Referent Systems and Relational Grammar *

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Abstract. Relational Grammar (RG) was introduced in the 70's as a theory of grammatical relations and relation change, for example, passivization, dative shift, and raising. Furthermore, the idea behind RG was that transformations as originally designed in generative grammar were unable to capture the common kernel of, e. g., passivization across languages. The research conducted within RG has uncovered a wealth of phenomena for which it could produce a satisfactory analysis. Although the theory of Government and Binding has answered some of the complaints, still it left many phenomena unaccounted for. Referent Systems (RSs) have been introduced by Kees Vermeulen in (Vermeulen, 1995) to overcome certain weaknesses of Dynamic Semantics. Their usefulness has not yet been realized in semantical theory. We shall show here that their significance cannot be overestimated. Namely, we will show in this paper that there exists a fundamental affinity to RG. Both handle the relation between an argument and a functor by means of a shared relational sign, which is unique for each argument. This assignment can be changed. What is interesting is that the notion of a chômeur, which is central to RG, finds a natural treatment in RSs. This coincidence is in our view not accidental but reveals some fundamental properties of the human language faculty.

Keywords: Relational Grammar, referent systems, dynamic semantics, grammatical roles

1. Introduction

The aim of this paper is twofold: (1) to formalize Relational Grammar by means of referent systems and (2) to show that both frameworks share basic intuitions about the handling of arguments in natural language that are not found elsewhere in syntactic and/or semantic theory. We hope that this proves the significance of these approaches in their respective areas, and that they will therefore receive greater attention than they have enjoyed up to now. Moreover, we hope to have shown that there is a fairly natural semantics to go with Relational Grammar, in case anyone had doubts about that.

Relational Grammar (RG, for short) is a theory of grammatical relations. It deals with questions of argument selection and relational change, such as passivization, dative shift, raising, to name just a few. The development of RG can be traced back to the mid seventies. It became apparent at this time that the then current theory of transformational grammar specified the structural changes brought about by operations of relational change in too concrete a

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detail, whereby missing evident generalizations. For example, it was not possible to state what was common about passives in various languages, since in order to do that one had to abstract away from accidental facts such as word order. If one took grammatical relations as primitives, however, a general rule of passive could be formulated directly. All that was required was to state that passive makes the object into the subject, thereby pushing the former subject out of its status. The surface ordering of elements can be handled independently of the relational change.

There exists a collection of papers edited by David Perlmutter and Carol Rosen, which survey the research that has been conducted within RG (see the quoted literature). Some of the criticism of transformational grammar has been overcome with the introduction of the Theory of Government and Binding (GB). Unfortunately, the range of phenomena that RG deals with is far wider than the one GB can handle, and many issues that have been brought up by RG have been sidestepped. GB in fact viewed relational changes as the combined effect of lexical rules (which fall outside of syntax proper) and some movement transformations. The weight of research was of course on the theory of transformations rather than relation change. The core of relation change was hidden in the lexicon and therefore not accounted for by the theory itself. The phenomenon of relational change is however so widespread in human languages that it is hard to accept that an all encompassing theory of grammar can simply fail to address the issue.

Dynamic Semantics has proven to be a very fruitful idea in many areas. Yet, its potentials have been mainly used to gain territory from pragmatics, for example in presupposition projection (see (Heim, 1983), (van Eijck, 1995) and (Beaver, 1995)). That this is so is a consequence of the particular view of semantics that is popular among semanticists: it assumes the supremacy of the syntactic parser (and the syntactic theory), which decides on the constituent analysis and on the identification of variables alias discourse referents. This semantics has come under attack by Albert Visser and Kees Vermeulen (see (Vermeulen, 1995) and (Vermeulen and Visser, 1996)). In their view, semanticists have been needlessly understating their case. For formal semantics is anyhow largely concerned with the identification of variables, as a quick look at Montague Semantics reveals. What is more, syntax does not do all the necessary variable handling itself. (GB for example dealt only with intrasentential anaphors.) So why should semantics not take the matter into its own hands? The outcome was a system that was — according to our views — remarkably visionary. The most basic system was that of referent systems. It replaced hidden assumptions on the choice of referents by explicit procedures for their identification. In doing so, it provided for the first time a home for syntactic categories that formal semantics has hitherto shunned: cases, gender, and agreement in general. This semantics started to look more like natural language than any other formal language before it.

The fact that referent systems were modelled after linguistic intuitions did not mean that it would naturally fit its purpose; I have undertaken elsewhere the task of outlining a semantics for natural language using referent systems (see (Kracht, 1999)). It turned out that referent systems operate on similar conventions as purely syntactic theories, for example the θ–criterion. [1] More than this, however, referent systems show a deep affinity to RG. The present paper developed from the intuition that the connections between RG and referent systems are more than superficial. RG can be understood better if analyzed as a particular variant of referent systems. Various laws of RG fall out immediately. Others still have to be stipulated but it is hoped that they too will receive a natural explanation in terms of referent systems. It should be said, though, that we do not deal with ascensions. This limits our case somewhat, but we are confident that ascensions can also be dealt with.

