A Scope Theory of Non-presuppositional Noun Phrases

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Abstract

Musan (1995) observed that the temporal interpretation of a non-presuppositional noun phrase is obligatorily dependent on that of the main predicate. To account for this generalization, this paper proposes that the temporal interpretation of a non-presuppositional noun phrase is determined by virtue of being in the scope of an operator. Upon an investigation of the interpretation of non-presuppositional noun phrases in the plural form, the paper argues under this scope approach that the numeral part of a non-presuppositional noun phrase splits from the rest of the noun phrase and undergoes LF raising.

1 Introduction

Musan (1995) observed that the temporal interpretation of a non-presuppositional noun phrase is obligatorily dependent on that of the main predicate. In order to account for this generalization, this paper advocates a "scope" theory, that is, it proposes that the temporal interpretation of a non-presuppositional noun phrase is determined by virtue of being in the scope of an operator that simultaneously determines the temporal interpretation of the main predicate. The paper observes that Musan's generalization gives rise to "distributed" temporally dependent interpretations of non-presuppositional noun phrases in the plural form and argues that this fact suggests under the scope theory that the numeral part of a non-presuppositional noun phrase be separated from the rest of the noun phrase and raised at LF. We also consider alternative theories to the scope theory and see that they are problematic on independent grounds. Finally, a novel approach to existential sentences (i.e., sentences that make an existential claim) is briefly introduced that exploits Lebesgue integration.

2 Musan's Generalization

Since Enç's (1981, 1986) work, it has been known that the evaluation time of a noun phrase in a sentence may be different from the evaluation time of the sentence's main predicate. For instance, if the noun *fugitive* and the main predicate *be in jail* in Enç's

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example (1) were evaluated with respect to the same time, the sentence would be claiming that some individuals are simultaneously fugitives and in jail, a contradiction.

(1) Every fugitive is now in jail.

Instead, (1) should be understood as ‘every individual who was a fugitive is now in jail.’ The noun *fugitive* can thus be evaluated with respect to some past time, even though the main predicate is evaluated with respect to the present time.

Following Enç’s work, Musan (1995) made an interesting generalization that such temporally independent readings are available only for presuppositional noun phrases, which in turn means the following:

(2) The temporal interpretation of a non-presuppositional noun phrase is always dependent on that of the main predicate.

The relevant concept of (non-)presuppositionality is due to Dieasing (1992). Noun phrases with a “strong” determiner (e.g. every rabbit, most rabbits, etc.) and partitive noun phrases (e.g. some of the rabbits, etc.) are presuppositional. On the other hand, noun phrases with a “weak” determiner (e.g. some rabbits, etc.) are ambiguous as to their presuppositionality, but their syntactic position or stress pattern may help disambiguate it in some cases. For instance, in Musan’s German data (3), the subject noun phrase in (3a) is presuppositional because the determiner, rather than the head noun, is stressed and it in effect means ‘some of the professors’, while the subject noun phrase in (3b) is non-presuppositional because the head noun is stressed.

(3) a. EINIGE Professoren waren in den sechziger Jahren glücklich.
some professors were in the sixties happy
‘Sóme professors were happy in the sixties.’
b. Einige PROFESSOREN waren in den sechziger Jahren glücklich.
some professors were in the sixties happy
‘Sm professors were happy in the sixties.’

Musan observes that while (3a) may be talking about current professors who were not necessarily professors in the sixties, (3b) only asserts the existence of people who were simultaneously professors and happy in the sixties. One can then see that Musan’s generalization holds here, as a temporally dependent interpretation of the subject noun phrase is forced in (3b), but not in (3a).

3 Sketching the Scope Theory

In this paper, I would like to put presuppositional noun phrases aside and focus on the fact that non-presuppositional noun phrases always receive temporally dependent readings. As an account for this obligatory temporal dependence, this paper advocates what I call the scope theory, and this is sketched in the present section.

Unless we adopt Musan's (1995) stage semantics approach (see Subsection 6.1), it is safe to assume that predicates such as nouns and verbs are interpreted with respect to an evaluation time interval for their temporal interpretation. The scope theory claims that the value of the evaluation time interval of a non-presuppositional noun phrase is determined by an operator that has the non-presuppositional noun phrase in its scope. If this operator simultaneously gives the evaluation time interval of the main predicate, a temporally dependent interpretation of the non-presuppositional noun phrase will automatically follow.

For illustration, let us consider the following sentence:

(4) Mary kissed a 20-year-old.

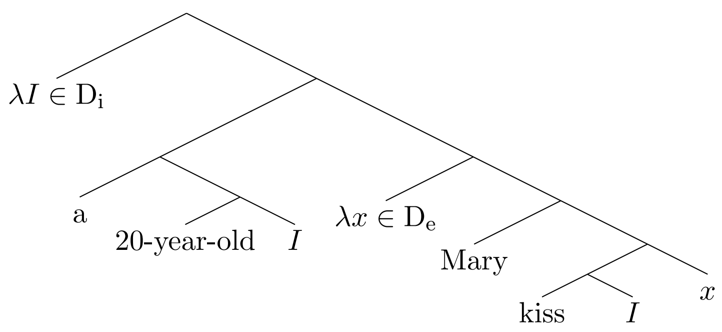
When (4) is uttered without an appropriate context so that *20-year-old* is non-presuppositional, it claims the existence of an individual who got kissed by Mary when he or she was age 20, as predicted by Musan's generalization. Let us assume that the the evaluation time interval of predicates is their first argument:

