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Multiple negation processing*

Abstract:
This paper considers negative triggers (negative and negative quantifiers) and the interpretation of simple sentences containing more than one occurrence of those items (multiple negation sentences). In the most typical interpretations those sentences have more negative expressions than negations in their semantic representation. It is first shown that this compositionality problem remains in current approaches. A principled algorithm for deriving the representation of sentences with multiple negative quantifiers in a DRT framework (Kamp & Reyle, 1993) is then introduced. The algorithm is under the control of an on-line check-in, keeping the complexity of negation auto-embedding below a threshold of complexity. This mechanism is seen as a competence limitation imposing (and licensing) the "abrogation of compositionality" (May 1989) observed in the so-called negative concord readings (Labov 1972, Zanuttini 1991, Ladusaw 1992). A solution to the compositionality problem is thus proposed, which is based on a control on the processing input motivated by a limitation of the processing mechanism itself.

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Multiple negation processing

One way of giving a semantics for natural language is to provide effective procedures for the translation of Natural Language sentences into the formulae of a logic. A semantic representation (SR) of a sentence S in a formal language is a formula accepted as a correct translation of S.

NATURAL LANGUAGE	-->	FORMAL LANGUAGE
Sentence		Formula

The association of those two syntactic objects (a sentence and a formula) provides a semantics for the sentence in the following way: if a SR of S is valid in such and such models, and if those models mirror exactly the real situations or states of information in which S is accepted as true, such a SR is an empirically correct translation of S.
Most varieties of formal semantics have put more constraints on the principles governing the production of empirically adequate translations of natural language sentences. The best known of those constraints is Montague's strong version of Frege's compositionality principle. Montague's basic methodological axiom is that translation procedures of S - as well as interpretation rules for SR - should be homomorphisms. The importance of giving a fully compositional account of natural language is that if we succeed, we can give a direct justification of language efficiency and learnability: language works efficiently, and can be learned easily because its form-meaning mapping is governed by simple and rigid principles.

The substantial move done by Discourse Representation Theory (Kamp, 1981, Heim 1982) is the introduction of a dynamic view of meaning in formal semantics. The process by which a SR is obtained from the processing of syntactic input is seen as an incremental updating of a previously established information structure; this process itself is a characterization of the meaning of the linguistic structure. In this view, the notion of translation rules is replaced by more complex "Construction Rules" that are instructions for updating representations[1]. The formal language introduced by DRT for SR, the DRS language, can be seen as a formal language designed for dynamic approaches of SR construction. It was originally introduced as a solution to problems with compositionality in the analysis of anaphora.

In this paper, I will propose an analysis of some natural language data which are at face value a problem for compositionality, namely sentences with multiple negative (or at least potentially negative) triggers. The paper provides a general algorithm schema for the mapping of negative triggers of a natural language (French) onto semantic representations. The formal language used for semantic representation is Kamp and Reyle's version of DRT (1993).
Moreover, I will try to give a principled solution to this problem in terms of a threshold of complexity on the on-line construction of a special kind of auto-embedded negative structures. This proposal has enough flexibility to cover negative concord languages as well as non-negative concord languages.

1. Multiple negation

1.1. The compositionality problem

In this section, I will introduce the general problem of multiple negation, postponing a more precise and detailed approach to the next sections.

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[1] Such representations are not representations of sentences, but representations of sequences of sentences (Discourses).

The main issue in focus is the interpretation of sentences like (1):

(1) Nobody loves nobody

According to May (1989), in one of its readings, (1) is true in no-love worlds, which, as May puts it, looks like an "abrogation of compositionality". Roughly speaking: we have two negative expressions in (1), and in the SR of (1) we get only one negation.
In the so-called "negative concord languages" (from Labov 1972), such a derogation would be a rule; in those languages, the semantic negation of a clause is achieved by means of multiple occurrence of constituents expressing negation in their own right[2]:

(2) *Nobody* said *nothing* to *nobody*
(non standard English)

(3) Mario *non* ha parlato di *niente* con *nessuno*
(standard Italian)

(4) *No* m'ha telephonat *ningù*
(Catalan)

In a language like French, sentences corresponding to (1) are ambiguous: they can have, beside the above mentioned "*no-love world*" reading, an "*Everybody loves somebody*" reading.

(5) Personne n'aime personne
[Nobody- loves- nobody]
Readings: *1. (= No-love world)*
2. (= Everybody loves somebody)

Even without using any explicit representation at the moment, it seems that this extra-reading paraphrased in 5(2) will be much easier to derive as a composition of two negations than 5(1); at least in this weak sense, 5(2) seems compositional, while 5(1) is not.
Nevertheless, although a simple French sentence can contain more that two negative constituents, it is not likely that the SR of the sentence can get that many negations. For instance, passing from (6) to (7), the reading is not affected by an additional negative:

(6) *Personne* ne dit *rien*
[Nobody- says- nothing]
Readings: *1. (= dumb world)*
2.(= Everybody says something)

(7) *Personne* ne dit *rien* à *personne*
[Nobody- says- nothing-to nobody]
Readings: *1. (= dumb world)*
2.(= Everybody says something to somebody)

Although (7) has more negatives constituents than (6), both get similar readings.
The compositionality problem can be stated as follows: each constituent in focus in (1)-(7) is presumed to be negative in the sense that its occurrence in a simple clause is a sufficient condition for the representation of the clause as a negative formula;

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[2] This characterization of negative-concord and the examples (2-3) are due to Ladusaw (1992).

nevertheless, when we get more than one such constituents, we don't necessarily get the representation of the whole as a function of all of its parts. Compared to the strong notion of compositionality used by Montague, based on homomorphism, an even weaker notion would be violated in this case, namely the functional nature of the interpretation relation.

1.2. Some proposals

I will not try to review here any proposal in details but I will try to characterize very briefly different available strategies.[3] The main point I wish to emphasize is that, at least in my view, none of those strategies can eliminate the compositinality problem.

1.2.1. The ambiguity hypothesis

One may think that the compositionality problem does not exist at all if two interpretations are allowed for the considered expressions: true negatives/negative polarity items; but I think it is only an illusion. The best this theory can do is to justify some readings; its main empirical weakness is that it cannot rule out many impossible readings. Generally speaking, such a theory could predict that interpretations like (8) are licensed:

(8)

NEG	NEG	NEG
exp_1	exp_2	exp_3
~~NPI~~	NPI	NPI

exp_n is for the succession of negative expressions; *NEG* notes the possibility of having the negative item, *NPI* the possibility of having the negative polarity item, ~~NPI~~ the impossibility of having the NPI. Any NPI has to be licensed; the interpretation NPI is thus ruled out for *exp_1*, and (possibly) licensed for *exp_2*, *exp_3*, etc. Any other interpretation is theoretically open, so (8), beside a negative concord reading, should have readings with two, three, etc., negations, which is not the case. The ambiguity hypothesis in itself would be thus of little interest on empirical grounds; the more it can do is eliminating some NPI readings. About the absorption of negations it can do nothing in itself. From a theoretical point of view, it cannot recommend itself on any intuitive basis: why should we have a systematic ambiguity negative/negative polarity item in many languages? If true, this would be precisely something we should ask a theory to account for. It is thus of no use to note here that this hypothesis can be falsified for some languages (e.g. French, Cf. infra 4.3).

1.2.2. The factorisation/incorporation hypotheses

Many proposals about negative concord languages share the assumption that each constituent is negative in its own right, and that some specific rule achieves a negation absorption or factorisation when there are many such constituents in a syntactic domain (May (1989), Haegeman and Zanuttini (1990), Zanuttini (1991)).
The guide lines of May’s 1989 proposal are as follows: when two identical occurrences of a monadic quantifier **no** occur within a syntactic domain, they can be interpreted in the standard way, but they can also be interpreted as one quantifier of a higher type (polyadic); this polyadic quantifier **NO** quantifies over pairs of individuals, and asserts that there is no such a pair (hence the no-love world interpretation)[4].
It sounds like a very ingenious way to solve the compositionality problem: instead

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[3] For a detailed discussion of different proposals for "negative concord" see Ladusaw (1992).

[4] Ladusaw (1992:7) shows convincingly in analysing Haegeman and Zanuttini's 1990 formulations that in this case, formulations in terms of "factorisation", are in fact negation absorption analyses.

of saying that one negation is lost, it says that with two simple negations we can build a more powerful one (quantifying on pairs). But it is actually based on an absorption or transformation rule, and any rule of that kind is overtly non-compositional, so although it can be empirically correct, it seems to me that in order to be considered as a principled translation procedure, it has to give some sort of answer to the following question: why should absorption/factorisation be licensed (or obligatory) in that particular case of more than one negative constituents in a single clause?
Laka (1990) argues on the contrary that all N-worlds are positive. In order to account for the negative reading of sentences with an N-word in initial position, like in (11) she has to assume the "incorporation " à la Klima of a negative in this positive word. This treatment too seems rather ad hoc.