This paper is organized as follows. We start with a brief introduction to RG in Section 2. Then we will explain the basic concepts behind referent systems (Section 3). After that we shall show in Section 4 how relational change is explained in terms of referent systems. Section 5 introduces stacked referent systems to account for the mechanics of θ–roles. Section 6 provides a detailed example; it reproduces an analysis of Kinyarwanda given by (Dryer, 1983). Finally, in Section 7 we will discuss the technicalities of the notion of a chômeur.

2. A Short Description of Relational Grammar

Relational Grammar assumes that a sentence is organized using grammatical relations. A predicate can take certain arguments, and these arguments can be distinguished by the relations they bear with that predicate. There are many relations. The central relations from the standpoint of syntax and morphology are 1, 2 and 3. (See the introduction to Relational Grammar (Perlmutter and Postal, 1983).) They correspond roughly to the more traditional terms of subject, direct object and indirect object. There are also more familiar relations such as beneficiary, location, instrument. RG assumes that a sentence is organized as a tree, where the grammatical relations are annotated. An example is shown in Figure 1 to the left. [2] This tree is not a dependency tree or stemma in the sense of (Tesnière, 1982). The predicate appears as a

[1] Jan van Eijck has pointed out to me that the conventions used to administrate pointer structures are also very similar.

[2] Actually, RG assumes that the structures (relational networks) are based on rooted directed acyclic graphs (see below for a definition). This is so because the structures contain a record of the entire derivation, which according to RG is necessitated by the fact that syntactic rules are sensitive to the initial stratum and some even to the intermediate strata. It is not clear to us that this is a necessary consequence, and we shall discuss this problem below. If however a relational network is reduced to a single stratum, one always gets a tree. Therefore, it is safe

Figure 1. Relation change: Passive

sister of its arguments. This is why a separate relation, that of a predicate, is needed in RG. It is denoted by P. The structures are formalized as follows.

DEFINITION 1. *Let G be a non–empty set and $\prec$ a binary relation on G. The pair $\langle G, \prec \rangle$ is called a* ***rooted, directed acyclic graph*** *with root r if the following holds.*

1. *For no x: $r \prec x$.*

2. *For every $x \in G$ there is a sequence $x \prec x_1 \prec x_2 \prec \ldots \prec x_n = r$. (If $x = r$ then $n = 0$.)*

3. *There is no sequence $x_0 \prec x_1 \prec \ldots \prec x_{n-1} \prec x_0$, $n > 0$.*

$\langle G, \prec \rangle$ is a ***tree*** *if in addition for each x there exists at most one y such that $x \prec y$. x is a* ***leaf*** *if there is no y such that $y \prec x$.*

If $x \prec y$ we say x is a *daughter* of y and that y is the *mother* of x.

DEFINITION 2. *Let T be a set. A* ***relational graph over*** *T is a quadruple $\langle G, \prec, \rho, L \rangle$, where*

1. *$\langle G, \prec \rangle$ is a tree,*

2. *ρ a partial function from $\prec$ to T,* [3] *and*

3. *L is a function from the leaves of $\langle G, \prec \rangle$ to the lexicon.*

T is the set of relational signs. [4] It is clear that there are certain appropriateness conditions on these relational graphs, which have to do with the valency

to assume that a relational network corresponds to a sequence of strata. This is how we shall present the theory below.

[3] In RG, ρ is typically total. This will be discussed below.

[4] RG distinguishes between relations and relational signs. A relational sign is merely a symbol that denotes an actual relation. However, the way these terms are usually employed, the difference is scant. We shall ignore this in the sequel, as the context will make clear what we are talking about.

of the predicates. We must assume that the lexicon specifies how many and what kinds of sisters a predicate can have. We shall not bother to precisify this further. The left hand side of Figure 1 is the structure of the following sentence.

(2.1) Mary lifts the piano.

Here, lifts is the predicate, Mary bears the 1–relation and the piano the 2–relation with this predicate. As sentences can also assume relations with predicates, this schema is recursive.

RG shares with Transformational Grammar the assumption that grammatical relations are changed in the process of a derivation. The difference between the two is the way in which this is spelt out in detail. RG is a less encompassing theory since it deals only with grammatical relations, though on the other hand it assumes that syntax is sufficiently modular to allow for such an approach. [5] RG is driven by the conviction that relational change is all that happens in a derivation, while for example word order is solved at surface structure only. We shall not discuss this issue in the sequel, however important it is for syntactic theory. A typical instance of an operation that changes relations is the passive. The passive morphology on the predicate has as its effect that the constituent previously bearing the 2–relation with that predicate now bears the 1–relation. The effect of passive on the structure on the left in Figure 1 is shown on the right. Notice that word order is not specified in the structure. The corresponding sentence is (2.2).

