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# FUNCTIONAL TOPICS*

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**Abstract**

It has long been observed that DPs containing a bound pronoun can occur left-dislocated in the German pre-field (see e.g. Vat 1981, Frey 2004b) while at the same time (Frey 2004b) argues that a left-dislocated DP has to be understood as the *aboutness topic* of the respective sentence. As the pronoun in the left-dislocated DP is bound from within the clause, this seems to be add odds with the claim that topicality of a DP results in a wide scope reading of this DP (as proposed e.g. by Cresti 1995, Ebert and Endriss 2004). We show that those examples in fact have *functional* wide scope readings as opposed to narrow scope readings and propose an extension of the approach of (Ebert and Endriss 2004) that can derive those readings and account for the occurrence restrictions of certain DPs w.r.t. left-dislocation and other topic positions.

## 1 Introduction

As (Frey 2004a, Frey 2004b) has argued, German exhibits two constructions that involve *topical* constituents only. First, *German left-dislocation* constructions, as illustrated in the following example (where RP is short for 'resumptive pronoun').

(1) Den Peter, den kann keiner leiden.
the peter RP can nobody like

'Nobody likes Peter.'

And second, constructions where a DP occurs in a position in the middle field, directly above the base position of a sentence adverbial expressing the speaker's estimation of an eventuality (Frey, 2004a, p. 157), such as *glücklicherweise (fortunately)*, *überraschenderweise (surprisingly)*, *anscheinend (apparently)*, *sicherlich (certainly)*, or *wahrscheinlich (probably)*. Note that only sentence adverbials mark the right edge of the topic position as these adverbials have the highest base position in the middle field. Temporal or locative adverbials do not have this property.

(2) dass den Peter anscheinend keiner leiden kann.
that the peter apparently nobody like can

'that apparently nobody likes Peter.'

In both (1) and (2) it is the constituent *den Peter* that is marked for topicality. As Frey argues, it is therefore this constituent that determines the aboutness topic of the respective sentences – they are both about Peter, of whom it is stated that (apparently) nobody likes him. This

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understanding of topicality in the aboutness sense goes back to Reinhart (1981), who ascribes this concept to Strawson (1964).

Under Reinhart's aboutness concept, certain indefinites and not only familiar items such as proper names can function as topics. The following examples illustrate that indefinite DPs such as *ein Freund von mir (a friend of mine)* or *drei Freunde von mir (three friends of mine)* are indeed felicitous in Frey's topic positions. Just as (1,2) make statements about Peter, the following sentences make statements about some friend/three friends of mine in the same way.

(3) Einen Freund / Drei Freunde von mir, den/die hat jeder gesehen.
a friend / three friends of mine RP has everybody seen.

'Everybody has seen a friend/three friends of mine.'

(4) dass einen Freund / drei Freunde von mir wahrscheinlich jeder gesehen hat.
that a friend / three friends of mine probably everybody seen has

'that probably everybody has seen a friend/three friends of mine.'

Reinhart's idea towards a formalization of aboutness topicality is to say that the topical element under discussion provides a *storage address* at which the remaining information of the sentence is stored. In this view, the preceding examples establish discourse referents for Peter and a friend/three friends of mine as storage addresses, at which the remaining information of the sentence (that of (apparently) being liked by nobody/that of (probably) having been seen by everybody) is stored. Some quantifiers however do not seem to be able to provide reasonable storage addresses – they are illicit in Frey's topic positions.

(5) a. *Mehr als drei / *wenige Freunde von mir, die kann keiner leiden.
more than three / few friends of mine RP can nobody like

b. dass *mehr als drei / *wenige Freunde von mir anscheinend keiner leiden kann.
that more than three / few friends of mine apparently nobody like can

Among the illicit quantifiers one finds those corresponding to modified numeral DPs, and non-upward monotonic ones, while singular indefinites and bare numerals seem to make good aboutness topics.

Considering truth-conditional interpretation, topic marking seems to have different functions. Example (6), without any overt topic marking, is ambiguous between a wide scope and a narrow scope reading for *einen politiker (a politician)*. It can either mean that there is some politician that everybody knows, or that it holds for everybody, that he knows a politician.

(6) Einen Politiker kennt jeder.
A politician knows everybody.

'Everybody knows a politician.'

However, the examples in (3) and (4), where the involved indefinite occupies a topic position, do not seem to be ambiguous in the same way. In particular, the narrow scope reading for the indefinite is not available any more. In general, topical indefinites can only receive a strong interpretation. For one, this strong interpretation can be a wide scope/specific/referential interpretation of the respective constituent (cf. Cresti 1995, Portner and Yabushita 2001, Ebert and Endriss 2004, Endriss 2006), which can be elicited by stressing the determiner (indicated with upper case letter in the following). Hence, the following minimal variant of (6) only has a reading where some particular politician is known by everybody.

(7) EINEN Politiker, den kennt jeder.
A politician RP knows everybody.

'Everybody knows some politician.'

Another option seems to be a generic interpretation of the respective constituent (Kuno 1972, Kuroda 1972), which the following sentence illustrates.

(8) Ein POLITIKER, der hat viele Feinde.
A politician RP has many enemies.

'A politician has a lot of enemies.'