1.2.3. The concord hypothesis

In Ladusaw (1992), a more sophisticated strategy is introduced. N-words in negative concord languages are seen as negative polarity items (Cf. Laka 1990) : none of them expresses negation, and there is in fact no visible formative expressing negation. If my interpretation of Ladusaw's proposal is correct, the line of explanation is roughly the following: all the expressions under consideration are indefinites NPIs ; so they must be licensed by a negation operator. Where does this operator comes from, and how is it expressed? Each expression is associated with a feature [neg] governed by the head feature convention of GPSG (Gazdar et al.(1985)); so this feature will be shared by every projection of this lexical head. This analysis seems to take seriously the notion of negative *concord*, seeing the problem as an *agreement* phenomenon. A direct consequence of this analysis is that only a single negation will be allowed in a clause.
There are many problems with this strategy too. Firstly, if one accepts it, one has to buy some sort of feature analysis for negation and one has to buy the idea that there is some agreement constraint relating negation and indefinites. Moreover, this strategy is designed for negative concord languages, and cannot apply to other languages. As Ladusaw himself puts it, if we find "evidence that individual instances of those items express independent negations within the same clausal domain, this counts as evidence that those items express negation". This is exactly the case of sentence 5(b). Nevertheless, the very same sentence can also be interpreted as expressing one negation, like in 5(a).

1.2.4. Common observation and problems with proposals

If we try to abstract from different theories and different languages, a common observation emerges which is as follows:

(9) A common observation about multiple negation:
n (potentially) negative expressions in a single clause tend to be represented as a single negation, negative quantifiers ending up as reference markers in the universe of this negation.

Even if in some languages we can have such sentences with two negations, a general fact seems to be that those readings are less natural, and that readings with more than two negations do not exist (Cf. supra examples (1-7) and infra section□3).

If we consider this observation and the different strategies available in the literature in order to account for this observation, we are left with two issues:
1. Theoretical motivation. Why does such a tendency exist? What does this *prima facie* violation of compositionality reveal about the form/meaning relationship in natural language?
2. Empirical adequation. If the tendency seems general, differences can be observed, within given languages and across languages, which are in need of careful inspection.

2. Negative triggers and negation

2. 1. Representation of negative sentences in DRT

Kamp and Reyle's 1993 version of DRT will be used as a formal language for the representation of negative sentences, as well as the classical semantics they associate with those negative representations.
The representation of the negative sentence (10) is the DRS (11):

(10) Jones does not own a Porsche

(11)

x Jones (x) ¬ [y Porsche (y) x owns y]

The DRS (11) is made of a top level DRS with a universe containing a discourse marker, and two conditions, *Jones (x),* and a *negative condition*, namely a DRS prefixed with the symbol□"¬".
This negative DRS in its turn has a universe of its own, and two conditions. The indefinite NP *a Porsche* has its discourse marker in the universe of this negative DRS, which corresponds to the interpretation of the indefinite NP in the scope of the negation. Any negative DRS being a part of a condition, nesting is allowed; a negative DRS can occur as a condition of a negative DRS, and so on.
The recursive verification algorithm for negative DRSs (12) from Kamp and Reyle (1993) will be used throughout this paper as a means to give an interpretation for any DRS containing negative conditions.

(12) Verification algorithm for a DRS (from Kamp and Reyle 1993)

Let K be a DRS, confined to a vocabulary V, and a set R of discourse markers. K is a pair U, (a subset of R), Con_K (a set of conditions).
f is a mapping function from U to M, the universe of a Model M.
1) f verifies the DRS K in M iff f verifies each of the conditions of K.
2) f verifies the condition C in K iff:
a) C is of the form x=y and f maps x and y onto the same element of U_M.
b) C is of the form P(x, y,...), P being a n-ary predicate in V, and f maps (x, y,...) onto a n-tuple of U_M belonging to the extension of the corresponding predicate in M
c) C is of the form ¬ K', and there is no mapping g from R into M which extends f, such that Dom(g)= Dom(f) U UK' and g verifies K' in M

Consider for instance (11); in order to verify this DRS in a given model, it must be the case that *x* can be mapped onto an individual *X* of U_M such that *X* belongs to the extension of *Jones*, and it must be the case that no extension *g* of this mapping (e.g., no function also mapping *x* on *X*) will be a mapping (*x, y*) onto (*X,Y*) such that *Y* is in the extension of *Porsche*, and (*X,Y*) is in the extension of *owns*.

2.2. Negative triggers

Let us call *negation* the symbol of the formal language; a negative trigger (we will often say just *negative*) is a natural language item translated as a negation.
More precisely we will assume the following definition:

> (13) **Negative**
> A negative is a member of a set of expressions S such that the occurrence of a unique member of this set in a simple sentence is necessarily translated as a negation.

Note that this definition can count a discontinuous expression as one negative (and not two). We will consider mainly negative triggers in French. In modern French, the basic negative trigger is (*ne*) V *pas, ne* being facultative in many dialects, especially in the spoken language. We will make the hypothesis that *pas* is a negative trigger, *ne* being an (optional) expletive form, i.e., a form with no contribution of its own to the construction of the SR[5]; if this assumption is wrong, then the only risk is that everything that we will say may be valid only for those dialects of French without *ne*. *Pas* is adverbial, and thus can occur only once in a single clause.
If a sentence gets a representation containing a negation, it will be called a negative sentence. It is worth noting that one must distinguish between a negative sentence and a sentence accepting easily a negative paraphrase:[6]

(14) Jean n'a pas accepté — negative sentence
[Jean did not accept]

(15) Jean a refusé — positive sentence
[Jean refused]

There is at least one important difference between the two sentences (14) and (15), although they are valid in the same possible worlds: in the negative sentence (16) an indefinite NP argument of the verb can be interpreted in the scope of the negation (in its universe, in DRT language), whereas in (17) it is impossible:

(16) Jean n'a pas accepté une étudiante cette année
[Jean did not accept a female student during this year]

(17) Jean a refusé une étudiante cette année
[Jean refused a female student during this year]

(16) and (17) can be synonymous, involving then a particular female student, who can be mentioned by a singular anaphoric pronoun in a following sentence; but only (16) can also mean that no female student has been accepted by Jean during the year. Roughly speaking, only (16) builds a negative DRS with a universe such that the indefinite could be a filler of this universe. In (17), no such universe exists. The dynamics of *ne pas accepter* and *refuser* are thus different. The difference is confirmed by the distribution of *aussi* and *non plus*.

(18) Jean n'a pas accepté. Marie non plus

(19) Jean n'a pas accepté. *Marie aussi

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[5] In fact, *ne* is an indication of the scope of the negation, especially in composed verbs: *Je peux ne pas le faire* et *je ne peux pas le faire* have a different interpretation. Nevertheless, this is compatible with the assumption that *ne* does not express negation.

[6] For more about the difference between expressions as *don't like* and *dislike*, see Linebarger (1980).

(20) Jean a refusé *Marie non plus

(21) Jean a refusé Marie aussi

Non plus requires the presence of a negative in the previous sentence whereas *aussi* is prohibited if a negative trigger is present.

According to those criteria, there is another class of negative triggers in French, including the following expressions: *rien, personne, aucun N, jamais, nulle part.*

(22) Personne n'a accepté une étudiante à son séminaire
[Nobody- accepts -a female student-to her seminar]

(23) Personne n'a accepté. Marie non plus
Personne n'a accepté. *Marie aussi

In (22), the indefinite *une étudiante* can be interpreted in the scope of the negation; *non plus* is licensed and *aussi* is prohibited in a parallel subsequent sentence.
In order to fix a terminology for this paper, from now on I will distinguish between:

(24) **Negative triggers:** pas
(25) **Negative quantifiers:** rien, personne, aucun N, jamais.

Negative quantifiers function as major constituents in the sentence, either as argument NPs (*rien, personne, aucun N...*) or as spatio-temporal adverbials (*jamais*). *Aucun* occurs in a determiner position, and is followed by a noun which can be followed by modifiers (complements and relative clauses). *Rien, personne* and *jamais* cannot be followed by a noun; *Rien personne* and *jamais* can be used without any complement. *Rien* and *personne* can be modified by relative clauses in the subjunctive mood (e.g. *Je n'ai rencontré personne qui ait lu ce livre).* [7]

The consequence we would expect is that negative quantifiers can co-occur in a simple sentence, and can co-occur with a negative trigger. This is the case in French, hence the multiple negation sentences.

(26) **Multiple negation sentence**
Simple sentence (one finite verb) with more than one negative

2.3. Basic Construction Rule for negative quantifiers

A simple construction rule for negative quantifiers produces an adequate SR for simple sentences with one negative quantifier :

(27) Proposal 1: **Construction Rule for negative quantifiers (CR-Neg-Q)**
1— Represent the sequence in process as a negative DRS K_1;
2— interpret the constituent as if it were an indefinite introducing its reference marker in the universe of the negative DRS K_1.

Proposal 1 correctly predicts that (28) has the same interpretation as (29) with a narrow scope interpretation of the indefinite in (29).

(28) Jean n'a pas accepté une fille à son séminaire cette année
[Jean-did not accept-a girl- in his seminary this year]

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[7] We keep here to the main features of the distribution of these items, a detailed characterization of the syntax of those items being beyond the scope of this paper.