(2.2) The piano is lifted by Mary.

We say that 2 is *advanced* to 1. One would therefore expect that there now be two constituents bearing the 1–relation with the predicate. This, however, is strictly forbidden. The law that excludes this is called the

> Stratal Uniqueness Law. For a given predicate there can be at most one constituent bearing a particular relation to that predicate.

In our terms, this means that if x and x' are different daughters of y then $\rho(\langle x, y\rangle) \neq \rho(\langle x', y\rangle)$. This is taken to mean that if the function is defined on both arguments, then the respective values are different. [6]

What happens therefore with the previous subject? In RG it is said that it loses its grammatical relation, it becomes a *chômeur*. So, in (2.2), is lift is the predicate, the piano bears the 1–relation with the predicate, and by Mary has no relation, which means that ρ must be undefined. In this case

[5] Incidentally, GB has absorbed some of the criticism levelled from supporters of RG against TG, though it has added other features that make it once again incompatible with RG. GB still holds, for example, that core grammatical relations are definable from the structure and need not be explicitly given.

[6] Notice that the Stratal Uniqueness Law does not prohibit a sentence having two predicates. This does not seem to be an option, so we have strengthened the principle slightly.

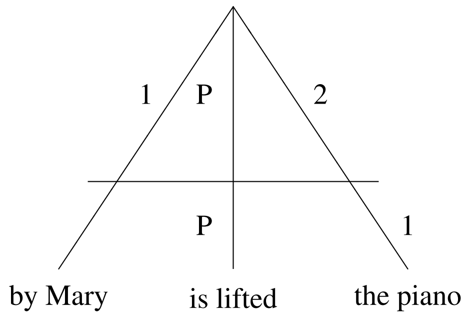

Figure 2. The Relational Network

we say that by Mary is a chômeur. To be a chômeur means being without a relation, and this in turn means that one is not eligible for any syntactic operation based on relations. Chômeurs are frozen, so to speak. In distinction to the received notation we shall write $\star$ to signal that a constituent is en chômage. We also hold that this is not a relational sign. In this we differ from RG. In RG, a 1 that becomes a chômeur gets a new relational sign, denoted by $\widehat{1}$. Similarly, a 2 that becomes a chômeur gets a different relational sign, denoted by $\widehat{2}$. However, RG loses all its charme if we would assume this and would contradict its basic philosophy. The basic philosophy is that the reason why a demoted subject cannot enter into a grammatical relation any more is that it has lost its grammatical relation. But in standard RG it does not lose its relation, it is merely shifted into a new one. We shall therefore depart from the actual proposal in the literature and say that 'chômeur' is not a grammatical relation; rather, it denotes the absence of a grammatical relation.

This is in a nutshell the basic proposal of RG. There are of course many more operations on relations, and many more laws, and we shall encounter some of them as we go along. However, what we have just seen is enough to explain the basic tenets of RG. First, RG distinguishes two levels in (2.2): the first level, before passive morphology has applied, which is identical to the level associated with (2.1), and another level, after passive morphology has applied. These levels are called *strata*. The first is called the *initial stratum* the second the *final stratum*. There can be more than two strata; the non–initial and non–final strata are called *intermediate*. The syntactic representation for (2.2) contains both strata, not just one. In RG, this is displayed as in Figure 2. This is important. For there are syntactic processes which are sensitive to the relations as they are in the initial stratum and other syntactic processes which are sensitive to the relations as they are in the final stratum. For example, reflexives must be bound by an antecedent which bears a higher relation; however, languages differ whether this comparison is made at the final stratum or at some earlier stratum. However, the ranking of relations is universal. The relations are ordered as follows:

$$3 < 2 < 1$$

In Russian, for example, a reflexive must be bound by some nominal whose relation is higher in the initial stratum. This is why in passives a reflexive can occupy the subject position. If one moves higher in the hierarchy one is said to be *advanced*, and if one moves lower one is said to be *demoted* or to *retreat*. It is possible also to be raised out of an embedded sentence (this is called *ascension*) but we will not be concerned with this possibility. English passive is in this nomenclature nothing but 2–to–1 advancement.

Before we can move on, we should perhaps say something about the notation. We are excluding from our discussion ascensions, so we shall deal only with the case that the structure of the underlying tree does not change. In this case, a rule can be specified as follows.