Stress on the N-complement (instead of the determiner) of the DP brings out the generic reading. We cannot go into further detail about the nature of stress and intonational marking and the general principle of topic interpretation that underlies both readings, but refer the reader to (Endriss and Hinterwimmer 2006) instead. In the following, we set aside the generic readings of topic-marked constituents and focus solely on the wide scope readings of indefinites.

In particular, we take (Ebert and Endriss 2004) as a basis for further investigations. There we argue that a topic marked constituent receives a wide scope reading as a result of the derivation of an appropriate storage address for the aboutness interpretation in the sense of (Reinhart 1981).

However, at first sight it seems as if there were obvious counterexamples to the claim that a wide scope interpretation is the result of interpreting a constituent as an aboutness topic. It has long been observed that DPs containing a bound pronoun can also occur left-dislocated in the German pre-field (see e.g. Vat 1981, Frey 2004b).

(9) a. Seinen$_i$ Doktorvater, den verehrt jeder Doktorand$_i$.
his supervisor, RP admires every PhD-student

'Every PhD student admires his supervisor.'

b. EIN Bild von sich$_i$, das hat jeder Schüler$_i$ mitgebracht.
a picture of himself, RP has every pupil brought-along

'Every pupil brought along some picture of himself.'

Such DPs also happily occur in Frey's German middle field position directly above the base position of a sentence adverbial.

(10) a. dass seinen$_i$ Doktorvater wahrscheinlich jeder Doktorand$_i$ verehrt.
that his supervisor probably every PhD-student admires

'that every PhD student admires his supervisor.'

b. dass EIN Bild von sich$_i$ überraschenderweise jeder Schüler$_i$ mitgebracht hat.
that a picture of himself surprisingly every pupil brought-along has

'that apparently every pupil brought along some picture of himself .'

Interestingly, the same occurrence restrictions on the determiner apply for DPs containing bound pronouns as for the corresponding DPs without such pronouns, as indicated in the following example.

(11) (*Mehr/*weniger als) drei Bilder (von sich), die hat jeder Schüler mitgebracht.
( more/ less than) three pictures (of himself), RP has every pupil brought-along

For instance, whereas *some*-indefinites and bare numeral DPs are natural in those topic positions, modified numeral DPs are infelicitous – with and without bound pronouns.

In the felicitous variants of those examples ((11) with the bare numeral and (9b)) the pronoun in the left-dislocated DP is bound by the universal quantifier of the clause. Hence it seems that this dislocated DP should take scope below its binder, which would come down to a narrow scope reading of the topical DP. This raises some obvious questions:

1. What does it mean for a dependent DP containing a bound pronoun to be the entity the sentence is 'about'?
2. What happens to the claim that topical elements always receive a wide scope reading?
3. How can the occurrence restrictions be accounted for?

In the following we will provide answers to these questions. In short, we will propose that DPs containing bound pronouns denote *nameable and informative functions*, which can take wide scope such as non-functional items. In other words, a sentence such as (9b) will receive a semantic representation along the lines of the following schema.

(12) $\exists f[f \text{ is a function into pictures } \wedge \forall x[\textsf{pupil'}(x) \rightarrow \textsf{bring-along'}(x, f(x))]]$

This sentence contains a *functional topic* - it is about the relationship of pupils and pictures of them, and this functional relation receives wide scope.

The next section shows how those functional wide scope readings can be told apart from narrow scope readings on empirical grounds and how the underlying restrictions of nameability and informativity can prevent the conflation of those readings on formal grounds. Section 3 gives a brief overview of (Ebert and Endriss 2004) and provides a conservative extension of that proposal which can derive the desired functional readings compositionally and predict the observed occurrence restrictions.

## 2 Functional Wide Scope

As indicated above, we aim at an explanation that employs functions to account for the readings of examples like (9b) and (10b). To this end it is important to get clear about the exact nature of these readings and to work out the differences between those functional wide scope readings and plain narrow scope readings.

### 2.1 Empirical Issues

In order to investigate the readings of (9b) in closer detail, we make use of acceptability differences of pair-list vs. function continuations that have been used to distinguish pair-list from functional readings in different contexts, e.g. in the context of questions (Groenendijk and Stokhof 1984, Chierchia 1993, Krifka 2001), functional relative clauses (Sharvit 1997), and scope phenomena (Schwarz 2001). Consider the following question-answer turns from (Krifka 2001).

(13) a. Which dish did every guest make?
1. Pasta.
2. His favourite dish.
3. Al, the pasta; Bill, the salad; ...

b. Which dish did most guests make?
1. Pasta.
2. His favourite dish.
3. # Al, the pasta; Bill, the salad; ...

While the wide scope reading of the wh-phrase requires answers like those in 1., the functional reading and the pair-list reading require answers like 2. and 3., respectively. The acceptability differences concerning the pair-list continuations in 3. show that (13b) lacks a pair-list reading which (13a) has.

We make use of the same diagnostic tool to keep apart narrow scope readings from functional wide scope readings (cf. Groenendijk and Stokhof 1984). Let us take a look at (14) first, where a bound pronoun occurs in a DP that is not overtly topic-marked[1].

(14) a. Jeder Schüler$_i$ hat ein Bild von sich$_i$ mitgebracht.
every pupil has a picture of himself brought-along

b. Ein Bild von sich$_i$ hat jeder Schüler$_i$ mitgebracht.
a picture of himself$_i$ has every pupil$_i$ brought-along

'Every pupil brought along a picture of himself.'