(29) Jean n'a accepté aucune fille à son séminaire cette année
[Jean-accepted- no-girl- in his seminary this year]

Moreover, it seems that the expected consequences on anaphora of such a representation do hold: anaphora to the postulated discourse referent is licensed within the negative DRS, as in (30), but not from a subsequent sentence, as in (31):

(30) Aucun garcon n'admet qu'on le critique
[No boy-admits-that-he is criticized]

(31) *Aucun garcon n'est venu. On le critique
[No boy-came. He is criticized]

Many languages have other lexical phrases of that kind, beside negative triggers like *pas*, namely expressions in argument or adverbial position, for which the above construction rule (27) produces correct representations.
The peculiarity of the construction rule defining such expressions (CR Neg-Q) can be illustrated by a comparison; due to CRNeg-Q, (32) will receive the same representation as (33) with a narrow scope indefinite; this interpretation is given in (34):

(32) John n'a pas lu un livre
[John-did not-read-a book]

(33) John n'a lu aucun livre
[John-read-no book]

(34)

x
John (x)

¬ | y
book (y)
x read y |

In the case of (32), this representation is derived with two independent Construction Rules, namely the rule for the negative trigger *pas*, which builds a negative DRS, and the rule for the indefinite *un livre* which can fill this DRS. In the case of (33), a single rule proceeding in two steps is doing the job: firstly a negative DRS K_1 is created, then this DRS receives a negative marker bound by two conditions inside that DRS. Negative quantifiers are so to speak doing two things at once: they create a negative DRS (as negative triggers do) *and* then, they fill it with a Reference Marker (as an indefinite in the scope of a negative would do). This formalization is a way of capturing the analysis of negative quantifiers as negative indefinites (i.e. as an existential quantification in the scope of a negation), which is well represented in the literature (Cf. among others Zanuttini 1991, Ladusaw 1992). Moreover, it does not introduce any complication in the reference framework; the distinction in DRT between DRS-builders (conditional, negation) and DRS-fillers (indefinite) is available; moreover the analysis of universally quantifying NPs in DRT (*every N)* considers them as DRS-builders-fillers, which is exactly the status we give to negative quantifiers in our representation.

3. The interpretation of multiple negation sentences

I will concentrate first on the co-occurrence of negative quantifiers in simple sentences (3.1-3.2), considering later (4.3) the co-occurrence of negative trigger and negative quantifiers in the same sentence.

3.1. Sentences with two negative quantifiers

The observation that sentences with two negative quantifiers are ambiguous has been made several times in the literature about French (cf. Muller 1987), most often about sentences with negative quantifiers in subject and object position, like (5). Using the DRT language, the two interpretations of the sentence are correctly represented by the following DRSs; a predicate logic paraphrase of each interpretation, as well as an informal paraphrase in English are provided.

(5a)	**(5b)**
Personne n'aime personne	**Personne n'aime personne**
mono-negative interpretation	□ bi-negative interpretation
$\forall x\ \forall y\ \neg$ (human x & human y & x loves y)	$\forall x\ \exists y$ (human x $\longrightarrow$ (human y & x loves y))
(= world without love)	*(= Everyone loves someone)*
¬ [x y human (x) human (y) x loves y]	¬ [x human (x) ¬ [y human (y) x loves y]]

In saying that the above DRSs correctly represent the interpretations, we mean that the application of Kamp and Reyle's verification algorithm (12) to these DRSs will make correct predictions about the truth conditions of each of the interpretations. Note that 5(a) and 5(b) are opposites, which means that the very same string of words can be used to contradict itself. We can imagine contexts in which it might happen. Suppose for instance your son tells you that he does not want to go to a party, and justifies his position by saying:

> (35) Pourquoi y aller puisque personne n'aime personne, dans ce groupe?
> [=Why should I go, since nobody loves anybody in this group?]

If you think he is wrong about that, you might object (36):

> (36) Mais c'est faux! Personne n'aime personne: Alain adore Pierre et Jeanne, tu aimes Sarah, etc...
> [=But you are wrong. Everybody loves somebody, Alain loves Peter and Jane, you love Sarah, and so on]

French native speakers are often inclined to say that the mono-negative reading 5(a) is standard, whereas the bi-negative reading 5(b) is more difficult to get, more artificial. Usually, if you ask a speaker what a sentence like (5) means, she would immediately grasp the 5(a) reading, and very often then, she would say something like "but it can also mean that everybody loves somebody". Nevertheless, there are many cases where pragmatic or plausibility constraints select the bi-negative reading and rule out the mono-negative reading, for instance in (37):

(37) Personne n'est l'enfant de personne
[nobody-is the child of-nobody]

In as much as its is difficult to imagine a world with human beings and with no parent-child relation, only the trivial bi-negative interpretation will be selected. Nevertheless, if you are considering a restricted group of humans, say, for instance, the staff of a factory, the mono-negative interpretation *no parent-child relation* will be available, and necessarily preferred, just because it is possible to find a factory with no parent child relation, but impossible to find a factory staff within which everyone has her parents (an infinite set since the relation is anti-symmetric). A last example; if you want to say that every student has made at least one mistake in an exercise, given that the aim of an exercise is to make no mistake, the normal way of saying is (38):

(38) Aucun étudiant n’a fait aucune faute
[=No student managed to do the exercise without any mistake]

For *aucun* it even seems that the preferred reading is the bi-negative one, at least for the configuration: *aucun N -V-aucun N.* Moreover it seems that the bi-negative interpretation is preferred if there is some syntactic material attached to one on the negative quantifiers.[8]
The detailed study of the conditions in which one reading will be preferred, or will be ruled out, is not in the scope of this paper. The only important thing for the present purpose is to observe that two opposite readings do exist for the same string of words. A correct theory should give an account for this ambiguity.
If the two readings are representations of one syntactic structure, the only plausible account for the ambiguity lies in two different processings for the lexical expressions of that structure.

The generation of the bi-negative reading 5(b) is straightforward in the present framework, once admitted that CR-neg-Q applies recursively and processes the negative quantifiers of the sentence from left to right.

(39) Proposal 2: **sentence processing for negative triggers**
Update the representation using a left-right processing for lexical negatives

The generation of the bi-negative 5(b) is achieved as follows:

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[8] There are two factors which gives a preference for the bi-negative reading:

1) the complexity of the syntactic material attached to the quantifiers (questions of D. Oherle and R. Kempson helped me to realize that). For instance, the bi-negative reading will be preferred (if not imposed) in the following examples:

(i) Aucune étudiant qui étudie les mathématiques ne lit aucun livre de philosophie
(no student working in mathematics-reads-no book of philosophy)
(ii) Presque personne n'aime personne
[Almost nobody-loves-nobody]

2) the fact that the sentence is processed in two steps, the most striking case being the succession question-answer.

(iii) Qui n'aime personne? Personne.
[Who loves nobody? Nobody.]

The only possible interpretation of the answer in (iii) is bi-negative: *Everybody loves somebody.*

(40) **Generation of the bi-negative reading 5(b)**

¬ x
human (x)
x aime personne

->

¬ x
human (x)
¬ y
human (y)
x loves y

1rst application of CR-Neg-Q — 2nd application of CR-Neg-Q

Note that (5) cannot be interpreted with the quantifier in object position outscoping the quantifier in subject position; there is no *Everyone is loved by someone* interpretation ($\forall y\ \exists x$ (human y —> (human x & x loves y)). It is precisely this interpretation which would be produced by a right-left application of CR-Neg-Q to the sentence, as illustrated in (41):

(41) Unattested processing for (5)

¬ y
human (y)
personne aime y

-->

¬ y
human (y)
¬ x
human (x)
x loves y

1rst application of CR-Neg-Q
quantifier in object position

2nd application of CR-Neg-Q
quantifier in subject position

Once proposal 2 is admitted, (41) is ruled out. As we shall see there are many other pieces of evidence supporting proposal 2.

Proposal 1 and proposal 2 can only produce the compositional (bi-negative) reading (5)b ; in order to get the mono-negative reading 5(a) something more is needed, that will be called *parasitism.*

(42) **Parasitism**.
If CR-Neg-Q applies to the output C of CR-Neg-Q, that is to say in the context of the negative DRS K_{neg}: ¬ [x [....Cx...]] K_{neg} then only the second part of CR-Neg-Q applies, the K1 of CR-Neg-Q being identified with K_{neg}.

The metaphoric term *parasitism* has been chosen to capture the idea that the second occurrence of the expression, so to speak, uses a negative domain made available by a previous expression, instead of creating a new one in its own right

Figure 1 is a visual representation of a schematic construction algorithm based on proposal 1, proposal 2 and (optional) parasitism.

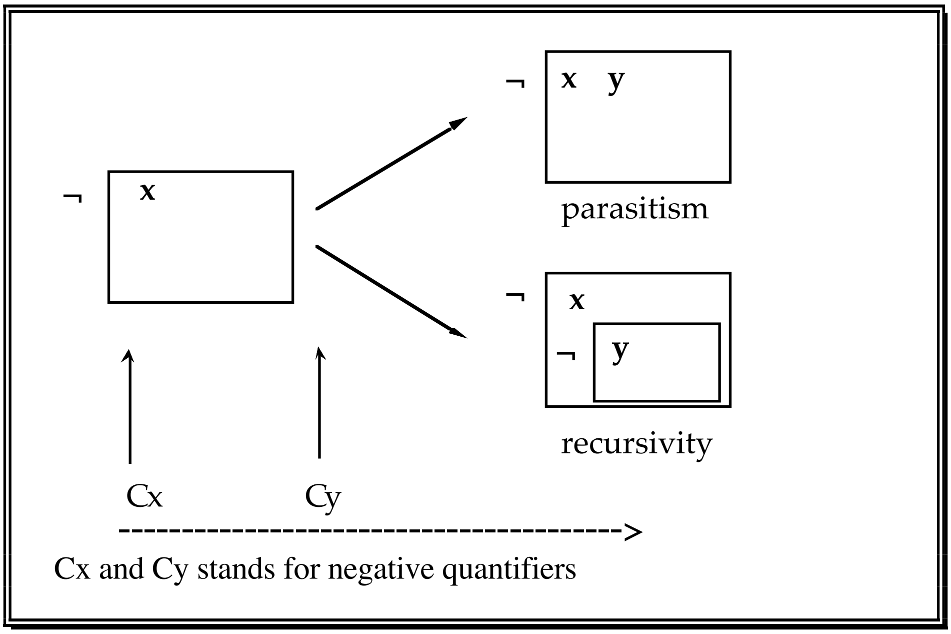


Fig 1.Processing of two negative quantifiers in Subj /Obj position

Fig 1 is a very general schema, any relevant detail of effective implementation being left aside. It is nothing but a way of getting the readings we have, and only those readings.