DEFINITION 3. *A* ***relational change rule*** *(RCR) is an injective partial function from T to T.*

DEFINITION 4. *Let f be an RCR and $S = \langle G, \prec, \rho, L\rangle$ and $S' = \langle G', \prec', \rho', L'\rangle$ be structures. We say that S'* ***is derived from S in one step using f*** *if $G = G'$, $\prec = \prec'$ and $L = L'$, and there is a $y \in G$ such that the following holds.*

1. *For all $y' \neq y$ and all $x \prec y'$: $\rho(\langle x, y'\rangle) = \rho'(\langle x, y'\rangle)$. (If one side is defined, so is the other, and they are equal.)*
2. *For all $x \prec y$ such that f is defined on $\rho(\langle x, y\rangle)$: $\rho'(\langle x, y\rangle) = f(\rho(\langle x, y\rangle))$.*
3. *If $\rho(\langle x, y\rangle) = f(\rho(\langle x', y\rangle))$ for some $x, x' \prec y$, $x \neq x'$, then ρ' is not defined on $\langle x, y\rangle$.*
4. *If the previous clause does not apply to $x \prec y$, and f is not defined on $\rho(\langle x, y\rangle)$ we have $\rho'(\langle x, y\rangle) = \rho(\langle x, y\rangle)$.*

Notice that the third clause is put in to secure compliance with the STRATAL UNIQUENESS LAW. Notice also that an RCR is not allowed to put something en chômage directly, a fact to which shall return later.

Let Σ be a set of RCRs. A Σ*–derivation* is a finite sequence $\langle S_i : i < n\rangle$ of structures where S_{i+1} results from S_i by applying a particular rule. For example, Figure 3 shows a two–step derivation of a passive sentence. Passive is the partial function $\{\langle 2, 1\rangle\}$, which is the (partial) function which maps 2

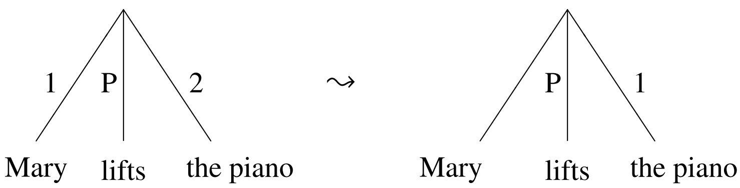

Figure 3. Relation change: Passive

to 1. [7] What is interesting is that we do not get anything like the structure of Figure 1, since no morphological change is indicated. To be able to produce the correct change, we should also specify in what ways the function L is changed to L'. In GB this problem is solved by assuming that the predicate is inserted at D–Structure with passive morphology, and so it has the case- and θ–grid of a passive verb already. Subsequent movements are triggered by the need to derive a correct S–Structure and LF. It seems that RG implicitly adopts this view, though I have not been able to verify this. In what is to follow, we shall sketch a different approach to the matter which will dispense totally with the notion of a derivation, and therefore eliminate this problem altogether.

We denote the passive RCR simply by $2 \mapsto 1$. This notation is used to refer to a particular rule. However, on many occasions we simply want to state that a relation change has occurred as the effect of applying a rule. Then we shall write $[\alpha \mapsto \beta]_i$. This means that there is a pair $\langle x, y\rangle$ such that $\rho_i(\langle x, y\rangle) = \alpha$ and $\rho_{i+1}(\langle x, y\rangle) = \beta$. It may or may not be the case that $\alpha = \beta$.

The role changing operations defined in the literature have one thing in common, namely that only one constituent changes its role. This is no accident. Otherwise, we could define another variant of passive, where subject and object simply are exchanged: $\{1 \mapsto 2, 2 \mapsto 1\}$. Call this RCR *exchange*. Exchange is a simultaneous combination of 2–to–1 advancement (passive) and 1–to–2 demotion. [8] Of course, we could obtain the effect of exchange by introducing a new role X and analyse exchange as the effect of three changes: $1 \mapsto X$, $2 \mapsto 1$ and then $X \mapsto 2$. This however is a questionable move as long as the existence and identity of X cannot be established independently. For if not there is no substantial insight gained from doing it this way, as any partial function is decomposable in this way using RCRs changing one element at a time.

[7] A partial function from a set A to a set B is a subset F of $A \times B$ such that if $\langle x, y\rangle \in F$ and $\langle x, y'\rangle \in F$ then $y = y'$. By this definition, any subset of a set of the form $M \times N$ can be regarded as a partial function from A to B as long as it is a subset of $A \times B$. This will be used implicitly in this paper.

[8] A demotion is sometimes also called a *retreat*.

However, notice that the execution of passive and 1–to–2 demotion in sequence has a different effect: it puts the subject en chômage and returns the object into object relation. Exchange on the other hand does not create any chômeur. However, to our knowledge such an operation is very rare. [9] As far as we know there is only one operation where more than one role is involved, namely causative formation. Since this is an instance of predicate formation, we shall dismiss that case from the present discussion, hoping to resolve it within a theory of ascensions. Therefore we shall propose the following law:

SINGLE CHANGE LAW. Relations may be changed only one at a time.