Both sentences in (14) can felicitously be followed by a functional explication of the pupil-picture relationship (15a) or by a pair-list explication of the pupil-picture pairs (15b).

(15) a. Nämlich das Bild seiner Einschulung.
Namely the picture of his school enrolment

b. Nämlich John ein Bild seines Geburtstags, Mary ein Bild ihrer Einschulung,
Namely John a picture of his birthday, Mary a picture of her enrolment,
Peter...
Peter...

Contrast this with the variant (9b) involving left dislocation and hence topic-marking of the DP. Here the acceptability pattern of the possible continuations changes. While the functional explication (15a) is still felicitous, the pair-list enumeration (15b) is unacceptable. We conclude that (9b) only has a *functional wide scope* reading, whereas (14a,b) have a genuine narrow scope reading in addition, which is verified by the fact that they can felicitously be followed by a pair-list continuation.

In conclusion, we have seen that topic-marked DPs containing pronouns bound from within the clause do not have narrow scope readings as it might seem at first sight, but only readings, where a function takes widest scope. Hence the general claim that topicality induces wide scope does not have to be dismissed, but on the contrary receives further support from the data – narrow scope readings elicited by pair-list continuations are excluded.

## 2.2 Restrictions on Functions

In an attempt to formalize functional wide scope readings, one directly runs into the problem of separating this reading from a narrow scope reading on truth-conditional grounds. Consider the following two formulae.

(16) a. $\forall x[\exists y[P(x,y)]]$

b. $\exists f[\forall x[P(x,f(x)]]$

[1]Note that in (14b) the DP if *fronted*, yet not left-dislocated.

Formula (a) exemplifies a narrow scope reading: for all $x$ there is a $y$ such that the predicate $P$ holds of $x$ and $y$. Formula (b) on the other hand exemplifies a functional wide scope reading: there is a function $f$ such that for all $x$ the predicate $P$ holds of $x$ and whatever $f$ assigns to $x$. The general problem is that the formulae are truth-conditionally equivalent[2]: whenever there is such a method $f$ as described above, then there is a corresponding $y$ (just assume $y = f(x)$); and if for every $x$ there is a $y$ then one can define a method $f$ that assigns that corresponding $y$ to every $x$. The transition from (16a) to (16b) whereby narrow scope existential quantifiers are eliminated is also known as *Skolemization* after the logician A. T. Skolem, who proposed this procedure.

The same problem presents itself in a different guise when looking at the truth conditions of a certain type of sentences containing downward entailing operators (see e.g. Reniers 1997, Schwarz 2001, Chierchia 2001). Consider the following sentence, where the pronoun of the dislocated DP is bound by a downward entailing quantifier in the clause.

(17) EInen Lehrer seiner Schule$_i$, den kann kein Schüler$_i$ leiden.
some teacher his school RP can no pupil like.

'No pupil likes some teacher of his school.'

The functional wide scope reading we are after would schematically look as follows:

(18) $\exists f[f \text{ is a function into teachers } \wedge \neg\exists x[\textsf{pupil'}(x) \wedge \textsf{like'}(x, f(x))]]$

Now suppose that there are two pupils Paul and Mary and two teachers Mr. Smith and Mrs. Jones, such that Paul likes Mrs. Jones and Mary likes Mr. Smith. First note that a narrow scope reading for *einen Lehrer seiner Schule (some teacher of his school)* would come out as false in this situation: there are pupils, i.e. Paul and Mary, who do like a teacher. However, (18) comes out as true, because the function that maps Paul to Mr. Smith and Mary to Mrs. Jones is as required. But without further comment on the nature of that function, this representation does not seem to be an available reading of (17). It *is* a reading however, if that function is not just an arbitrary assignment of pupils to teachers, but some nameable concept. In this example this could be a concept like

(19) a. his/her maths teacher, or

b. the teacher, who gave him/her his/her lowest grade.

This can again be attested by observing that (the German translations of) (19a,b) make good continuations for (17).

In the literature, this restriction has been explicated by demanding from the functions to be *natural* (e.g. Chierchia 1993, Sharvit 1997). What makes a function 'natural', however, has been elaborated only to a certain extent. For instance, Sharvit (1997) proposes that a function is natural if it is *salient*. But if salience is understood as 'contextually given' or 'familiar', we would not expect to have felicitous 'surprisal' continuations of the following sort to (9b) (e.g. uttered by a teacher talking about her pupils).

(20) EIN Bild von sich$_i$, das hat jeder Schüler$_i$ mitgebracht.

Nämlich – überraschenderweise – ein Bild das zeigt, wie er Nudelsuppe isst.
'Namely – quite surprisingly – a picture showing him eating noodle soup.'

[2]assuming the axiom of choice

We propose to elaborate the concept of naturalness by two criteria: *nameability* and *informativity*. A function is *nameable* if it is possible to refer to it by a (possibly complex) linguistic expression. Crucially, an enumeration of pairs does not *name* a function – although it may circumscribe (part of) the mapping. This kind of linguistic 'definability' is also hinted at in ( Chierchia 1993, p.212) ('[...] *natural functions, i.e. functions that we can readily access or define*') and in ( Jacobson 1999, p.160) ('*The term "natural function" is perhaps not the most felicitous one – a better one would be a "procedurally defined function".* [...] *A random list of ordered pairs* [...] *is not a recipe in the same sense.*').

However, nameability alone is not sufficient to derive the desired readings. Consider (9b) again (repeated below), together with a subsequent functional continuation.