3.2. Sentences with more than two negative quantifiers

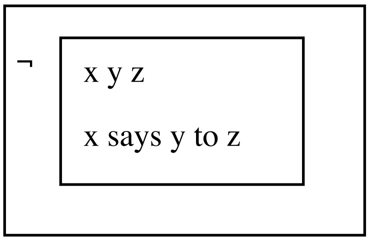
Let us now consider the interpretation of sentences containing an arbitrary number of negative quantifiers, for instance (7) repeated for convenience in (43):

(43) Personne ne dit rien à personne
[Nobody- says- nothing-to nobody]

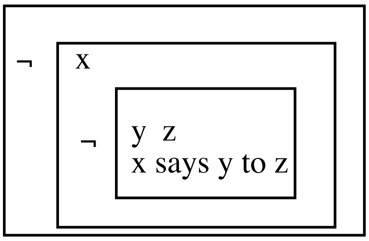
(43) has two interpretations, identified by (44) and (45)[9].

[9] For the sake of simplicity we don't write inside the DRSs the restrictors of the quantifiers: *personne* always quantifies over humans, and *rien* over things.

(44) Personne ne dit rien à personne
Mono-negative interpretation
(= dumb world)



(45) Personne ne dit rien à personne
Bi-negative interpretation
(= Everybody says something to somebody)



Exactly as before, the preferred reading is the mono-negative one; generally, the bi-negative reading seems less accessible. If one of the negative quantifiers is stressed, the bi-negative reading is highly favoured:

(46) **Personne** // ne dit rien à personne

It is much easier to get a bi-negative reading in (46) than in a neutral version. Proposal 1 and 2 plus parasitism can generate those two readings.

(47) **Generation of the mono-negative reading (44)**

Personne	ne dit **rien**	à **personne**
CR Neg-Q	parasitism	parasitism
One negation is introduced	only CR_2 applies	only CR_2 applies

(48) **Generation of the bi-negative reading (45)**

Personne	ne dit **rien**	à **personne**
CR Neg-Q	recursivity	parasitism
One negation is introduced	One negation is introduced	only CR_2 applies

However, it may be interesting to compare what we get with what is theoretically licensed, if recursivity and parasitism play freely. Figure 2 is a schematic representation of all the combinations that a program applying freely the two operations from left to right would produce.

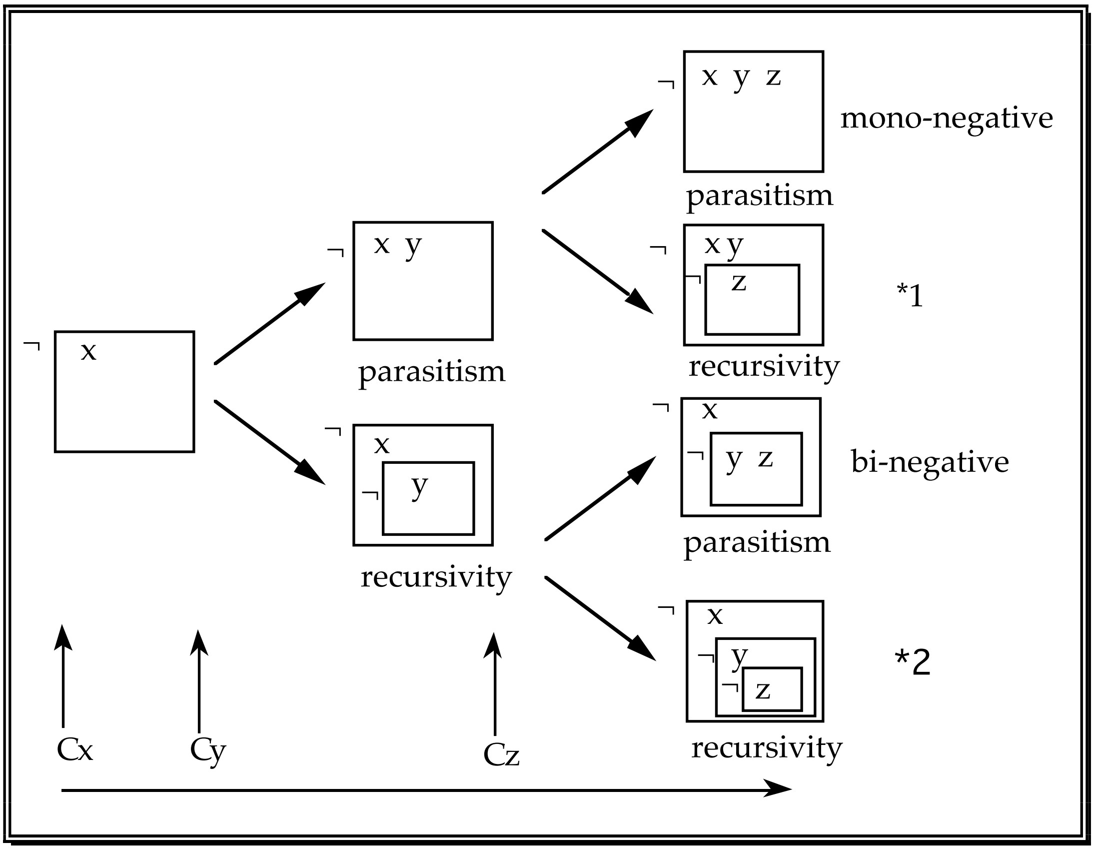
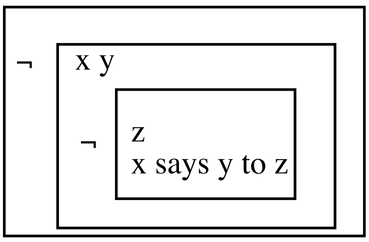


Figure 2: The set of potential representations.

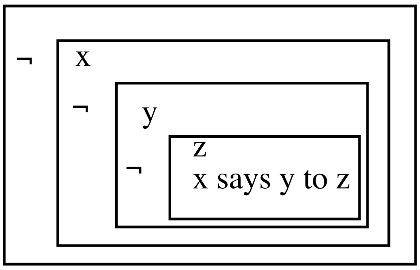
Only two out of four representations do correspond to interpretations human interpreters are able to associate to that string; they were given above in (44) and (45).
Nevertheless, the starred DRSs are well formed DRS, and their interpretation (it would be more exact to say their potential interpretation) is easily computable by the basic recursive algorithm of Kamp and Reyle.

(49) Personne ne dit rien à personne
Bi-negative interpretation *1:



$\forall x \ \forall y \ \exists z$ (x says y to z)
Every speech act has an addressee

(50) Personne ne dit rien à personne
Tri-negative interpretation *2:



$\forall x\ \exists y\ \forall z\ \neg$ (x says y to z)
Anybody has something she hides from everybody

For (50) a few comments about the interpretation are in order. Let us take a restricted set of things to be said, Y, and a restricted set of potentials sayers, X. If (38) quantifies over those sets, what the DRS means is that *for any pair (x,y)*, there is at least one z such that x said y to z. The DRS does not mean that for any pair (x,y) *such that x said y*, there is at least one z such that x said y to z.[10]
Any speaker with an exposure to formal logic can understand the paraphrases of the starred representations, and can imagine situations in which they are true; she can say how the world is when those DRSs are verified. What a speaker cannot do is to associate those representations with the string under consideration. Moreover this impossibility is strong: it is not similar to the well known situations in which complex nestings are to be processed, e.g., relative clauses, or standard nestings of negations (about which more will be said later).