(5) a. $[\![\text{20-year-old}]\!] = \lambda I \in \mathrm{D_i}.\, \lambda x \in \mathrm{D_e}.\, \textsf{20-yr-old}(I)(x)$
b. $[\![\text{kiss}]\!] = \lambda I \in \mathrm{D_i}.\, \lambda x \in \mathrm{D_e}.\, \lambda y \in \mathrm{D_e}.\, \textsf{kiss}(I)(x)(y)$

Assuming that time interval arguments are projected as variables in syntax (cf. Percus, 2000), the relevant operator can be taken to be a λ abstraction that simultaneously binds the evaluation time interval of the non-presuppositional noun phrase and that of the main verb. If we assume a generalized-quantifier meaning for *a* as in (6a), the non-presuppositional noun phrase in the object position needs QR'ing, but only below the temporal λ abstraction for the desired binding. We thus obtain the LF in (6b), whose denotation is computed to be what is given in (6c):

(6) a. $[\![\text{a}]\!] = \lambda f \in \mathrm{D_{\langle e,t\rangle}}.\, \lambda g \in \mathrm{D_{\langle e,t\rangle}}.\, \exists x \in \mathrm{D_e}\, [f(x) \wedge g(x)]$

b.



c. $\lambda I \in \mathrm{D_i}.\, \exists x \in \mathrm{D_e}\, [\textsf{20-yr-old}(I)(x) \wedge \textsf{kiss}(I)(x)(\textsf{Mary})]$

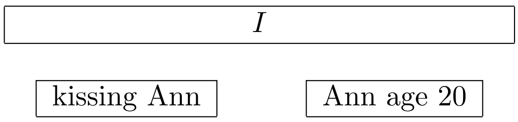
By existentially closing the open time interval variable in (6c), we expect to obtain the truth conditions for the observed temporally dependent reading.

In order to ensure temporal dependence, however, we need to clarify the exact interpretation of the predicates 20-yr-old and kiss. Suppose the following interpretations:

(7) a. 20-yr-old$(I)(x)$ is true iff x is of age 20 in some subinterval of I.
b. kiss$(I)(x)(y)$ is true iff there is an event of y's kissing x and its running time interval is a subinterval of I.

With these, (6c) actually does not guarantee temporal dependence even though the two predicates are saturated with one and the same time interval. To see this, one need only consider models like the following:

(8)



In (8), a big time interval I contains the running time interval of the kissing and the one-year period during which the kissee was 20, but they do not overlap. Mary thus kissed Ann before Ann turned 20 here. In order to guarantee temporal dependence, we should therefore accept either or both of (9a) and (9b):[1]

(9) a. 20-yr-old$(I)(x)$ is true iff x is of age 20 throughout I.
b. kiss$(I)(x)(y)$ is true iff I is exactly the running time interval of an event of y's kissing x.

4 A Scope Puzzle about Plural Noun Phrases

Having sketched the scope theory, we now examine the temporal interpretation of non-presuppositional noun phrases in the plural form and see that the scope theory seems to run into a scope paradox.

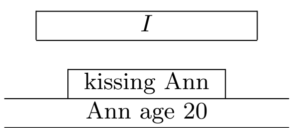
Consider (10):

(10) In the last five years, Mary kissed three 20-year-olds.

When (10) is uttered out of the blue and the plural object noun phrase *three 20-year-olds* is thus interpreted non-presuppositionally, it claims that Mary kissed three people and

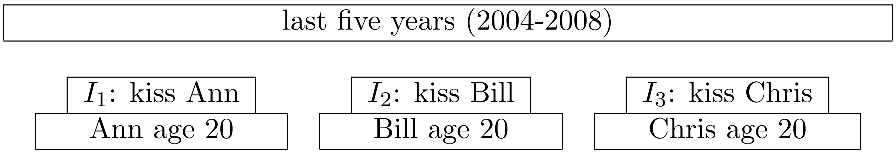
[1]For example, if we accept (9a), 20-yr-old(I)(Ann) means that Ann is age 20 throughout I. Therefore, in this case, even if we do not accept (9b) and only adopt (7b) for the interpretation of kiss, kissing must have taken place while Ann was 20, as illustrated by the following model:

(i)



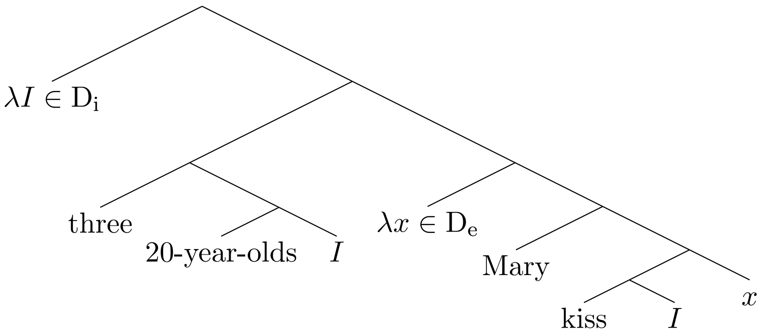
each of them was age 20 when Mary kissed him/her. Thus, *three 20-year-olds* receives a temporally dependent reading, as predicted by Musan's generalization. Interestingly, however, it is required neither that these three have been simultaneously age 20 nor that they have simultaneously gotten kissed by Mary (cf. Szabó, 2006). For instance, if uttered at the end of the year 2008, (10) can truthfully describe the scenario depicted by following model:

(11)



The question is whether this reading can be predicted by the the scope theory, which would assign the following LF to (10):

(12)



In what follows, I consider two conceivable attempts at interpreting this LF and argue that neither can yield the desired truth conditions. This leads to a conclusion that (12) is not the correct LF for (10).