Using the SINGLE CHANGE LAW we can see that there can be only two operations involving 1 and 2: either advancement to 1, leaving the previous subject en chômage, or demotion of subject to 2, pushing the previous object en chômage. The latter kind of operation has been shown to exist. For example, Postal claims that Antipassive, which on the surface looks like an object putting itself en chômage, is actually a two step sequence of the following kind:

$$\begin{bmatrix} 1 \\ 2 \end{bmatrix} \mapsto \begin{bmatrix} 2 \\ \star \end{bmatrix} \mapsto \begin{bmatrix} 1 \\ \star \end{bmatrix}$$

In an analysis of Georgian, Alice Harris (in (1984)) proposes the following successive changes:

$$\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \mapsto \begin{bmatrix} 3 \\ 2 \\ \star \end{bmatrix} \mapsto \begin{bmatrix} 3 \\ 1 \\ \star \end{bmatrix}$$

This sequence of relational changes, called *Inversion*, is like a rochade in chess. The subject retreats to 3 putting the indirect object en chômage. After that the direct object advances to 1.

There is natural tendency (not a law) to favour advancements over demotions. However, RG proposes a law that forbids at least some instances of demotions. A relation is a *term relation* if it is either 1, 2 or 3, otherwise it is a *non–term relation* or an *oblique relation*. 1 and 2 are called *nuclear*.

THE OBLIQUE LAW. If β is oblique then $[\alpha \mapsto \beta]_i$ implies $\alpha = \beta$.

Here are some more laws which have been proposed in the RG literature:

FINAL 1 LAW. At the final stratum, each predicate has a 1.

1 ADVANCEMENT EXCLUSIVENESS LAW. In the course of a derivation, only once per predicate can there be an advancement to 1.

[9] A possible candidate is the inverse marker of inverse marking languages. However, before we can claim that this constitutes counterevidence, the case must be carefully examined. Inversion in Choctaw as formulated in (Davies, 1986) and (Davies, 1984) seems to be another candidate. However, the relevant change can be analyzed as two changes in succession, namely as 2–to–3 Retreat followed by antipassive.

The apparatus of RG contains also the notion of a dummy (*it* in English, *il* in French and *er* in Dutch, for example), which can fill a grammatical relation. [10] They are needed sometimes to satisfy the FINAL 1 LAW. However, the following must hold.

NUCLEAR DUMMY LAW. A dummy can only bear a nuclear relation.

Finally we have the

MOTIVATED CHÔMAGE LAW. $[\alpha \mapsto \star]_i$ only if there is a relational change $[\beta \mapsto \alpha]_i$.

So, no constituent can put itself en chômage; it must be pushed into chômage by another constituent moving into the relation that the constituent has. The reader may check that by our definitions of RCRs and derivations, the MOTIVATED CHÔMAGE LAW is automatically complied with.

Now that we know how relations are changed, we also need to know how they are assigned. Here, RG assumes that at the initial stratum they are assigned using the θ–grid of the verb. Basically, verbs with identical θ–grid shall end up having identical relations assigned, or more concretely, if a θ–role is assigned role α with respect to one predicate it shall get role α also with respect to any other predicate. This principle is called the UNIVERSAL ALIGNMENT HYPOTHESIS (UAH). It is stated as follows (originally proposed in (Perlmutter and Postal, 1984); see also the discussion in (Rosen, 1984)):

UNIVERSAL ALIGNMENT HYPOTHESIS. There exist principles of universal grammar which predict the initial relation borne by each nominal in a given clause from the meaning of the clause.

The details are not so well–worked out in the literature, but we shall pick out a particular case. [11] If a verb has an actor, then the actor will always end up bearing the role 1. So an actor is always a deep subject. A theme will end up 2 if an actor is present. The verb to lift has an actor and a theme. Hence, the actor is assigned the role 1 and the theme the role 2. In English, 1 is subject and 2 is object. Hence, the final stratum of (2.1) is identical to the initial stratum. The final stratum of (2.2) cannot be the initial stratum since that would violate the UAH. Indeed, the sentence is in the passive voice, and the direct object has been advanced to subject, pushing the former subject en chômage.

[10] A referee suggested that Dutch *er* is a difficult case. However, this is not of immediate concern here. That *er* is a dummy has been claimed in (Perlmutter and Postal, 1983).

[11] Van Valin and LaPolla have defended the UAH in (1997). They propose a particular algorithm for mapping the lexical representation to the θ–grid and further to the relational grid.