(51) I gave the girl the boy admires a book

(52) I gave (the girl ((the boy the dog bit)) admires) a book

In those so-called "performance limitations" the processing of complex embeddings may be impossible in a short time, and the structure then receives no interpretation. If more time is given to the human processor, she will get the same result as the program.
In the present case, the sentence is easy to process for a speaker, but some potential constructs (*1 and *2) are completely inaccessible. Nevertheless those constructs are derived with nothing more than the basic rules which produce accessible constructs; it is not clear then whether this limitation is to be seen as a weak

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[10] The last mentionned interpretation is seen as tautological once admitted that the addressee argument is obligatory for the verb *to say*. The interaction of multiple negation and the argument structure of the verb is in need of more investigations. I am grateful to Ivan Derzhanski for having pointed that to me. The difference between obligatory and optional arguments (in a sense to be made more explicit) is undoubtedly relevant. A limitation of this paper is that it considers only arguments belonging to the argument structure of the verb and spatio-temporal locations. Different problems arise if one consider arguments of the kind exemplified by *pour personne* in (i):

(i) Personne ne travaille pour personne
[Nobody-works-for nobody]

(i), in addition to mono and bi-negative readings previously exemplified in this paper (respectively paraphrased in (a) and (b)) has a reading paraphrased in (c):

(a) No work world *(mono-negative)*
(b) Everyone works for somebody
(c) If someone works, he/she works for somebody

The way of properly deriving the (c) reading, which I assume to be bi-negative, would remain to discuss in details.

competence limitation (since only rules working elsewhere are concerned), or as a strong performance limitation (because it is a yes/no matter, not a matter of degree).[11]
At this point, the solution has two major shortcomings:
The generation mechanism which is necessary for producing existing readings is two powerful; moreover, it is based on an ad hoc operation, parasitism, which is overtly non compositional.
I would like to propose a solution to both questions, which views parasitism as a complexity regulator.

3.3. Parasitism as a complexity regulator

If we look at the class of possible interpretations for simple French sentences with an arbitrary number of Negative quantifiers, a simple characterization is possible: the resulting representation will have at most one negation nesting, no more than one binding from outer to inner negation, and the highest negation will be introduced by the leftmost negative quantifier. What we seem to have is a limitation on the possible complexity of those structures. What we have called parasitism has the result that the complexity of the representation is kept below a threshold. Parasitism will be optional when below the threshold, and obligatory when the threshold is reached. It is thus possible to consider that parasitism behaves exactly as a complexity regulator which is defined with respect to a threshold. So we will add a third proposal to 1 and 2:

(53) Proposal 3: **complexity regulation of CR NEG-Q**
The application of CR Neg-Q in a clause is constrained by a threshold of complexity:
1. the maximal depth of nesting is one;
2. the maximal number of bindings from outer negation is one.
Parasitism applies optionally below the threshold.
Parasitism must apply when the threshold is reached.

Proposal 3 is seen as a constraint on the on-line processing of negative quantifiers within a clause. It is just one among many ways of telling the story of fig 2. More will have to be said to substantiate the claim that this constraint has something to do with complexity, although this idea does not seem *a priori* conter-intuitive, at least regarding $(53)_1$. The case of $(53)_2$ is probably more controversial: in what sense the bi-negative (49), with two bindings from the outer negation, should be said more complex than the bi-negative (45), with only one of such bindings? It could be argued in that case, that although the representation itself is not more complex, the processing path is so: looking at fig.2, we can infer the strategy "once you have called parasitism, stick to it". This looks sound if parasitism is a means of limiting the complexity: once you have called a complexity regulator, it would make no sense to call a complexity increasing processing operation.[12]
It is worth noting that a system designed along these lines seems to produce the correct results for an arbitrary number of negative quantifiers. Consider for instance (54), which contains four negative quantifiers:

(54) Personne ne dit jamais rien à personne
[Nobody- says- never-nothing-to nobody]

(54) has only two possible representations: either parasitism is always applied, and we get a mono-negative representation, or recursivity is applied on the second quantifier, after which only parasitism applies.
The other observation worth making is that when we take this way of telling the

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[11] I am grateful to Eva Ejerhed for having pointed to me that this limitation was not unquestionably a competence limitation, which was my initial view.
[12] This view of case *2 has been suggested to me by Robin Cooper (p.c.).

story in terms of limitations on complexity, even the first step might seem less odd. We do have some representations with negative nestings, but the maximal depth of nesting is one, so we observe a very strong limitation on complexity. It is then sound to think of the minimal nesting itself as a complex structure, a threshold. Then the application of parasitism at the first step would be a natural way to keep the complexity of the structure below this threshold. Note that the empirical distinction between the preferred reading (mono-negative) and the marked one (bi-negative) is straighforwardly captured by the hypothesis, since the later one is assumed to reach the threshold for complexity.
Thus, the hypothesis that comes to mind, is that the processing of negative quantifiers is regulated by a clause-bound dynamic limitation on the complexity of representations: negative quantifiers both trigger the introduction of a negative DRS and fill its universe with a Reference Marker; they do so unless the output of both actions would cross the threshold of complexity; in those cases, only the second action is performed (what we call parasitism).

4. On the Complexity of negation nesting

The aim of this section is to substantiate the claim that the above mentioned constraint is related to the inherent complexity of some negation nestings.

4.1. Classical double negation elimination

The double negation law $\neg(\neg P) \Rightarrow P$ has something to do with complexity, since we can see it as a simplification rule; it is easy to state this law as: don't worry about processing too many embedded negations, just simplify; the maximal number of negation you may ever have to actually process then is in fact one. Logicians as Ramsey for instance were very reluctant about the idea that negation is a true recursive operator. Ramsey suggests that it might be an illusion, due to the fact that in natural language, negation is expressed by a discrete word, which as such, can be repeated. For Ramsey, we would have a more exact picture of what is going on for propositional negation if in order to express the negation of P we would choose to write, or to spell, P upside down; it would follow transparently then that $\neg(\neg P)$ is nothing but P, and so on.

(55) Natural language negatives Vs Ramsey's negatives

NL negatives	Ramsey's negatives
The door is open	The door is open
The door is not open	The door is open
It is not true that the door is not open	The door is open
It is not true that it not true that the door is not open	The door is open

PL negatives	Ramsey's negatives
π	π
$\neg\pi$	π
$\neg\neg\pi$	π
$\neg\neg\neg\pi$	π

The processing of such sentences by humans is complex for many reasons:
1. the semantics of simple negation in itself is complex because it reverses truth values;
2. the processing of multiple negation is complex because this operation must be reiterated.
This kind of complexity is conscious for natural language users, and gives rise to

well known performance limitations. Nevertheless, it is also reasonable to argue that there is no processing complexity at all, since when processing an arbitrary number of such negatives, in practice, you never have to consider more than one negation at once: when one negative is found, you have one negation in process, when another one is found, you have no negation in process, etc. (Cf. Ramsey). As any course book in elementary logic reminds you, all you have to check is whether the number of negatives you process is odd.
However, this kind of elimination holds for formulae like $\neg (\neg (X))s$ iff X is not bound in ()s; for instance, in a formula like $\neg (\exists y \neg (Xy))$ no simple elimination can be done. It is very interesting to observe that if the analysis we proposed in (27) for negative quantifiers is correct, parasitism is optional precisely when such structures would be built, and when such structures would become more complex, then parasitism is obligatory.

4.2. Complex negation nesting

In Kamp and Reyle (1991), a calculus is introduced for first order Discourse Representation Language. The Double Negation Reduction rule is one of Kamp and Reyle's deduction rules. If a DRS like (56) can be proved,

(56)

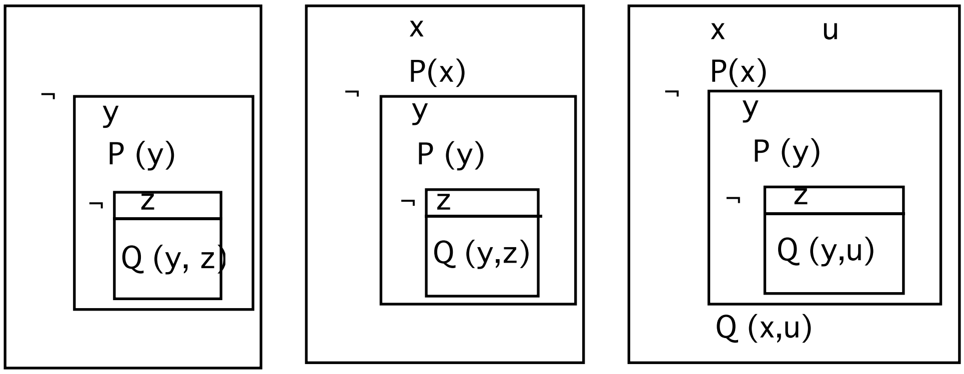
$$\neg \boxed{\neg \boxed{\begin{array}{l} \quad x \\ P(x) \end{array}}}$$

then a DRS like (57) can be:

(57)

$$\boxed{\begin{array}{l} \quad y \\ P(y) \end{array}}$$

However, as observed by the authors, "when the DRS to which the outer negation applies, contains material beside the DRS to which the inner negation applies, Double Negation Elimination is more complicated" (p.16). The case considered by Kamp and Reyle (1991) has exactly the same structure as the bi-negative representation produced by the recursive application of CR-Neg-Q (see for instance (5)b above).