4.1 Attempt I: Simple Pluralization of the Individual Argument

The first attempt is to utilize Link's (1983) * operator to pluralize the individual arguments of 20-year-old and kiss. This gives us the following denotation for LF (12):[2]

(13) $\lambda I \in \mathrm{D_i}.\, \exists X \in \mathrm{D_e}$
$[|X| = 3 \wedge [*\lambda x \in \mathrm{D_e}.\, \textsf{20-yr-old}(I)(x)](X) \wedge [*\lambda x \in \mathrm{D_e}.\, \textsf{kiss}(I)(x)(\textsf{Mary})](X)]$

[2] $|X|$ means the number of the atomic individuals constituting the plural individual X. Assuming that the unstarred predicates 20-yr-old and kiss are true only of atomic individuals, (13) can be rewritten without the * operator as in the following, where $\sqsubseteq_\sigma$ is the partial order relation on a lattice of entities of type σ.

(i) $\lambda I \in \mathrm{D_i}.\, \exists X \in \mathrm{D_e}\, [|X| = 3 \wedge \forall x \in \mathrm{D_e}\, [x \text{ is atomic} \wedge x \sqsubseteq_{\mathrm{e}} X \rightarrow \textsf{20-yr-old}(I)(x)]$
$\wedge \forall x \in \mathrm{D_e}\, [x \text{ is atomic} \wedge x \sqsubseteq_{\mathrm{e}} X \rightarrow \textsf{kiss}(I)(x)(\textsf{Mary})]]$

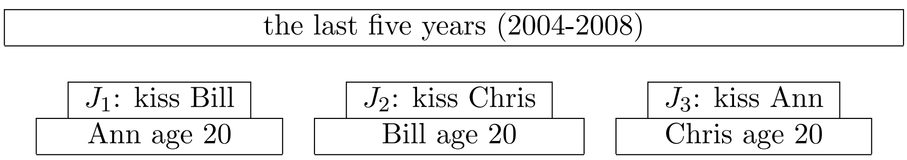
By existential closure of the time interval variable, we obtain truth conditions that claim the existence of a single time interval. The reader may recall now that we should accept either (9a) or (9b). If we accept (9a), in order for sentence (10) to be true, there will have to be a single time interval in which all the three people were simultaneously age 20. On the other hand, if we accept (9b), it will be required that the three people have simultaneously gotten kissed by Mary. Thus, either way, we end up with too strong truth conditions for (10).

4.2 Attempt II: Cumulative Relation Formation

The second attempt utilizes the double * operator (Krifka, 1986, Sternefeld, 1998) to form a cumulative relation between individuals and time intervals. This gives us the following denotation for LF (12):[3]

(14) $\lambda I \in \mathrm{D_i}.\, \exists X \in \mathrm{D_e}\, [|X| = 3 \wedge [{*}{*}\lambda x \in \mathrm{D_e}.\, \lambda J \in \mathrm{D_i}.\, \textsf{20-yr-old}(J)(x)](X)(I) \wedge$
$[{*}{*}\lambda x \in \mathrm{D_e}.\, \lambda J \in \mathrm{D_i}.\, \textsf{kiss}(J)(x)(\textsf{Mary})](X)(I)]]$

Applying existential closure to (14), we obtain truth conditions that claim the existence of a plurality of time intervals and a plurality of individuals. Note now that the obtained truth conditions are satisfied under the following model, as $I = J_1 \sqcup_\mathrm{i} J_2 \sqcup_\mathrm{i} J_3$ exemplifies the existentially quantified variable for a plurality of time intervals.[4]

(15)


In this scenario, none of the three kissees was age 20 when he/she was kissed by Mary, hence no temporal dependence. The obtained truth conditions are therefore too weak to capture the correct meaning of (10).

4.3 What Goes Wrong

The truth conditions that correctly capture the meaning of (10) should look like (16), or equivalently, (17):

(16) $\exists X \in \mathrm{D_e}\, [|X| = 3 \wedge [{*}\lambda x \in \mathrm{D_e}.\, \exists I \in \mathrm{D_i}\, [\textsf{20-yr-old}(I)(x) \wedge \textsf{kiss}(I)(x)(\textsf{Mary})]](X)]$

[3]For a possibly more accessible representation, one can rewrite (14) without the double * operator. For example, $[{*}{*}\lambda x \in \mathrm{D_e}.\, \lambda J \in \mathrm{D_i}.\, \textsf{20-yr-old}(J)(x)](X)(I)$ is equivalent to the following.

(i) $\forall x \in \mathrm{D_e}\, [x \text{ is atomic} \wedge x \sqsubseteq_\mathrm{e} X \rightarrow \exists J \in \mathrm{D_i}\, [J \sqsubseteq_\mathrm{i} I \wedge \textsf{20-yr-old}(J)(x)]]$
$\wedge\, \forall J \in \mathrm{D_i}\, [J \text{ is atomic} \wedge J \sqsubseteq_\mathrm{i} I \rightarrow \exists x \in \mathrm{D_e}\, [x \sqsubseteq_\mathrm{e} X \wedge \textsf{20-yr-old}(J)(x)]]$

[4]$\sqcup_\sigma$ represents the join operation on a lattice of entities of type σ.