(21) a. EIN Bild von sich$_i$, das hat jeder Schüler$_i$ mitgebracht.

Nämlich das Bild, das er mitgebracht hat.
'Namely, the picture that he brought along.'

Obviously, the continuation *names* a functional concept and hence fulfills the nameability criterion. However, the functional concept it describes is *uninformative* w.r.t. the clause. If a speaker simply wanted to convey the information that every pupil brought along some arbitrary picture, i.e. if she wanted to convey the information of the narrow scope reading, she would use the simpler (14). In information structural terms, this illustrates that the involved topical function must be *informative*, i.e. it must not express the information conveyed by the comment. If it did, the comment would not convey any new information about the topic and hence be redundant. Therefore, structuring the information into this particular topic-comment by left-dislocation of the respective DP would be inadequate. This is the motivation for imposing *informativity* as a second criterion: all involved functions must be informative, i.e. they must not be redundant w.r.t. the clause.

In the following we will spell out the formal details of a compositional approach that derives functional wide scope readings. Together with the restrictions of the involved functions to nameable and informative ones, this approach accounts for the data presented above.

## 3 A Compositional Derivation of Functional Wide Scope Readings

In (Ebert and Endriss 2004) we present a formal approach towards a compositional interpretation of topic-marked indefinites. The mechanism we propose elaborates the 'topic as storage address' metaphor of Reinhart (1981) in a way that simultaneously accounts for the (possibly exceptional, island-free) wide scope behaviour of topical indefinites as well as for the occurrence restrictions for certain determiners as pointed out in (11). In the following we will briefly summarize the ideas in (Ebert and Endriss 2004) and propose a conservative extension to functions that preserves all main characteristics of the original approach.

### 3.1 Ebert & Endriss, 2004

We take all DPs (i.e. also indefinites) to denote generalized quantifiers (GQs), where we follow (Kadmon 1985) w.r.t. to the lexical quantifier semantics. To this end, one has to make use of some version of dynamic semantics as put forward in *Dynamic Predicate Logic* (Groenendijk and Stokhof 1991), for instance. Spelled out in this dynamic framework, the semantic representations for some generalized quantifiers look as follows:

(22) a. ein Politiker (some politician) $\leadsto$ $\lambda Q.\exists x[\text{politican'}(x) \wedge Q(x)]$

b. drei Politker (three politicans) $\leadsto$ $\lambda Q.\exists X[|X| = 3 \wedge X \subseteq \text{politician'} \cap Q]$

c. mindestens drei Politiker (at least three politicians)
$\leadsto \lambda Q.\exists X[|X| \geq 3 \wedge X = \text{politician'} \cap Q]$

d. höchstens drei Politiker (at most three politicians)
$\leadsto \lambda Q.\exists X[|X| \leq 3 \wedge X = \text{politician'} \cap Q]$

In Kadmon's proposal the anaphoric potential of a quantifier is directly encoded in its lexical semantics. For instance, in (22b) the generalized quantifier (GQ) corresponding to *three politicians* introduces a discourse referent $X$ for a set that comprises exactly three elements and that is a subset of those politicians that have the property $Q$. In contrast to this, the GQ corresponding to *at least three politicians* in (22c) introduces a discourse referent that refers to a set of cardinality $\geq 3$ which exhausts, i.e. is equal to, the set of politicians which have property $Q$. This accounts for the exhaustivity w.r.t. anaphoric reference that a GQ such as (22c) exhibits as opposed to a non-exhaustive GQ such as (22b).

(23) a. Three politicians ate bananas. They felt sick afterwards.

b. At least three politicians ate bananas. They felt sick afterwards.

The first sentence of (23a) agrees with a situation in which there were more than three politicians that ate bananas. However, with the second sentence, the speaker does not assert that more than three politicians felt sick: *they* in the second sentence refers to a set of three politicians, irrespective of how many ate bananas. This is different in (23b). Although the first sentence agrees with exactly the same situations as the first sentence of (23a), the speaker asserts with the second sentence that more than three politicians felt sick, given that more than three politicians ate bananas. For instance, if six politicians ate bananas, the pronoun *they* can only refer to the set of all six politicians that ate bananas and not to a set of five or four. Although the two GQs are truth-conditionally equivalent (in non-dynamic terms), their dynamic potential is different. This difference is directly reflected in Kadmon's GQ semantics and will become important later.

During the compositional computation of the final meaning representation we follow (Krifka 1992) and employ *structured meanings* of the form $\langle T, C\rangle$, which consist of a topic component $T$ and a comment component $C$. The idea is that a topic-marked constituent with semantics $\varphi$ introduces a topic-comment structure $\langle \varphi, \lambda X.X\rangle$ where $X$ has the same type as $\varphi$. The remainder of the sentence then combines with this structure according to the following composition rules (taken from (Krifka 1992)).

(24) 1. $\langle T, C\rangle(\beta) = \langle T, \lambda X.[C(X)(\beta)]\rangle$, where $X$ is of the same type as $T$

2. $\beta(\langle T, C\rangle) = \langle T, \lambda X.[\beta(C(X))]\rangle$, where $X$ is of the same type as $T$

For instance, consider the following sentence:

(25) DREI Politiker, die kennt jeder.
Three politicians RP knows everybody.

'Everybody knows three politicians.'