A B C

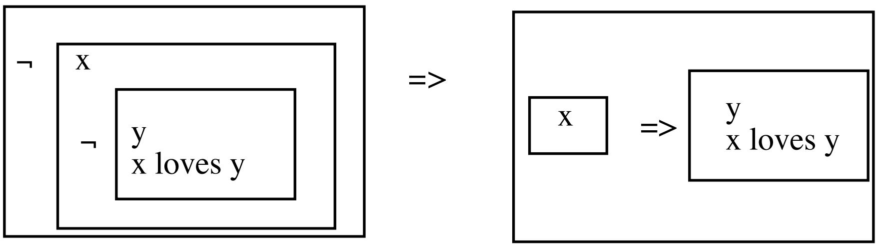
fig 3. Elimination of complex negation (from Kamp and Reyle 1991)

(A) is the representation of the relevant structure in Kamp and Reyle. The outer negation has a non-empty universe (the discourse marker *y)* and this discourse marker is bound from the inner negation by the condition Q (y, z) According to the claim of this paper, this is exactly this representation that we get from the recursive processing of two successive negative quantifiers (see for instance 5(b)). It is worth noting, that Kamp and Reyle do not consider any specific linguistic data, they just examine from a general point of view the different cases of "double negations" created by the DRT language, and the valid inference allowed by each representation.
What they claim for (A) is roughly what follows: in any Model where you can prove (A), and where moreover you can prove a second premise as illustrated in (B), then it is logically valid to infer that the conclusion highlighted in (C) can be proved in that Model: this rule says that if A is true, then every time there is an individual that instantiates the outmost condition of (A), then it must be the case that there is an individual which satisfies the inner condition of (A), i.e., it says that (A) allows the same inference as the conditional statement (58):

(58) $\exists$ x P (x)--> $\exists$ u Q (x, u)

Remaining close to the DRT formalism the negation elimination would look like (59):

(59) Double negation elimination in bi-negatives



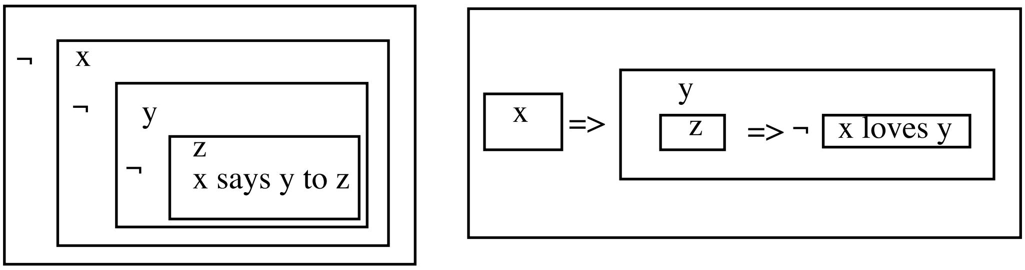
$\neg\ \exists$ x ($\neg$ ($\exists$ y (R x y))) $\forall$ x $\exists$ y (R x y)

To say that Double Negation Elimination is "more complicated" in that case, as do the authors, is an understatement: in fact, what we have is not a simplification via double negation elimination, but actually a reformulation of the original negative nesting by means of inference rules.
In the simple case of negation nesting(Cf. 56-57), you actually get an equivalent

representation just by wiping out the negations (see the move from 56 to 57 supra). But in (59) what you must achieve in order to eliminate negations and get an equivalent representation is a complete reformulation using different connectives. It is for instance not so difficult to consider the simplification in the first case as the result of an on-line processing, something like: I am processing a negation, I come across another one, well, I give up both... But in the case of (59), such an on-line processing leads to much more complications. We might suggest the following: this interpretation of the sentence does not seem to be spontaneous, it requires some sort of afterthought, because it is not directly accessible, but only after negation elimination, via a conditional representation like in (59). In this very strong speculative version of the hypothesis, bi-negatives could not be processed, and would only be reformulated.

As for tri-negatives, negation elimination would look like (60):

(60) Negation elimination in tri-negatives



$\neg(\exists x (\neg(\exists y (\neg(\exists z (Rxyz))))))$ $\forall x \exists y \forall z \ \neg (R x y z)$

In this case, we keep one negation, and we get a very complex logical structure which seems difficult to compute on-line.

Maybe we have now a better understanding of what is exactly the specific complexity problem for this kind of negative nesting: the problem is precisely that the universe of the *outer* negation is bound by a condition of the *inner* negation, which rules out any on-line simplification. The depth of embedding will then make the representation more and more complex to process.

Hence, it is worth examining the behaviour of the two kinds of negatives distinguished in (24-25), negative triggers and negative quantifiers, when they are in the same sentence. We will then be able to sketch a general typology of negative embeddings and say in exactly which conditions the kind of derogation to compositionality called here *parasitism* takes place.

4.3. Multiple negation with trigger and quantifiers

If a sentence containing both a negative trigger *pas* and a negative quantifier is processed, the representation *cannot* be mono-negative, which means that no parasitism can take place from a negation introduced by a negative quantifier to a negation introduced by a negative trigger. They are, as it were, processed each on their own side.

When the negative quantifier is in subject position, the sentence has a reduced degree of acceptability, as in (60):

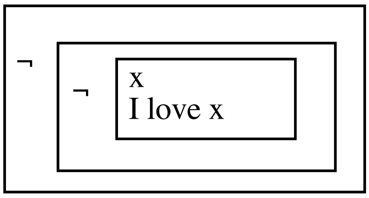
(61) (?) Personne ne m'aime pas
[Nobody-don't-me-love]

The acceptability of the sentence improves if the negative quantifier follows the negative trigger as in (62):

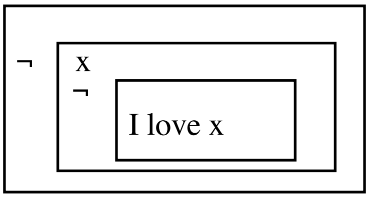
(62) Je n'aime pas personne
[I-don't-love-nobody]

Both sentences are used mainly as echo-sentences, and both have only a bi-negative interpretation. Moreover, the only interpretation available is produced by a strict left-right processing of the sentence:

(63) Correct representation of (62)
Je n'aime pas personne



(64) Incorrect representation of (62)
Je n'aime pas personne



Kamp and Reyle's algorithm tells us that (63) is true iff there is at least one person x such that I love x. This is the correct interpretation of the sentence, and it will be obtained if we process the negative trigger *pas* first, building a negative DRS, and then process the negative quantifier in the scope of this higher DRS. If we process the universe-negative first, and then the negative, we get (64) the meaning of which, according to the algorithm (12) is equivalent to: for every x, I love x.
A few comments may be in order about this case. Firstly it seems to contradict any attempt to see expressions like *personne*, *rien,* etc. in multiple negation as negative polarity items (Cf. supra 1.2.1). The context in (62) is a very typical licenser for polarity item, but the only interpretation admissible for *personne* in this context is a true negative interpretation. This is the more interesting point, since *personne, rien*, *jamais,* actually can be used as polarity items in some *other* contexts. Although undoubtedly attested, this use of some negative quantifiers as Polarity Sensitive Items is not without constraints in French:
1— This use is very rare, and much more rarer in the spoken language.[13]
2— The most easily accepted item in this use is *jamais*, and if *jamais* is present, it is easier to use another negative quantifier as PI in the sentence.
3— Some negative quantifiers cannot be used as PI in the absence of *jamais*, e.g., *aucun N.*
On the matter of negative quantifiers and corresponding polarity items, French might be opposed to English very roughly as follows: both French and English

[13] It actually means that the use of negative quantifiers as NPI is mainly licensed in those dialects of French in which *ne* is almost obligatorily present in negative sentences. One might suspect a causal relation between these two facts.

have negative quantifiers, but English has distinct polarity items, whereas in French, some lexical items can be either negative quantifiers or polarity sensitive items; those lexical items in French, although licensed by some polarity contexts, are not licensed by a clause mate negation trigger.
Consider for instance (65) and (66):

(65) Je ne crois pas que personne ait jamais dit cela
[I-don't think that-nobody-has-never-said-that]

(66) J'y arriverai, si personne y arrive jamais
[I will succeed if-nobody-succeeds-never]

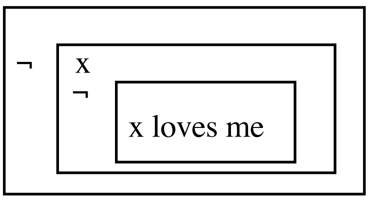
In these contexts, *personne,* and *jamais* have no negative meaning at all, their English translation will use polarity items, and they can be replaced in French by standard indefinites without changing the interpretation as is (65') and (66'):

(65') Je ne crois pas que quelqu'un ait dit cela un jour

(66') J'y arriverai, si quelqu'un y arrive un jour

So, if one is inclined to analyse *personne* as a polarity item in *personne n'aime personne*, one will have to admit that *personne* in subject position, but not the standard negation *pas*, licenses a polarity item interpretation of *personne* in object position, which seems hopelessly *ad hoc*. Many other arguments are against the idea that the second occurrence of a negative quantifier is a polarity item. In French, the polarity sensitive interpretation is only available if *ne* is *not* licensed: in (65) and (66) above, if *ne* occurs in the same clause as *personne* and *jamais*, then the negative interpretation of those items is restored. In the multiple negation case, *ne* is licensed. So the polarity sensitive theory for multiple negation sentences would lead to give up an important generalization about the form-meaning mapping in French. Moreover, as Muller (1987) has shown, some languages have no independent use of negative quantifiers as polarity items, whereas they have mono-negatives readings corresponding to the occurrence of more that one negative.
Another interesting point about (62) is that the linear order of negatives gives the only attested scope hierarchy, which agrees with proposal 2 above. For sentence (61), if accepted, for instance as a denial of *X ne m'aime pas*, its only correct representation is (67):