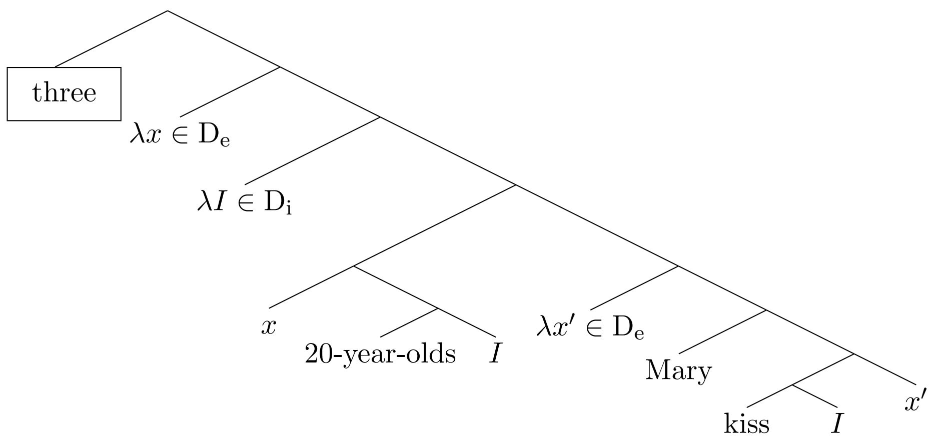
(17) $\exists J \in D_i\, \exists X \in D_e$
$[|X| = 3 \wedge [{*}{*}\lambda x \in D_e.\, \lambda I \in D_i.\, \textsf{20-yr-old}(I)(x) \wedge \textsf{kiss}(I)(x)(\textsf{Mary})](X)(J)]$

Thus, while *20-year-olds* must be in the scope of the binder of its time interval argument for the temporally dependent reading, *three* ought to be interpreted above this binder, after 20-year-olds and kiss are combined and then some pluralization operation is applied. This is why no attempt at interpreting LF (12) seems to pan out. It then appears that the scope theory runs into a scope paradox here, because given the fact that *three* and *20-year-olds* make a syntactic constituent, it looks as if this noun phrase should be in two distinct positions, below and above the binder of the time interval variables.

5 Proposal

In order to solve the puzzle illuminated above, I propose that the correct LF is obtained by separating the numeral part off from the rest of the non-presuppositional noun phrase and moving it to right above the binder of the time interval variables. Just like a usual QR operation, this LF movement creates a λ abstraction over individuals. The correct LF for (10) thus looks as follows:

(18)

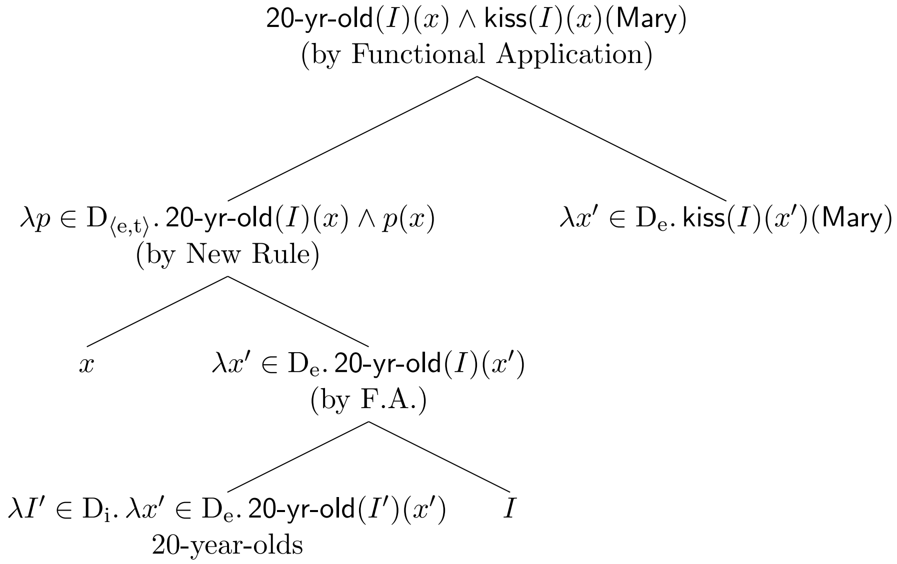


Since the denotations of the head noun and the main predicate must be combined by set intersection, I posit the following new rule of semantic composition:

(19) New Rule of semantic composition
Let α and β be sisters such that $[\![\alpha]\!]$ is of type e and $[\![\beta]\!]$ is of type $\langle e, t\rangle$. Then,
$[\![\alpha \frown \beta]\!] = \lambda p \in D_{\langle e,t\rangle}.\, [\![\beta]\!]([\![\alpha]\!]) \wedge p([\![\alpha]\!])$

The following, which is a partial LF of (18), shows how the new rule works:

(20)



Thus, as the denotation of the sister of the numeral *three*, we obtain the following relation R holding between an individual and a time interval:

(21) $R = \lambda x \in \mathrm{D_e}.\, \lambda I \in \mathrm{D_i}.\, \textsf{20-yr-old}(I)(x) \wedge \textsf{kiss}(I)(x)(\textsf{Mary})$

R is then "pluralized" with the double * operator, and the numeral *three* specifies the number of the atomic individuals in the plurality of individuals denoted by the pluralized individual variable to be 3.[5] By existential closure, the following truth conditions can finally be obtained, which is exactly what we had in (17).

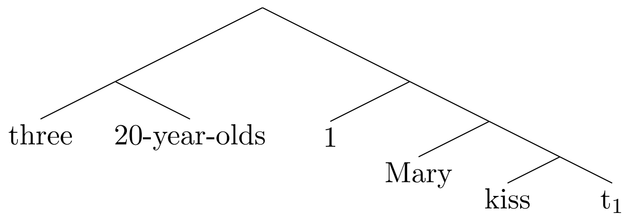
(22) $\exists J \in \mathrm{D_i}\, \exists X \in \mathrm{D_e}\, [|X| = 3 \wedge {**}R(X)(J)]$

6 Alternative Lexical Theories and their Problems

The scope theory derives the temporally dependent reading from the syntactic configuration of scope. By contrast, one might alternatively argue that the temporal dependence is due to the lexical semantics of the numeral determiner. Let us call this the "lexical" approach. As we have seen above, under the scope theory, an LF split of the numeral part off non-presuppositional noun phrases seems to be required to solve an apparent scope paradox. If the lexical approach is actually on the right track and the scope theory is wrong, however, there can be no "scope" paradox to begin with, and straightforwards LF without fancy LF movement like (23) should suffice. This section therefore considers two conceivable implementations of the lexical approach. It is argued that these theories are untenable for independent reasons.