3. Referent Systems

We assume that the reader is familiar with the basic concepts of DRT. Otherwise, (Kamp and Reyle, 1993) provides an introduction and a reference book for things to come. All that is required is an understanding of what a DRS is, how it is interpreted, and how it is built from a sentence. We will need only the basic machinery, no logical connectors for DRSs and the like. However, knowledge of predicate logic is — as always — indispensable. Consider having to build a representation for a sentence using discourse representation structures. Then there are basically two options. The first is to assume that the parser delivers a structural analysis together with indices, which get assigned to the variables that are plugged into the individual DRSs. Recall namely that a DRS is a pair $[V : \Delta]$, where V is a set of variables and Δ a set of open formulae. The DRSs of dog, cat, bite and the indefinite determiner a(n) are, for example, $[\varnothing : \mathsf{dog}'(x)]$, $[\varnothing : \mathsf{cat}'(x)]$, $[\varnothing : \mathsf{bite}'(x, y)]$ and $[\{x\} : \varnothing]$. If we want to translate the sentence (3.1) into a DRS it would obviously be a mistake to simply fuse together these three DRSs. Rather, we need to use as input the parse (3.2), and interpret the indices as referring to variables in some fixed way.

(3.1) A dog bites a cat.

(3.2) $[\mathsf{A}_1\ \mathsf{dog}_1]\ [\mathsf{bites}_{1,2}\ [\mathsf{a}_2\ \mathsf{cat}_2]]$

The translation from (3.2) goes as follows. First, assign to each word a DRS, by choosing an alphabetic variant of the abovementioned DRS. For example, replace the variables x and y by the variables x_i, where i is the corresponding index in (3.2). [12] After that, the DRSs are merged together. The merge operation, called *Zeevat–merge*, is

$$[V_1 : \Delta_1] \quad \bullet \quad [V_2 : \Delta_2] \quad = \quad [V_1 \cup V_2 : \Delta_1 \cup \Delta_2]$$

In the Zeevat–merge, the name of the variable is globally assigned. If x occurs in V_1 and in V_2, then both DRSs are taken to point at the same object by x. For example, if a denotes $[\{x\} : \varnothing]$, then a_2 denotes $[\{x_2\} : \varnothing]$, and likewise cat_2 denotes $[\varnothing : \mathsf{cat}'(x_2)]$. The constituent $\mathsf{a}_2\ \mathsf{cat}_2$ is then translated by

$$[\{x_2\} : \varnothing] \quad \bullet \quad [\varnothing : \mathsf{cat}'(x_2)] \quad = \quad [\{x_2\} : \mathsf{cat}'(x_2)]$$

The reason that this works as intended is that the parser is responsible for doing the indexing. If the sequence a cat is parsed as $\mathsf{a}_2\ \mathsf{cat}_3$, for example, then the resulting translation would be

$$[\{x_2\} : \mathsf{cat}'(x_3)]$$

[12] Here is a problem, raised by Albert Visser, concerning the identity of x and y. Should x be replaced by x_1 or by x_2 and correspondingly y by x_2 or by x_1? There is nothing in the representation that tells us which variable to choose. This question of detail is to our knowledge not really addressed in the relevant literature.

The failure is therefore not attributed to the merge algorithm but rather to the parser.

Another procedure, which does not rely on the parser for identification of the variables, has been described by Kees Vermeulen in (1995). Assume that variables are sequence of 1s and 2s. Then, if x is a variable, then so is $\langle x, 1\rangle$ and $\langle x, 2\rangle$. We denote the former by x^1 and the latter by x^2. Here, the basic operation is as follows:

$$[V_1 : \Delta_1] \quad \circ \quad [V_2 : \Delta_2] \quad = \quad [\iota_1[V_1] \cup \iota_2[V_2] : \iota_1[\Delta_1] \cup \iota_2[\Delta_2]]$$

Here, $\iota_1 : V_1 \to V_1 \times \{1\} : x \mapsto x^1$ and $\iota_2 : V_2 \to V_2 \times \{2\} : x \mapsto x^2$ are injective mappings. Further, $\iota_1[\Delta_1]$ is the result of replacing each variable x in Δ_1 by x^1, and $\iota_2[\Delta_2]$ the result of replacing each x in Δ_2 by x^2. In this way, the two sets of variables are made disjoint. We assume that by default the two DRSs are not talking about the same object, or to put it in another way, we assume that the name of a variable is only locally assigned.

We therefore introduce an additional component in the semantic representation, which contains names for variables. This component, called a *referent system*, has only one purpose: to enable the DRSs to communicate to each other whether or not a particular variable that one of them uses is to be taken to point at the same object as the same as another variable used by the other DRS. The semantic structures are therefore pairs $\langle\rho, \Delta\rangle$, where ρ is a referent system and Δ a DRS. The referent system ρ is doing the management of variables during the merge. Notice that ρ and Δ need not contain the same variables. The variables are called *referents*, since they are different from the ordinary variables of logic. The latter are linguistic objects (of the formal language); so they are merely pieces of ink. What the variable stands for, however, is something that is best described as a memory slot. The referents shall be exactly these slots rather than the pieces of ink that denote them.