The semantic composition would run as follows. We simplify matters and assume that the left-dislocated DP is interpreted in its originating position and furthermore ignore tense. Note that '$(22b)$' in the following formulas should be read as an abbrevation for the generalized quantifier semantics for *drei Politiker (three politicians)* in (22b).

(26)

| *Jeder* | *kennt* | $[$*drei Politiker*$]_T$ |
|---|---|---|
| *Everybody* | *knows* | *three politicians* |
| $\lambda Q.\forall x[\textsf{person'}(x) \rightarrow Q(x)]$ | $\lambda g \lambda x.g(\lambda y.\textsf{know'}(x,y))$ | $\langle (22b), \lambda g.g \rangle$ |
| $\lambda Q.\forall x[\textsf{person'}(x) \rightarrow Q(x)]$ | $\langle (22b), \lambda g \lambda x.g(\lambda y.\textsf{know'}(x,y)) \rangle$ | |
| $\left\langle \lambda Q.\exists X[\lvert X \rvert = 3 \wedge X \subseteq \textsf{politician'} \cap Q],\ \lambda g.\forall x[\textsf{person'}(x) \rightarrow g(\lambda y.\textsf{know'}(x,y))] \right\rangle$ | | |

As *drei Politiker (three politicians)* is topic-marked it introduces a topic-comment structure of the form

(27) $\langle \lambda Q.\exists X[\lvert X \rvert = 3 \wedge X \subseteq \textsf{politician'} \cap Q], \lambda g.g \rangle$,

where the semantic representation of the generalized quantifier ends up in the topic component and $g$ is a variable of the same type (i.e. of type $\langle \langle e,t \rangle, t \rangle$).
By construction of these representations and by definition of the composition rules, the 'standard' semantic value can be computed by application of the comment to the topic in each step of a derivation. Application of the comment to the topic component in the final representation from above would yield the (unavailable) narrow scope reading

(28) $\forall x[\textsf{person'}(x) \rightarrow \exists X[\lvert X \rvert = 3 \wedge X \subseteq \textsf{politician'} \cap \lambda y.\textsf{know'}(x,y)]]$.

However, this is of course not the actual interpretation that we want to ascribe to (25). As the sentence is structured into topic and comment we propose a topic interpretation principle by taking Reinhart's aboutness metaphor literally: the topical component should provide a storage address at which the information of the comment component is stored. In formal terms, such an address would be a *discourse referent*. As the topical component is a generalized quantifier (GQ), it does not straightforwardly yield such a storage address/discourse referent and therefore a representative for the GQ has to be created that can fill this role. We suggest to take one of the minimal witness sets $\textsf{MinWit}(g)$ (Barwise and Cooper 1981) of the generalized quantifier $g$ in question as a suitable representative (cf. Szabolcsi 1997). Those are sets that are minimal in the GQ w.r.t. the subset relation.

(29) $P \in \textsf{MinWit}(g) \quad \equiv \quad P \in g \ \wedge \ \neg \exists Q \in g[Q \neq P \wedge Q \subseteq P]$

For this minimal witness set representative a new discourse referent is established, which subsequently stands proxy for the actual generalized quantifier in the application of the comment. Hence the topic interpretation principle we propose for a structured meaning representation $\langle T, C \rangle$ goes along the following schema:

(30) $\exists D[D \in \textsf{MinWit}(T) \wedge C(D)]$

The type conflict that arises when applying the comment $C$ (which expects a GQ as an argument) to the set-type discourse referent $D$ is resolved by distribution, i.e. by type lifting $D$ to $\lambda P.D \subseteq P$.
In the case above, the minimal witness sets of the GQ corresponding to *drei Politiker (three politicians)* are all sets that contain exactly three politicians and no other individual. The outlined topic interpretation principle yields in this case

(31) $\exists D[\lvert D \rvert = 3 \wedge D \subseteq \textsf{politician'} \wedge \forall x[\textsf{person'}(x) \rightarrow D \subseteq \lambda y.\textsf{know'}(x,y)]]$.

This is the actually observed wide scope reading for the topic-marked DP: there is a set of three politicians such that everybody knows those politicians. As our approach is a purely information structure-driven semantic approach, we also predict exceptional wide scope readings for topic-marked DPs that occur in scope-islands as in the following example from (Ruys 1992).

(32) If [three relatives of mine]$_T$ die, I will inherit a fortune.

$\exists D[|D| = 3 \wedge D \subseteq \mathsf{relatives\_of\_me}' \wedge [D \subseteq \mathsf{die'} \rightarrow \mathsf{i\_inherit\_a\_fortune'}]]$

Note that our interpretation mechanism predicts that the DP *three relatives of mine* takes *collective* wide scope, which seems to be borne out indeed (cf. Ruys 1992).

Furthermore, we can naturally account for the occurrence restrictions to certain determiners in topic positions as indicated in (5). The ability of a DP to occur in topic positions follows directly from the potential of the corresponding generalized quantifier to provide a 'reasonable' storage address for the topic interpretation. The idea is, that the interpretation of a GQ as aboutness topic along the lines of the outlined topic interpretation principle above should not result in any change w.r.t. truth conditions when no other scope-taking operators are involved. In addition, such an interpretation should not destroy any anaphoric possibilities. In other words, the only detectable functions of topic may be the introduction of an additional discourse referent and hence an additional anaphoric possibility for subsequent discourse, and a truth-conditional difference only if other scope-taking operators are involved (namely, a wide scope reading for the GQ). We hence formulate the following *topic condition* that every GQ has to pass in order to be an admissible aboutness topic.