[5] It is merely a simple exercise to spell out an appropriate lexical entry for *three* to go with LF (18). I omit doing this, since we end up having a special operator called CUM between the numeral and the λ abstraction below it that is actually responsible for the pluralization job as discussed shortly.

(23)



6.1 Musan's Stage-Semantics Approach and Bi-clausal Sentences

The first theory under the lexical approach that we consider is Musan's (1995) stage-semantics approach. Musan has actually considered the scope approach and rejected it for reasons that I cannot discuss here due to space limitation.[6] To account for her generalization, Musan instead proposes that noun phrases quantify over stages of individuals, which are pairs of an individual and a time interval. Predicates under this theory take stages of individuals as their arguments, and the temporally dependent reading of a non-presuppositional noun phrase arises as a result of one and the same stage of an individual being simultaneously predicated of by the noun and by the main predicate. Under Musan's approach, (10) would be analyzed as follows:[7]

(24) There are 3 maximal[8] stages of individuals x_{st} situated in the last five years such that $[\mathsf{20\text{-}yr\text{-}old}(x_{\mathrm{st}}) \wedge \mathsf{kiss}(x_{\mathrm{st}})(\mathsf{Mary})]$ holds.

(24) *per se* does not necessarily express temporal dependence, however. In order for this to work as desired, it is necessary to postulate a principle such as (25). With (25), the truth conditions in (24) correctly capture the "distributed" temporally dependent reading that we have been focusing on.

(25) For any predicate P and any stage of an individual x_{st}, if x_{st} is an argument of P, the event described by P occurs at the temporal extension of x_{st}.

Inadequacies of Musan's approach become evident, however, once we consider bi-clausal examples like the following:

(26) a. When he was young, John promised to marry three 20-year-olds on their 30th birthday.
b. When he was young, John wanted to marry three 20-year-olds on their 30th birthday.

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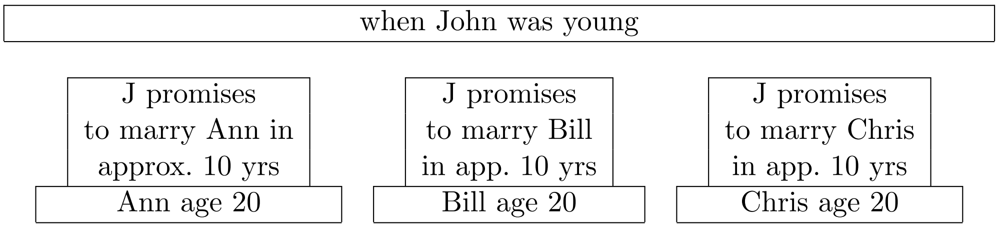
[6]For details, see Musan (1995) and Shimada (2009).

[7]These truth conditions can be derived from LF (25), by defining an appropriate lexical entry for *three* and assuming that the index 1 in (23) is translated into a λ abstraction over stages of individuals.

[8]For a given individual, Musan proposes counting only the maximal stage of that individual that satisfies relevant properties. This way, one can avoid counting different stages of one and the same individual separately.

When these sentences are uttered out of the blue and *three 20-year-olds* is thus interpreted non-presuppositionally, its temporal interpretation obligatorily depends on the matrix predicate *promised/wanted*. For instance, (26a) is a true statement for the scenario depicted by the following model:

(27)

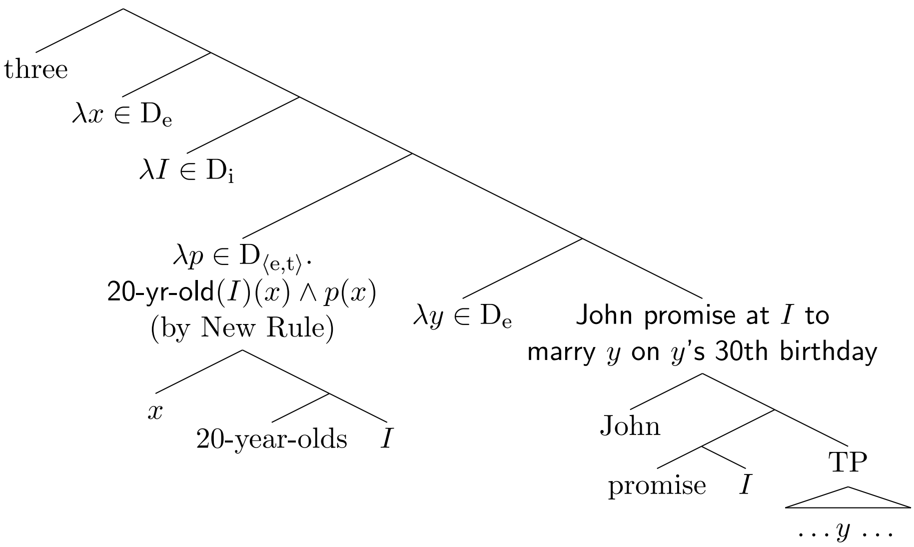


Here, John made a promise to each person when he/she was age 20, and the content of the promise was that he would marry them in ten years. Note that *three 20-year-olds* clearly cannot depend on the embedded predicate *marry* for its temporal interpretation. If it did, a contradictory reading would arise as some people would have to be simultaneously age 20 and age 30 at some point.