(67) Correct representation of (61)
(?) Personne ne m’aime pas

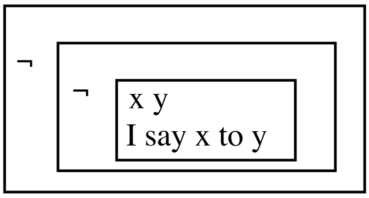


The meaning of (67) is: there is no x that does not love me. The other scope hierarchy would mean: it is false that there is no x such that x loves me; (61) cannot be interpreted this way. Again, the correct result is obtained iff the triggers are processed following their linear order.
Evidence supporting these observations comes from sentences with more than two negative quantifiers like (68):

(68) Je ne dis pas rien à personne
[I-don't-say-nothing-to nobody]

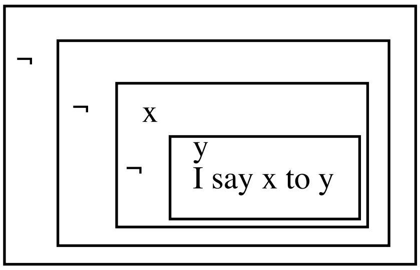
This sentence can only mean: I say at least one thing to at least one person. So the only correct representation in the present framework is (69):

(69) Correct representation of (68)



Three things are of special interest in this respect:
1) again, only a left-right processing gives the correct representation.
2) again, there is no parasitism from the negative quantifier to the negation introduced by a previous negative (*pas*). They are independent.
3) much more interesting: parasitism necessarily applies from negative quantifier 2 (*personne*) to negative quantifier 1 (*rien*) , although we are only at the second step of the processing of negative quantifiers.
Had recursivity applied, the resulting representation for (68) would have been (70):

(70) Maximally recursive (incorrect) representation of (68)
(68) Je ne dis pas rien à personne



What (70) means is: there is at least one x such that, for every y, I do not say x to y. This is not a correct representation for (68).
This seems to mean that the regulation constraint on complexity is sensitive to the higher negation. The construction algorithm must process in this order:

je ne dis pas	**rien**	à **personne**
Negative rigger	Negative quantifier 1	Negative quantifier 2
	recursivity	parasitism
One negation is introduced	One negation is introduced	only CR_2 applies

When processing Neg-Q 1, the algorithm has already a negation in process (from the previous processing of the negative trigger); it is instructed by Neg-Q 1 to introduce another negation and to fill the universe of this negation: things then work as if by so doing the threshold of complexity were already reached; consequently, no more negations can be introduced, and Neg-Q 2 will parasite the most recently introduced negation (Neg-Q 1).
Remember that CR Neg-Q in French can only parasite a negative quantifier; in other words, if a regulation mechanism is postulated, the effects of this mechanism

can only show from a negative quantifier to a negative quantifier. Nevertheless, as it appears from (70), a negative can have some effects, since its processing will count as a complication of the current structure .
Such a difference between those two kinds of negatives is not ignored by linguists. The French linguist Tesniere (1959) distinguished between two kinds of negatives: "négatifs imperméables", doing their negative job in any circumstance, and "négatifs perméables" which can loose their negative force in some contexts. In this sense French negative quantifiers are *perméables*, while French negative trigger is *imperméable*.

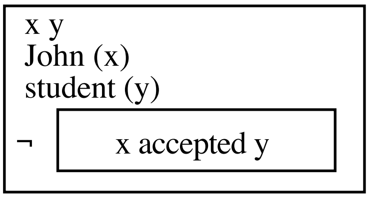
Classical negation elimination in nestings can only take place if the outer universe is empty. Consider (71) and (72), involving the negative trigger *pas* and the standard indefinite *un N*:

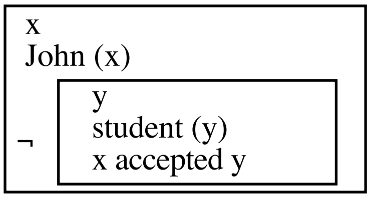
(71) John n'a pas accepté un étudiant
[John-did not-accept-a student]

(72) Il n'est pas vrai que John n'a pas accepté un étudiant
[It is not true that John did not accept a student]

For the sake of simplicity, we will assume that *it is not the case that P,* is represented as *not P*. (71) will have two distinct representations: in (73)a the indefinite is interpreted at the top level, in (73)b, it is interpreted in the universe of the negative DRS.

(73) Representations of (71)
John n'a pas accepté un étudiant



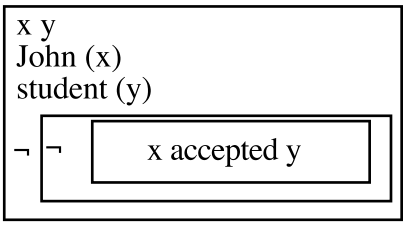


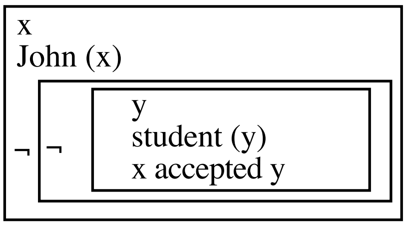
(73)a
Wide scope indefinite

(73)b
Narrow scope indefinite

For (72) we will thus expect at least two representations:

(74) Representations of (72)
Il n'est pas vrai que John n'a pas accepté un étudiant





(74)a

Wide scope indefinite

(74)b

Narrow scope indefinite

Negation elimination is not prohibited in that particular case, since there is no binding from outer to inner negation (the relevant fact is thus the emptiness of the

outer universe). As suggested in (54)/(55) above, negation elimination will trigger a "merging"[14] between the inner material (the material of the inner DRS) and the outer DRS (in (74), the top-level DRS): the discourse referents go up to the outer DRS, and the set of conditions in the inner DRS is included in the set of conditions of the outer DRS.
If we eliminate the negations we get the same deduction for the two DRSs:

(75) Representation of (74)a and (74)b after double negation elimination

```
x y
John (x)
student (y)
x accepted y
```

This consequence is correct, since the two sentences are true exactly in the same worlds, i.e., iff there is at least one student y such that John accepted y.
Now there is another virtual representation we should have considered for the sentence (72), namely an interpretation of the indefinite in-between (74)a and (74)b, i.e. in the universe of the outer negation, as in (76):

(76) Potential "medium scope" interpretation of the indefinite

```
x y
John (x)
¬ [ y
    student (y)
    ¬ [ x accepted y ] ]
```

According to the verification algorithm, (76) means that John accepted every student; but although this virtual representation does not seem to be ruled out by any known principle, this is not a correct interpretation for the sentence (76): now if we look at (76) we can see that this interpretation of the indefinite would precisely create this kind of complex structure with binding from outer to inner negation, the kind of structure which in our hypothesis is beyond the threshold of complexity.
The interesting thing about these complexity constraints in (72) is that they do not concern negative quantifiers, but two independent expressions, namely negative triggers and indefinites. It can be taken then as an independent confirmation of the inherent complexity of this kind of negative nesting.

4.4. No-parasitism cases

This sections provides some empirical evidence supporting the complexity analysis. Given that there are two potential interpretations for any multiple negation sentence involving negative quantifiers, we can try to look at contexts where one of them is ruled out.
The bi-negative interpretation is seen as a threshold and thus inherently exposed to be ruled out. It is thus difficult to use those cases to prove anything.
The bi-negative interpretation is ruled out if the subject is not a negative quantifier, and if the negative quantifiers are arguments:

[14] See the "Merge" operation in Zeevat (1989).

(77) Marie ne dit rien à personne
[Mary-do not-say-nothing-to nobody]

This sentence can only mean than Mary is dumb; there is no interpretation such as: Mary says everything to somebody. With the negative quantifier *jamais*, the ambiguity is restored;

(78) Marie ne dit jamais rien
[Marie-says-never-nothing]

(78) can mean that Mary says always something.
I just mention this fact, for which I have no explanation, and give now some interesting no-parasitism cases, i.e. cases in which the bi-negative reading is obligatory;.

Stress.
It has been previously noted that a strong stress on the first negative quantifier tends to rule out the mono-negative interpretation:

(79) **Personne** // n'aime personne
[= Everybody loves somebody]

This is true also, and maybe even more so if the second occurrence is heavily stressed:

(80) Personne n'aime // **personne**
[= Everybody loves somebody]

Question/answer.
The following question/answer succession has only one interpretation:

(81) Q . Qui n'a rien fait?
R. Personne
[= Everybody has done something]

Although, the sentence (82) has two readings.

(82) Personne n'a rien fait
[= Everybody has done something]
[= Nobody has done anything]

Moreover there is a clear contrast between (81) and (82); in (82), as it was previously mentioned for (5), the preferred reading is the mono-negative one; in (81), this reading is ruled out. Again, as for a stressed quantifier in (79-80), the interpretation that is ruled out is the mono-negative interpretation, i.e., the interpretation that requires an application of the limitation mechanism (parasitism).
It is straightforward to account for that, once admitted that the constraint is a processing constraint, i.e. a constraint on what you can do within a processing unit. Suppose that stress triggers a focus/topic partition. Both focus/topic and question/answer association suppose some sort of a two steps, or two parts processing[15]: each part has to be processed in its own right. If this is so, in each part there is one negative to process, and as a consequence, the representation of the whole construction will have one negation per negative, hence cannot be mono-negative. It must be also noticed that the negative interpretation of negative quantifiers when they are used in isolation in answer to questions supports the claim that their inherent meaning is negative.

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15 This analysis suggests interesting issues about stress and Questions/answers which are beyond the scope of this papers.