(33) A generalized quantifier $g$ fulfills the Topic Condition if for all sets $Y$

1. $\exists D[D \in \mathsf{MinWit}(g) \wedge D \subseteq Y] \quad \equiv \quad g(Y), \qquad$ and
2. all anaphoric possibilities that are available in $g(Y)$ remain available in

$$\exists D[D \in \mathsf{MinWit}(g) \wedge D \subseteq Y]$$

For instance, the generalized quantifier in (22b) corresponding to *three politicians* fulfills the topic condition. As its minimal witness sets are those sets containing exactly three politicians, we get the following instantiation of point 1 of (33).

(34) $\exists D[|D| = 3 \wedge D \subseteq \mathsf{poltician'} \wedge D \subseteq Y] \quad \equiv \quad \exists X[|X| = 3 \wedge X \subseteq \mathsf{politician'} \cap Y]$

Obviously, this equivalence holds indeed. Furthermore the anaphoric possibilities of the right hand side are the same as the ones on the left hand side: the right hand side allows $X$ to range over subsets of politicians with property $Y$ of cardinality three, while the left hand side allows $D$ to range over the same sets. As subsequent discourse can pick up those existentially bound and hence dynamically accessible variables $X$ and $D$, it is offered the same anaphoric possibilities. In conclusion, the generalized quantifier corresponding to *three politicians* fulfills both points of the topic condition. In fact, all GQs corresponding to bare numeral DPs as well as singular indefinites fulfill the topic condition and are hence eligible to topic interpretation as detailed above.

On the other hand, all downward entailing GQs do not fulfill point 1 of the topic condition, because their unique minimal witness set is the empty set $\emptyset$. Hence, point 1 of the topic condition does not hold:

(35) $\exists D[D = \emptyset \wedge D \subseteq Y] \quad \not\equiv \quad g(Y).$

The left hand side is tautological and hence not equivalent to the right hand side as long as $g$ is not the trivial determiner that comprises all sets. This excludes DPs headed by *wenige (few)*, *höchstens n (at most n)*, and *kein- (no)* from topic interpretation. A similar argument rules out non-monotonic GQs such as those corresponding to DPs headed by *genau n (exactly n)*.

At last, all exhaustive upward entailing GQs are ruled out due to point 2 of the topic condition. To see this consider (22c) and observe that its minimal witness sets coincide with those of (22b). Hence, it passes the first point of the topic condition just as (22b) does. But with respect to anaphoric potential we have to compare $\exists D[|D| = 3 \wedge D \subseteq \mathsf{politician'} \wedge D \subseteq Y]$ and $\exists X[|X| \geq 3 \wedge X = \mathsf{politician'} \cap Y]$. While the former allows reference to $D$s that contain exactly three politicians with property $Y$, the latter allows reference to $X$s that contain three *or more* politicians with property $Y$. Hence, some of the anaphoric possibilities available in the latter, original quantifier semantics are lost in the former and thus (22c) (and in fact all exhaustive upward entailing GQs) fail the second point of the topic condition. Altogether this accounts for the occurrence restrictions observed in (5).

### 3.2 An Extension to Functional Topics

To deal with functionally dependent elements, we lift the entire framework of (Ebert and Endriss 2004) to functional types. A dependent DP such as *ein Bild von sich (some picture of himself)* is translated as a function from individuals to generalized quantifiers, assigning every individual $x$ the GQ 'a picture of $x$'. The following shows a derivation of the DP *ein Bild von sich (a picture of himself)*.

(36)

| *ein* | *Bild* | *von* | *sich* |
|---|---|---|---|
| *a* | *picture* | *of* | *himself* |
| $\lambda P \lambda Q.\exists x[P(x) \wedge Q(x)]$ | $\lambda x.\mathsf{picture}(x)$ | $\lambda y \lambda x.\mathsf{of}(x,y)$ | $\lambda \mathbf{z}.\mathbf{z}$ |
| $\lambda P \lambda Q.\exists x[P(x) \wedge Q(x)]$ | $\lambda x.\mathsf{picture}(x)$ | $\lambda \mathbf{z} \lambda x.\mathsf{of}(x,\mathbf{z})$ | |
| $\lambda P \lambda Q.\exists x[P(x) \wedge Q(x)]$ | $\lambda \mathbf{z} \lambda x.\mathsf{picture}(x) \wedge \mathsf{of}(x,\mathbf{z})$ | | |
| $\lambda \mathbf{z} \lambda Q.\exists x[\mathsf{picture}(x) \wedge \mathsf{of}(x,\mathbf{z}) \wedge Q(x)]$ | | | |

In the spirit of (Jacobson 1999), semantic composition involving functional elements such as *sich (himself)* above is carried out by 1. saturating the functional argument (here: $\mathbf{z}$), 2. performing the standard semantic composition, and 3. abstracting over the functional argument again. The result is a function that assigns to each $\mathbf{z}$ the generalized quantifier 'a picture of $\mathbf{z}$'. Note that the empty quantifier $\emptyset_{\langle\langle e,t\rangle,t\rangle}$ is assigned to all $\mathbf{z}$ of which no pictures exist.

(Jacobson 1999) proposes the following $Z$-operator to take care of the binding of functional elements by other constituents.