What is important here is the fact that *three 20-year-olds* is an argument of the embedded predicate *marry* and not an argument of the matrix predicate *promised/wanted*. Given (25), however, one can see that Musan's theory only predicts that *three 20-year-olds* is obligatorily dependent on the embedded predicate for its temporal interpretation, and not on the matrix predicate, contrary to the fact. Musan's account is hence untenable.

By contrast, the scope theory should have no problem with bi-clausal examples as in (26). To explain (26a), for instance, one need only assume a λ abstraction simultaneously binding the time interval arguments of *20-year-olds* and *promise* and a movement of *three* to right above this binder as illustrated below:

(28)



6.2 Lexical-Internal Binding of Time Interval Arguments and Scha's Cumulative Reading

The second theory under the lexical approach that we consider agrees with the scope theory in assuming that predicates take separate arguments for individuals and time intervals. This theory therefore also derives the temporally dependence of a non-presuppositional noun phrase by having a single binder simultaneously bind the time interval arguments of the head noun and the main verb. However, the binder in question is now encoded in the lexical entry of the numeral, and not present in syntax.

Let us see how this "lexical-internal binding" theory works. So that LF (23) may produce the desired interpretation, we should first assume that the time interval argument of a predicate is generally the innermost argument:

(29) a. $[\![\text{20-year-old}]\!] = \lambda x \in \mathrm{D_e}.\, \lambda I \in \mathrm{D_i}.\, \mathsf{20\text{-}yr\text{-}old}(I)(x)$
b. $[\![\text{kiss}]\!] = \lambda x \in \mathrm{D_e}.\, \lambda y \in \mathrm{D_e}.\, \lambda I \in \mathrm{D_i}.\, \mathsf{kiss}(I)(x)(y)$

With the lexical entry in (30a) for the numeral *three*, the denotation of LF (23) becomes (30b), and by applying existential closure to (30b), we obtain (17), the desired truth conditions for (10).

(30) a. $[\![\text{three}]\!] = \lambda p \in \mathrm{D_{\langle e,\langle i,t\rangle\rangle}}.\, \lambda q \in \mathrm{D_{\langle e,\langle i,t\rangle\rangle}}.\, \lambda J \in \mathrm{D_i}.\, \exists X \in \mathrm{D_e}$
$[|X| = 3 \wedge [{*}{*}\lambda x \in \mathrm{D_e}.\, \lambda I \in \mathrm{D_i}.\, p(x)(I) \wedge q(x)(I)](X)(J)]$
b. $\lambda J \in \mathrm{D_i}.\, \exists X \in \mathrm{D_e}$
$[|X| = 3 \wedge [{*}{*}\lambda x \in \mathrm{D_e}.\, \lambda I \in \mathrm{D_i}.\, \mathsf{20\text{-}yr\text{-}old}(I)(x) \wedge \mathsf{kiss}(I)(x)(\mathsf{Mary})](X)(J)]$

A problem of this theory is revealed when one considers sentences with more than one non-presuppositional noun phrase in the plural form like the following:

(31) Five 30-year-olds kissed three 20-year-olds.

As observed by Scha (1981), sentences like this have a cumulative reading, where none of the noun phrases takes scope over the other(s). Essentially, the cumulative reading of (31) can be paraphrased as 'there were five 30-year-olds who kissed some 20-year-old or another, and there were three 20-year-olds who got kissed by some 30-year-old or another.' What is interesting is that when (31) is uttered out of the blue so that neither noun phrase is presuppositional, Musan's generalization gives rise to a reading according to which each kisser was age 30 when he/she did his/her kissing, and each kissee was age 20 when he/she was kissed.

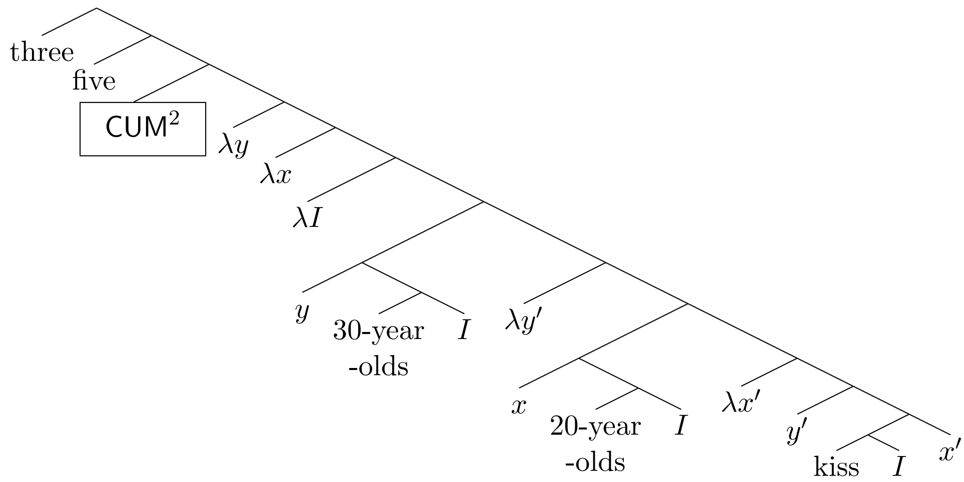
On the lexical-internal binding theory, each numeral is responsible for the temporal dependence of the noun phrase it is part of by virtue of creating a simultaneous binding of the time interval arguments of the head noun and whatever predicate it takes as its second argument. This means that when there are more than one non-presuppositional noun phrase in a sentence, each one necessarily takes scope below or above the other(s) at LF. For instance, (32) is one of the two possible LFs for (10), and it yields the denotation in (33):

(32) [[five 30-year-olds] [$\lambda y \in \mathrm{D_e}$ [[three 20-year-olds] [$\lambda x \in \mathrm{D_e}$ [y kiss x]]]]]

