics appears as part of the restrictor list. With the simple assumption that the NPI-licensing potential of the highest determiner carry over to the entire restrictor list, we immediately account for the data.

(32) $\langle \mathbf{Every}, \mathbf{The} \rangle \langle x, y \rangle \langle \mathbf{politician}(x), (\mathbf{name\text{-}of}(y, x) \wedge \ldots \mathbf{NPI} \ldots) \rangle (\mathbf{be\text{-}on\text{-}list}(y))$

This unit-like behavior in NPI-licensing extends to other constellations as well. A definite DP is not a barrier for NPI licensing, whereas a universal quantifier is (see (33-a)). When a definite NP contains a universal quantifier it will, however, turn into a barrier under an IL reading, (33-b).

(33) a. Niemand hat [dem/ *jedem Berater] auch nur irgendetwas erzählt.
no one has the/ every advisor anything told
'No one told the/every advisor anything.'
b. *Niemand hat [dem Berater [jedes Präsidenten]] auch nur irgendetwas erzählt.
'Noone told [the advisor of [every president]] anything.]'

Finally, we know that definite NPs do not license NPIs, but the determiner *die wenigsten* ('few') licenses NPIs in its scope. This is shown in (34-a) and (34-b). As might be expected by now, if an NPI-licensing determiner is syntactically embedded inside the definite NP but is used in an IL reading, an NPI can be licensed. Such a constellation is given in (34-c).

(34) a. *[Die Biographie] enthält auch nur irgendwelche neuen Informationen.
'The biography contains any new information.'
b. [Die wenigsten Biographien] enthalten auch nur irgendwelche neuen Informationen.
'Few biographies contain any new information.'
c. [Die Biographie [der wenigsten Politiker]] enthält auch nur irgendwelche Infos.
'[The biography [of few politicians]] contains any information.'

The NPI data provide additional support for the polyadic analysis. Only this analysis captures the fact that the NPI-licensing potential of the syntactically higher determiner is replaced by that of the syntactically embedded quantifier in IL. Non-polyadic theories do not offer a similarly simple account for these data.

6. Intermediate modal operators (Sauerland 2005)

It is important to come back to the question of whether or not the non-polyadic readings of (5) exist at all. Sauerland (2005) acknowledges the inseparability of quantifiers from the same NP, but he shows that this does not mean that no semantic material can occur between the quantifiers. He shows with (35) that modal operators may very well occur there. The most natural interpretation of the sentence is such that there are two countries such that Mary wants to marry someone from them. In other words, there is a reading in which the modal semantics takes intermediate scope between the determiner **Two** and **Some**.

(35) Mary wanted to marry someone from these two countries. **Two** $>$ **want** $>$ **Some**

Sauerland's observation also applies to modals for German. Sentence (36) has two IL readings: in one reading (**Every** > **want** > **Some**) for each EU country Alex wants to know someone from that country; in the second reading (**want** > **Every** > **Some**) Alex has the wish that for each EU country she gets to know someone. The contrast is clear if we assume that Alex doesn't know that Latvia is in the EU. Under the first reading, the sentence is only true if Alex wants to get to know someone from Latvia as well. In the second reading, the sentence is true even if Alex is not interested in getting to know someone from Latvia. Both readings are available to me.

(36) Alex will [jemanden aus [jedem EU-Land]] kennen lernen.
Alex wants to get to know someone from every EU country.

We saw in section 5 that NPI licensing requires a polyadic analysis. If we include an NPI in the same way we did in (31-b) above, we can test whether one of the readings of (36) disappears. A relevant example sentence is (37). If Alex does not know that Latvia is in the EU then the sentence is true even if Alex does not want to get to know an Esperanto learner from Latvia. To me, no reading is available that enforces that Alex wants to get to know an Esperanto learner form Latvia. This shows that the intermediate scope of the modal is not available under in an unambiguously polyadic reading.

(37) Alex will [jemanden$_i$ aus [jedem EU-Land]] kennen lernen,
[der$_i$ jemals Esperanto gelernt hat].
'Alex wants to get to know someone from every EU country
who has ever learned Esperanto.'

With this result we can go back to the question of whether we need the polyadic as well as the non-polyadic readings for sentences with quantifiers within quantifiers. The intermediate scope data from Sauerland (2005) require a non-polyadic analysis whereas the NPI-licensing data require a polyadic analysis. This shows that, in fact, both kinds of readings are necessary.[2]

7. Conclusion and outlook

I have argued in this paper that NPs with embedded quantifiers show a behavior that can neither be reduced to that of their syntactically highest determiner nor to that of a syntactically embedded determiner that takes wide scope. The data are the same here whether the embedded NP is part of a PP (IL) or of a relative clause (TS). Existing approaches to inverse linking and telescoping address the unit-like behavior at best indirectly. I proposed a polyadic analysis instead. Polyadic analyses

[2]Alternatively one might assume different world indices, i.e., that in (36) the noun *EU countries* can either be interpreted with respect to Alex's wish-worlds or to the real world. Under such an analysis, the polyadic reading would be sufficient.

are technically difficult for many approaches to the syntax-semantics interface, but can easily be integrated into LRS. We then saw new data on NPIs that follow directly from the polyadic analysis. Finally, rarely discussed data on intermediate scope of modal operators in IL showed that we need both a polyadic and a non-polyadic analysis for IL.

The paper addressed a number of issues, but could only scratch their surface. To get a clearer picture we would need case-by-case studies of individual determiner combinations. It is also necessary to investigate the constraints on telescoping further. Finally, the relation to other cases of polyadic quantification needs to be explored.

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