We shall first concentrate on the referent systems and then put them together with the DRSs. Let us begin with the example shown in Figure 4. Suppose the semantic structure for bites declares by some means that x is the subject referent and y the object referent. Suppose further that the semantic structure for a cat can likewise declare that its referent — let it be z — is an object referent. Then there is no problem in understanding between the two that x and z are pointing to the same object. Hence, after merging these structures x and z will be substituted by the same referent. The naming convention will be that the referents of the first structure will get the superscript ^{1} and the referents of the second structure will get the superscript ^{2}. So, after merge x will be replaced by x^1, y by y^1 and z by — x^1! Suppose we merge further with the subject. The referent system of the constituent a dog declares its referent x to be that of a subject, so that when merged with the structure of bites a cat the referent x of a dog and the referent x^1 (!) of bites are mapped onto

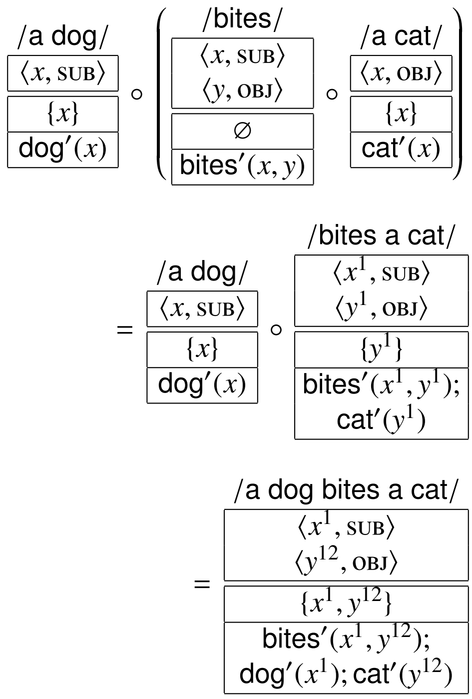

Figure 4. Merge of referent systems

the same referent. [13] The basic idea of referent systems is therefore to tag a certain 'name' to a referent by which it will be crossidentified under merge. We have indicated that x has name α by writing $\langle x, \alpha \rangle$. The names correspond to some traditional grammatical categories, for example subject and object, and hence in many languages the name is morphologically realized.

This is the basic mechanism of referent systems. We shall now explain in a little more detail the mechanics of the referents. Referents are variables with the name stripped off. Referents have no properties, they are only equal or distinct. As with DRSs above, two referent systems, say ρ_1 and ρ_2, when being merged, will make by default all their referents distinct, by mapping a referent x of the first system to x^1 and a referent y of the second system to y^2. Only when ρ_1 and ρ_2 agree that x and y are talking about the same object, there will be only one copy of them left after merge. In that case, both x and y are mapped to x^1. Notice that it makes no difference whether one calls some referent x both in ρ_1 and in ρ_2: referents have no names by themselves, and if they reside in distinct referent systems, they are replaced by different

[13] The reader may check that if we first merge a dog with bites and then the result with a cat, then we get an alphabetic variant of the result in Figure 4. In terms of satisfiability in a model, they are equivalent.

variables by default. What can make them the same after merge is having the same name, not being called by the same letter x.

Now how can two referent systems agree that two of their referents shall be shared? Above we have made use of simple name tags, corresponding to the roles in RG. These tags are called *names* in referent systems. Referent systems both give a referent a name, say SUB, which may stand for 'is a subject referent', and if two referents have the same name they shall be shared. However, this system is too simple. First, we must assume that directionality is also important. In English, a subject is identified by being to the left of the verb. Case plays only a marginal role in English. To take a different example, appositions can in certain languages assign different cases depending on whether they precede their complement or whether they follow it. This is typically accompanied by a difference in meaning. [14] Therefore, directionality plays a role in assigning meaning. A second, very crucial fact is that the name given to a referent can change, and it can even be lost. We shall therefore have to include statements about the change in name for a particular referent. Particular attention is drawn to the possibility of a referent not having a name at all. We call this an *anonymous referent*. In the present discussion the existence of anonymous referents is of extreme importance. As we shall see, they correspond to the chômeurs of RG. They cannot partake in the game of identification and name change, since they have lost their name entirely.

In the original work on referent systems it was assumed that referent systems distinguish two kinds of names: one for identifying a referent to the left and another (not necessarily a different one) for identification to the right. However, the way in which the order and the actual name handling were originally coupled is unsuited for linguistic purposes. It was therefore proposed in (Kracht, 1999) to disentangle two things: the fact that a referent is expected to the left or to the right and the fact that its name is changed or lost after merge. To keep matters simple and to be able to concentrate on the fundamental issues, we shall not be concerned with order at all. Hence, meaning composition is commutative throughout this paper.