(33) $\lambda K \in \mathrm{D_i}.\, \exists Y \in \mathrm{D_e}\, [|Y| = 5 \wedge [{*}{*}\lambda y \in \mathrm{D_e}.\, \lambda J \in \mathrm{D_i}.\, \textsf{30-yr-old}(J)(y) \wedge \exists X \in \mathrm{D_e}$
$[|X| = 3 \wedge [{*}{*}\lambda x \in \mathrm{D_e}.\, \lambda I \in \mathrm{D_i}.\, \textsf{20-yr-old}(I)(x) \wedge \textsf{kiss}(I)(x)(y)](X)(J)]](Y)(K)]$

Obviously, this does not represent the scopeless, cumulative reading.[9] The other possible LF for (10) only has the scopes of the two noun phrases reversed and thus does not work either.

Being a syntactic account, the scope theory can easily accommodate such cumulative readings. On the scope theory, the temporal dependence of multiple non-presuppositional noun phrases should be due to a λ abstraction that simultaneously binds the time interval arguments of the head nouns and the main predicate. In order to account for the scopeless reading of (31), one essentially needs to create a relevant 3-place relation between a time interval, an individual and another individual and "pluralize" that relation by the triple * operator. To that end, I propose that the numeral of each non-presuppositional noun phrase is raised to above this temporal λ abstraction in such a way that a later instance of movement always targets a position right above the λ abstraction created by the previous instance of movement as proposed in Beck & Sauerland (2000). Finally, a special operator which I call $\textsf{CUM}^2$, is inserted right above the last-created, and thus the highest λ abstraction:

(34)


$\textsf{CUM}^2$ has the following denotation and is responsible for (triple) pluralization:

[9](33) does not even correctly express a non-cumulative reading whose truth conditions are given by the following:

(i) $\exists Y \in \mathrm{D_e}\, [|Y| = 5 \wedge \forall y \in \mathrm{D_e}\, [y \text{ is atomic} \wedge y \sqsubseteq_e Y \rightarrow$
$\exists X \in \mathrm{D_e}\, [|X| = 3 \wedge \forall x \in \mathrm{D_e}\, [x \text{ is atomic} \wedge x \sqsubseteq_e X \rightarrow$
$\exists I \in \mathrm{D_i}\, [\textsf{30-yr-old}(I)(y) \wedge \textsf{20-yr-old}(I)(x) \wedge \textsf{kiss}(I)(x)(y)]]]]]$

(35) $$[\![\mathsf{CUM}^2]\!] = \lambda R \in \mathrm{D}_{\langle \mathrm{e},\langle \mathrm{e},\langle \mathrm{i},\mathrm{t}\rangle\rangle\rangle}.\, \lambda n \in \mathrm{D}_\mathrm{n}.\, \lambda m \in \mathrm{D}_\mathrm{n}.\\ \exists X \in \mathrm{D}_\mathrm{e}\, \exists Y \in \mathrm{D}_\mathrm{e}\, \exists J \in \mathrm{D}_\mathrm{i}\, [|X| = n \wedge |Y| = m \wedge {*}{*}{*}R(X)(Y)(S)]$$

Here, n is the semantic type of numbers. Since the role of pluralization has now been taken over by the CUM^2 operator, numerals simply denote numbers. For example, $[\![\text{three}]\!] = 3 \in \mathrm{D}_\mathrm{n}$ and $[\![\text{five}]\!] = 5 \in \mathrm{D}_\mathrm{n}$. The truth conditions for (34) are now computed as follows:

(36) $$[\![(34)]\!] = [\![\mathsf{CUM}^2]\!]\, (\lambda y.\, \lambda x.\, \lambda I.\, \textsf{20-yr-old}(I)(x) \wedge \textsf{kiss}(I)(x)(y))([\![\text{five}]\!])([\![\text{three}]\!])\\ = \exists X \in \mathrm{D}_\mathrm{e}\, \exists Y \in \mathrm{D}_\mathrm{e}\, \exists J \in \mathrm{D}_\mathrm{i}\, [|X| = 3 \wedge |Y| = 5 \wedge [{*}{*}{*}\lambda y \in \mathrm{D}_\mathrm{e}.\, \lambda x \in \mathrm{D}_\mathrm{e}.\\ \lambda I \in \mathrm{D}_\mathrm{i}.\, \textsf{20-yr-old}(I)(x) \wedge \textsf{kiss}(I)(x)(y)](Y)(X)(J)]$$

The reader may verify that the intended cumulative reading is now correctly captured.

For cumulative readings with k non-presuppositional noun phrases, I define CUM^k as follows and propose that CUM^k is inserted in place of CUM^2:

(37) $$[\![\mathsf{CUM}^k]\!] = \lambda R \in \mathrm{D}_{\langle \mathrm{e}^k,\langle \mathrm{i},\mathrm{t}\rangle\rangle}.\, \lambda n_1 \in \mathrm{D}_\mathrm{n}.\, \lambda n_2 \in \mathrm{D}_\mathrm{n}.\, \ldots \lambda n_k \in \mathrm{D}_\mathrm{n}.\\ \exists X_1 \in \mathrm{D}_\mathrm{e}\, \exists X_2 \in \mathrm{D}_\mathrm{e}\, \ldots \exists X_k \in \mathrm{D}_\mathrm{e}\, \exists J \in \mathrm{D}_\mathrm{i}\\ [\textstyle\bigwedge_{i=1}^{k} |X_i| = n_i \wedge {*}^{k+1} R(X_1)(X_2)\ldots(X_k)(J)]$$

To recapitulate, the scope theory is capable of accounting for cumulative readings because a single binder in syntax is simultaneously responsible for the temporal dependence of all the non-presuppositional noun phrases.