Relative clauses.
In French, some negative quantifiers can be the antecedent of a relative clause containing a negative quantifier:

(83) Jean ne connaît aucun adulte qui ne lise aucune bande dessinée
[= Every adult that John knows reads some comic strip]

Although (83) contains two negative quantifiers, it is not ambiguous, as sentence (84) underlying the relative clause would be:

(84) Aucun adulte ne lit aucune bande dessinée
[=Every adult reads at least one comic strip]
[=There is no adult reader of comic strips]

Again, the missing interpretation is the mono-negative one; one might suppose that the antecedent of the relative clause and the relative clause itself are two different processing units; each of them thus introduces a negation, and there is no regulation by parasitism as in the simple sentence case. This makes sense since the hypothesis is about a clausal complexity regulation.
Consider now relative clauses with two negative quantifiers, one of which is the antecedent of the relative pronoun, as in (85):

(85) Je ne connais aucun roman dans lequel personne n'aime personne
[I know-no novel-where-nobody-loves-nobody]

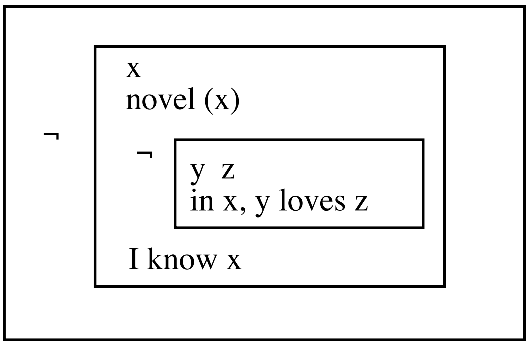
I think that the only possible interpretation of (85) is (86):

(86) Only correct paraphrase of (85):
(=In every novel I know, there is love)

To get this interpretation in the now usual way, we must assume that the relative clause as a whole is mono-negative, i.e., that parasitism *must* occur between the third quantifier and the second one. It seems to be the same situation as in the *Je ne dis pas rien à personne* case (cf. (67) above). No parasitism can occur from the second occurrence to the first one. In a case like (85), I assume that it is so because we have two different clauses. Nevertheless, the first occurrence counts for the complexity of the whole structure. Consequently, the third occurrence of the negative quantifier must parasite the second one, although any parasitism is prohibited from one clause to one another, namely from the second quantifier to the first one.[16]
The only correct representation of (85) is thus as in (87):

[16] This case would deserve a more careful inspection, since it seems to suggest that the antecedent of the relative clause is not considered as a part of the domain relevant for parasitism inside the relative clause.

(87) Correct representation of (85):



Other operators on the first negative:
If the adverb *presque* [almost] is adjoined to the first occurrence of a negative quantifier, we get the following interpretations:

(88) Personne n’a vu aucun film de Bresson
[Nobody-has seen-no film by Bresson]
Mono or bi-negative

(89) Presque personne n'a vu aucun film de Bresson
[Almost-nobody-has seen-no film by Bresson]
Bi-negative only (?)

(90) Presque personne n'a rien mangé hier soir
[Almost-nobody-has eaten-nothing-yesterday]
Bi-negative only (?)

(91) Presque personne n'est jamais venu
[Almost-nobody-never-came]
Bi negative only

(92) Personne n'a presque rien mangé
[Nobody-eaten-almost-nothing-]
Bi negative only

So we observe a strong tendency to avoid parasitism if the first negative quantifier is in the scope of a specific operator. What could be suggested tentatively in this case is that parasitism is ruled out since it would lead to interpreting the second negation in the scope of an operator which has only the first quantifier in its scope.

5. Conclusion.

It is commonly assumed that nestings are difficult to process, and it is well known that processing structures with embedded negations is complex. Considering a particular natural language, this paper has tried to substantiate the claim that multiple negation sentences in this language can be explained on the basis of two independent assumptions:
1. The complexity one can achieve in processing a certain kind of negation nesting is constrained by a threshold.
2. In the language considered, the limitation is done by parasitism, i.e. by downgrading negative quantifiers (negation+indefinite) to indefinites.

The validity of the assumption for a particular language has been tested in this paper against some data, but a deeper inspection should be done.
It is likely that the content of the hypothesis requires a closer inspection as well. Firstly it seems that the two parts have a different status. (1) is a candidate for a generalization across natural languages on the form-meaning relationship. The hypothesis would claim that no natural language can process more that two negative expressions building the kind of representation discussed in this paper. It must be recalled here that the lexical negation enclosed in verbs like *dislike* does not seem to have any relevance for the constraint under consideration. The hypothesis is thus about the processing of lexical triggers in a restricted space (the clause); the kind of negative information enclosed in lexical items like *dislike* does not seem to be relevant for this constraint. [17]
If we can find enough data supporting this hypothesis, further speculation will be useful as to whether this is a constraint specific to negation or a type of constraint relevant in other areas.
(2) is a more specific hypothesis on the way in which a particular language manages to be in accordance with this constraint, or on what this particular constraint licenses in this language.
Note that the hypothesis is flexible. The notion of threshold allows some variations, and the notion of parasitism is not assumed to be general; the constraint (1) can be satisfied by other means, for instance by grammatical co-occurrence prohibition and the use of polarity items. Moreover parasitism can be parametrised. French illustrates a case of weak selective parasitism: the representation of a clause can contain one negative nesting, and there is no parasitism from a negative quantifier to a negative trigger. Consider now an hypothetical dialect of English within which *I don't like nobody* would only mean [I don't like anybody] and *Nobody doesn't like me* would only mean [Nobody likes me]: this dialect would likely be a case of strong generalized parasitism: no nesting is licensed in a clause, and once a negation has been introduced, any other potentially negative expression looses its negative force.
According to the "compositionality problem" for multiple negation this hypothesis gives the following answers. There is a derogation to compositionality for multiple negation in languages like French, and this derogation is to some extent controlled by a global constraint on the complexity of processible structures. Note that the operation called "parasitism" is not exactly any operation: it concerns a lexical expression with a two-steps meaning (builder-filler, negation+indefinite) and parasitism might be seen as a structured operation between the meaning of a lexical expression and its context. Parasitism amounts to "skipping" a part of the meaning (the "building of a context" part), exactly in the situation where an identical context has been already created by processing a similar expression. Moreover, the licenser-trigger of this derogation to compositionality predicts the interpretation of the result; we thus have a derogation to compositionality, but the final interpretation is perfectly determined by the constraint which licenses it (we know that we will have one, at most two negations per clause).
Consider for the sake of comparison a calculator which can process only two numbers at once, but which takes as physical input a magnetic card which can contain an arbitrary sequence of numbers: usually you will present the calculator with a card containing only two numbers, but if you give it more, in a certain sense, it is harmless: the calculator will process the first two and ignore the rest. Let us discuss a little bit this comparison. The hypothesis of a limited calculator assumed in this paper is a way of explaining why the potentially negative expressions are "harmless". It has been observed in the literature that many languages do not have specific expressions with the role of polarity items as

[17] We have assumed all over this paper that it is sound to work with a concept of representation such that *don't like* has a negative representation, while *dislike* has not a negative representation.

exemplified by English. As far as negative contexts are concerned, our hypothesis would tell a plausible story about why negative quantifiers *can* do the job.in this context.[18]

This kind of hypothesis does not explain at all why natural languages tend systematically to mark indefinite argument positions in negative sentences. A recent hypothesis assumed by D. Dowty in an unpublished paper is that the marking of argument positions in downwards monotonic contexts is useful for driving on-line inferences, hence the existence of negative polarity items in many languages. The marking or argument positions can also play other roles. Consider this last example. The following French sentences are true in exactly the same situations:

(93) Personne ne mange
[Nobody-eats]

(94) Personne ne mange rien
[Nobody-eats-nothing]

In (93) the object-argument is not instantiated, while in (94) it is instantiated by a negative quantifier. This instantiation of the argument does not make a great difference for truth conditions, except for the fact that (94) is ambiguous (between a mono and a bi-negative reading). Nevertheless, in many cases, the instantiation of the argument makes a difference.

(95) Personne n'écrit rien
[Nobody-writes-nothing]

(96) Personne n'écrit rien à personne
[Nobody-writes-nothing-to nobody]

In (96) the instantiation of the indirect complement selects the interpretation *to send messages to someone*, while in (95), it is more likely that the verb just means *to write something;*

(97) Jean ne lit rien
[Jean-reads-nothing]

In a sentence like (97), the time location is not fixed unambiguously; the sentence can be taken to be true now, or to be true in general. If the negative temporal expression is used, we will get a reference marker in the scope of the negation, and the general interpretation is selected, as in (98).

(98) Jean ne lit jamais rien
[Jean-reads-never-nothing]

The instantiation of the argument by a down-graded negative is most often a way of getting something that would not be achieved without it: in all contexts it marks the unambiguous interpretation of an indefinite in the scope of a negation, and in some contexts the intended argument structure of the predicate. So what might be taken as a mechanical rule ("concord") is actually meaningful.

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[18] In French, negative triggers and most negative quantifiers come from true indefinites; they were then used as negative polarity items in association with the negative *ne*, and finally as negative expressions by themselves (hence the optional status of *ne).* The negative meaning for French negative quantifiers has been so to speak "inherited" from contextual licensing. The relationship of this meaning to the meaning of the expression may, for that reason, be more easily defeasible in context. We can see then that negative quantifiers and negative polarity items can be very close categories, and that expressions can move from one category to another.

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