(37) $Z \quad \equiv \quad \lambda R_{\langle e,\langle e,t\rangle\rangle} \lambda f_{\langle e,e\rangle} \lambda x_e.R(f(x))(x)$

The operator $Z$ is basically a type shifter for transitive verbs and is applied when a transitive verb has to be composed with a function of type $\langle e,e\rangle$, e.g. the function *his maths teacher*. The following illustrates how Jacobson's mechanism derives the correct semantic representation for *Every pupil likes his maths teacher.*

(38) *Every pupil* (*likes* (*his maths teacher*))

$\lambda Q.\forall x[\textsf{pupil'}(x) \rightarrow Q(x)]$ $Z(\textsf{like'})$ $\lambda \mathbf{z}.\textsf{math\_teacher'}(\mathbf{z})$

$\lambda Q.\forall x[\textsf{pupil'}(x) \rightarrow Q(x)]$ $\lambda f \lambda x.\textsf{like'}(f(x))(x)$ $\lambda \mathbf{z}.\textsf{maths\_teacher'}(\mathbf{z})$

$\lambda Q.\forall x[\textsf{pupil'}(x) \rightarrow Q(x)]$ $\lambda x.\textsf{like'}(\textsf{maths\_teacher'}(x))(x)$

$\forall x[\textsf{pupil'}(x) \rightarrow \textsf{like'}(\textsf{maths\_teacher'}(x))(x)]$

Since we have to deal with functional generalized quantifiers as in (36), we need a higher typed version of $Z$ such that the result of applying it to a transitive verb can combine with such a functional generalized quantifier. The following definition of $Z_1$ is a variant of Jacobson's $Z$ and Winter's $Z_0$ (see Winter 2004) that accomplishes this task.

(39) $Z_1 \quad \equiv \quad \lambda R_{\langle e,\langle e,t\rangle\rangle} \lambda \mathfrak{R}_{\langle e,\langle\langle e,t\rangle,t\rangle\rangle} \lambda x_e.\mathfrak{R}(x)(\lambda y.R(x,y))$

In the following derivation of the topic comment structure for (9b) we again simplify matters and assume that the left-dislocated DP is interpreted in its originating position. Note that '(36)' in the following formula has to be read as an abbreviation for the semantic representation of the functional generalized quantifier in the bottom line of (36).

(40) *Jeder Schüler* *brachte* $[$*ein Bild von sich*$]_T$ *mit*
*Every pupil* *brought-along* *a picture of himself*

$\lambda Q.\forall x[\textsf{pupil'}(x) \rightarrow Q(x)]$ $Z_1(\textsf{bring'})$ $\langle (36), \lambda \mathfrak{R}.\mathfrak{R}\rangle$

$\lambda Q.\forall x[\textsf{pupil'}(x) \rightarrow Q(x)]$ $\lambda \mathfrak{R} \lambda x.\mathfrak{R}(x)(\lambda y.\textsf{bring'}(x,y))$ $\langle (36), \lambda \mathfrak{R}.\mathfrak{R}\rangle$

$\lambda Q.\forall x[\textsf{pupil'}(x) \rightarrow Q(x)]$ $\langle (36), \lambda \mathfrak{R} \lambda x.\mathfrak{R}(x)(\lambda y.\textsf{bring'}(x,y))\rangle$

$\left\langle \lambda \mathbf{z} \lambda Q.\exists x[\textsf{pic'}(x) \wedge \textsf{of'}(x,\mathbf{z}) \wedge Q(x)],\ \lambda \mathfrak{R}.\forall x[\textsf{pupil'}(x) \rightarrow \mathfrak{R}(x)(\lambda y.\textsf{bring'}(x,y))] \right\rangle$

The type-lifted transitive verb bring', i.e. $Z_1(\textsf{bring'})$, expects a functional DP such as *ein Bild von sich* (*some picture of himself*) as its argument. This DP is the topic of the sentence and therefore introduces the topic-comment structure

$$\langle \lambda \mathbf{z} \lambda Q.\exists x[\textsf{picture}(x) \wedge \textsf{of}(x,\mathbf{z}) \wedge Q(x)], \lambda \mathfrak{R}.\mathfrak{R}\rangle.$$

The comment part of this DP, i.e. $\lambda \mathfrak{R}.\mathfrak{R}$, combines with the remaining comment of the sentence according to the rules laid out above.

As pointed out before, topic-comment structures are designed in a way such that the comment can always be applied to the topic. If this application is performed for the final structure in (40), the result is the (again unavailable) narrow scope reading for the indefinite.

(41) $\forall x[\textsf{pupil}(x) \rightarrow \exists z[\textsf{pic}(z) \wedge \textsf{of}(z,x) \wedge \textsf{bring}(x,z)]$

However, as we deal with a topic-comment structure here, the topic interpretation principle that we outlined in the preceding subsection applies: first, a suitable representative for the indefinite has to be found, second a discourse referent for this representative has to be created, and third, the representative stands proxy for the entire GQ and combines with the comment part of the sentence. Exactly the same procedure is performed with functional topics.