7 Prelude to a Lebesgue Integral Approach for Event-related Readings

In my dissertation (Shimada, 2009), I developed a new theory of the semantics of sentences that claim the existence of certain entities, based on mathematical measure theory. On this new theory, the truth conditions of existential sentences are in general expressed by virtue of Lebesgue integration.[10] I would like to introduce this new approach in this final section, albeit very cursorily.

Krifka (1990) observes that sentence (38) has two readings that can be paraphrased as in (39), and calls the reading in (39a) the object-related reading as it counts the number of the relevant objects (individuals), and the reading in (39b) the event-related reading as it counts the number of the relevant events:

(38) Four thousand ships passed through the lock last year.

[10] For measure theory and Lebesgue integration, the reader is referred to textbooks such as Halmos (1974), Rudin (1987) and Wheeden & Zygmund (1977).

(39) a. There are four thousand distinct individual ships that passed through the lock last year. (object-related reading)
b. There were four thousand events of a ship passing through the lock last year. (event-related reading)

If one simply employs existential quantification over ship-individuals and writes a formula like the following, the object-related reading may, but the event-related reading can never be captured.

(40) $\exists x_1 \exists x_2 \ldots \exists x_{4000} [x_1 \neq x_2 \wedge x_1 \neq x_3 \wedge \ldots x_{3999} \neq x_{4000} \wedge \mathsf{ship}(x_1) \wedge \mathsf{pass\text{-}through\text{-}the\text{-}lock}(x_1) \wedge \cdots \wedge \mathsf{ship}(x_{4000}) \wedge \mathsf{pass\text{-}through\text{-}the\text{-}lock}(x_{4000})]$

Krifka constructs a special function or relation to account for the event-related reading.

What we should note is the fact that when (38) is uttered out of the blue, the subject noun phrase receives a temporally dependent reading. Since Krifka's analysis does not even talk about the temporal interpretation of noun phrases, it cannot possibly account for the temporal dependence without modification.

Let us see, then, how we can account for the temporally-dependent event-related reading under the theory in Shimada (2009). For (38), we assume an LF raising of *four thousand* and obtain the relation between an individual and a time interval below in the same way as the relation in (21) was obtained for sentence (10):

(41) $R_1 = \lambda x \in \mathrm{D_e}.\, \lambda I \in \mathrm{D_i}.\, \mathsf{ship}(I)(x) \wedge \mathsf{pass\text{-}through\text{-}the\text{-}lock}(I)(x)$

I showed in Shimada (2009) that the truth conditions of temporally-dependent event-related reading of (38) are then given by virtue of Lebesgue integration as follows:

(42) $$\int_{\{I \mid I \subseteq \mathsf{last\text{-}year}\}} \lambda I \in \mathrm{D_i}.\, \mathsf{ATOM}\left(\bigsqcup\nolimits_{\mathrm{e}} \{x \mid R_1(x)(I)\}\right) d\mu \geq 4000$$

Here, ATOM is a function that returns the number of atomic individuals in a given (plural) individual, and μ is the counting measure (viz., the measure that gives the cardinality of a given set).

The Lebesgue integral approach also provides an elegant analysis for existential sentences that describe events of continuous production or consumption. I argued in Shimada (2009) that Lebesgue integration is indeed fundamentally required to account for such sentences. Consider the following example:

(43) Machine P produced forty-nine liters of Liquid XYZ yesterday.

In this case, in place of a pure numeral, the whole measure phrase *forty-nine liters* undergoes LF-raising, and we obtain the following relation:

(44) $R_2 = \lambda x \in \mathrm{D_e}.\, \lambda I \in \mathrm{D_i}.\, \mathsf{XYZ}(I)(x) \wedge \mathsf{produce}(x)(I)(\mathsf{Machine\ P})$

Using the Radon-Nikodým theorem from measure theory, I showed in Shimada (2009) that for almost all time point t, the rate $\varrho(t)$ of Machine P's production of XYZ per unit time at t is given by the following:

(45) $$\varrho(t) = \lim_{h \to 0} \frac{1}{2h}\, \mathsf{liter}(t) \left(\bigsqcup_{t' \in (t-h,\, t+h)}{}_{\mathrm{e}} \bigsqcup{}_{\mathrm{e}} \{x \mid R_2(x)([t', t'])\} \right)$$

Here, liter is a function that returns the volume of a given individual measured at a given time point. The truth conditions of (43) are then given by integrating ϱ as follows:

(46) $$\int_{\{t \mid t \in \mathsf{yesterday}\}} \varrho \, d\mu \geq 49$$

Here, μ is the Lebesgue measure.

8 Conclusion

This paper argued for a scope account of the obligatory temporally dependent reading of non-presuppositional noun phrases. As far as I can see, the lexical approach is the only viable alternative to the scope theory. As discussed in Section 6, however, the two conceivable implementations of the lexical approach both face independent problems. Therefore, unless one finds yet another alternative account of the temporally dependent reading of non-presuppositional noun phrases, the scope approach advanced in the current paper seems to be the only approach on the right track. However, as discussed in Section 4, the scope theory seems to run into a scope paradox, and it was proposed that the numeral splits and gets raised at LF to get around this problem. Finally, the paper introduced the new Lebesgue integral approach to existential sentences developed in Shimada (2009). The split of the numeral (or of the whole measure phrase) proposed in this paper might have appeared a little odd to the reader, but as cursorily suggested in the final section, it actually forms a basis for the Lebesgue integral theory of existential sentences. For more thorough treatment of the problems discussed in this paper, the reader is referred to Shimada (2009).

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