We propose to straightforwardly extend the storage address creation process by *minimal witness functions* (MinWitFunc) $f$, which find a minimal witness set for every quantifier $\mathcal{G}(y)$ of a functional generalized quantifier $\mathcal{G}$.

$$(42)\quad f \in \mathsf{MinWitFunc}(\mathcal{G}) \quad \equiv \quad \forall y.f(y) \in \begin{cases} \mathsf{MinWit}(\mathcal{G}(y)) & \text{iff } \mathsf{MinWit}(\mathcal{G}(y)) \neq \emptyset \\ \{\{*\}\} & \text{else} \end{cases}$$

We define $f$ in a way such that for all $y$, $f(y)$ is a minimal witness set of the corresponding GQ $\mathcal{G}(y)$, if such a minimal witness set exists. Otherwise $f(y)$ yields the singleton set containing the 'absurd individual' $*$, which falsifies every predicate that is applied to it[3]. The treatment of topic-comment structures can be straightforwardly adapted to the new definition of functional address generation through MinWitFunc in order to handle functional DPs. The new topic interpretation schema corresponding to (30) looks as follows.

$$(43)\quad \exists f[f \in \mathsf{MinWitFunc}(T) \wedge C(f)]$$

As in the non-functional case discussed above, this treatment leads to a type conflict, as the comment $C$ expects a parameterized GQ and not a parameterized set. This conflict is solved analogously to the type lift discussed above by type lifting the function $f$ to $\lambda y \lambda Q.f(y) \subseteq Q$ The topic interpretation of (40) eventually yields the following result.

$$(44)\quad \exists f[\mathsf{MinWitFunc}(f, \lambda y \lambda Q.\exists x[\mathsf{pic'}(x) \wedge \mathsf{of'}(x,y) \wedge Q(x)])] \\ \wedge \forall x[\mathsf{pupil'}(x) \rightarrow f(x) \subseteq \lambda y.\mathsf{bring'}(x,y)]$$

Paraphrased, this formula says that there is a function assigning to every individual $y$ a minimal witness set of pictures of $y$ (i.e. a singleton set containing one picture of $y$) such that for every pupil $x$ the picture that $f$ assigns to her is among the things that she brought. Together with the requirement that $f$ must be a nameable and informative function this yields the desired functional wide scope reading of (9b).

Now consider the case that obtains if one of the pupils, say Paul, does not have pictures of himself. In this case, the quantifier *some picture of Paul* is the empty quantifier. According to the definition in (42), the minimal witness function $f$ would yield the set containing the absurd individual $*$ when applied to paul'. As the absurd element does not satisfy any predicate, the singleton set containing it is certainly not a subset of the set $\lambda y.\mathsf{bring'}(\mathsf{paul'}, y)$, i.e. the set of things brought by Paul. In this case, the formula given in the last line of (44) would be false, which is wanted according to our intuitions. Sentence (9b) is considered as false, if it is not the case that every pupil brought along a certain type of picture of himself – for whatever reason that might be.

As another example, consider (17) again. After composition of the corresponding topic-comment structure the final representation according to the topic interpretation principle is as follows.

$$(45)\quad \exists f[\mathsf{MinWitFunc}(f, \lambda y \lambda Q.\exists x[\mathsf{teacher'}(x) \wedge \mathsf{of\_school'}(x,y) \wedge Q(x)])] \\ \wedge \neg\exists x[\mathsf{pupil'}(x) \wedge f(x) \subseteq \lambda y.\mathsf{like'}(x,y)]$$

(45) actually represents the correct truth conditions for (17). The sentence is true in case there is a nameable function $f$, e.g. the function that maps individuals $x$ to their maths teachers, such that no pupil $x$ likes $f(x)$. If there exists no such nameable $f$ the sentence is considered as false. Certainly, there might exist other functions $g$ that are such that no $x$ brought along $g(x)$, but as long as these functions are not nameable, they cannot make the formula true. If they are nameable, they can and do. But then intuition tells us that the formula should be true, as well.

[3]Thanks to an anonymous reviewer for pointing us to the problem of non-existent minimal witness sets and for suggesting this way out of it.

As a last step, the topic condition has to be modified to handle functional DPs. Therefore, the topic condition in (33) has to be extended accordingly to accommodate minimal witness functions and parameterized GQs. Basically we say that a parameterized GQ $\mathcal{G}$ fulfills this new topic condition, if for all individuals $y$ 1. there is no truth-conditional effect w.r.t. the new topic interpretation scheme and 2. the creation of a discourse referent does not destroy anaphoric possibilities. We will not give the formal definition here, but refer the reader to (Endriss 2006) instead for spelled out details. Most importantly, the explanations of the preceding section for the occurrence restrictions in the non-functional case carry over to the functional case: while GQs corresponding to bare numeral DPs and singular indefinites make good aboutness topics, downward entailing, non-monotonic, and exhaustive upward entailing GQs cannot fill this role. This accounts for the observations in (11).

## 4 Conclusion

We have shown that a conservative extension of (Ebert and Endriss 2004) can account for the readings that one observes when DPs containing bound pronouns occur as aboutness topics. Those *functional topics* give rise to functional wide scope readings as opposed to narrow scope readings which we set apart from the former by looking at available continuations. As our extension preserves all characteristics of the original approach we can explain the occurrence restrictions that one encounters with constructions that mark certain constituents as topical. One additional issue we could not discuss is the relation of functional wide scope readings and the readings that are predicted by approaches that make use of *choice functions* to derive (non-functional) exceptional wide scope readings for certain indefinites (e.g. Kratzer 1998, Winter 2004). For this and further details about the issues discussed in this paper we refer the reader to (Endriss 2006).

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