DEFINITION 5. *Let N be a set, called the set of* ***names*** *and $\star \notin N$. A* ***name change statement*** *is a pair $\langle A, B\rangle \in (N \cup \{\star\})^2$, usually written $A \mapsto B$. An* ***argument handling statement (AHS) over*** *N for x is a pair $\nu = \langle x, A \mapsto B\rangle$, where $A \mapsto B$ is a name change statement. x is its* ***referent****, A the* ***input name*** *(if $A \in N$) and B the* ***output name*** *(if $B \in N$). If $A = \star$, ν is said to have* ***no input name****, and if $B = \star$ then ν is said to have* ***no output name****.*

[14] Finnish is such a language. Of course, to demonstrate that such facts necessitate the introduction of order sensitivity at the level of referent systems is a different matter. We appeal here to common sense rather than hard proven facts.

DEFINITION 6. *A* ***referent system over*** *N is a finite set of argument handling statements over N subject to the following constraints:*

1. *No two AHSs share the same referent.*
2. *No two AHSs share the same output name.*
3. *No two AHSs share the same input name.*

A referent x is ***anonymous*** *in N if either N contains no AHS involving x or it contains the AHS* $\langle x, \star \mapsto \star \rangle$.

A crucial definition is also the following.

DEFINITION 7. *A referent system is* ***basic*** *if it contains at most one AHS with an output name.*

We shall assume here without justification the following law.

BASICNESS. All referent systems must be basic.

This encodes the typing regime of categorial grammar, where a functor can have many arguments but only one result. Since we do not have categories without accompanying variables, the restriction on basic referent systems boils down to assuming that the result category is always unique. For the category of an item is reflected in the type of the referent that bears the (unique) output name. For example, we shall say that a particular NP is subject because it has the output name 1. We shall assume that all lexical entries shall have basic referent systems. By the definition of merge below this will be inherited by all referent systems, so it becomes in fact a global condition. As the reader will notice later, this takes care of the SINGLE CHANGE LAW.

We shall now describe how referent systems behave under merge. After that we shall dock the DRSs to the referent systems. Basically, we need to know when two referent systems agree to share a referent. We will begin by defining a partial operation $\circ$ on AHSs. To that end, let $\langle x, A \mapsto B \rangle$ be an AHS. The meaning of the input name, A, is the following: if the referent x assumes the role of an argument in the merge, then it is looked for under the name A. In that case the other AHS must be of the form $\langle y, C \mapsto A \rangle$. The two name handlers, $A \mapsto B$ and $C \mapsto A$, shake hands, so to speak and reduce to $C \mapsto B$. (Recall that $A \neq \star$.)

$$\begin{array}{llcllcl} (1) & \langle y, C \mapsto A \rangle & \circ & \langle x, A \mapsto B \rangle & = & \langle y^1, C \mapsto B \rangle \\ (2) & \langle x, A \mapsto B \rangle & \circ & \langle y, C \mapsto A \rangle & = & \langle x^1, C \mapsto B \rangle \end{array}$$

Here the condition is that $B \neq C$ (otherwise this is ambiguous, see Section 7). The referents are indexed by 1 if coming from the first referent system or by 2 if coming from the second. If x from the first is identified with y from the second, then only the referent x^1 survives. We call the argument handling statement containing x in (1) and (2) the *functor* and the other the *argument* in the merge. [15] Intuitively, the functor consumes the name shared, while the argument provides it.

This describes how two argument statements combine. Referent systems however contain a set of them. A general definition for the merge of referent systems would therefore roughly be as follows: lump all argument statements together, and identify those that can be identified. However, this can lead to certain anomalous situations. The first is that the output simply fails to be a referent system.

$$\boxed{\begin{array}{l}\langle x, A \mapsto B\rangle \\ \langle y, C \mapsto D\rangle\end{array}} \circ \boxed{\begin{array}{l}\langle v, C \mapsto A\rangle \\ \langle w, D \mapsto B\rangle\end{array}} = \boxed{\begin{array}{l}\langle x^1, C \mapsto B\rangle \\ \langle y^1, C \mapsto B\rangle\end{array}}$$

Here, the two referent systems are merged, giving rise to a set of two AHSs sharing both an input and an output name. These anomalies can even occur if the referent systems are basic, for example when we choose $B = \star$.

Another thing that can happen is that the AHSs are caught in a chain reaction:

$$\boxed{\begin{array}{l}\langle x, A \mapsto B\rangle \\ \langle y, C \mapsto D\rangle\end{array}} \circ \boxed{\langle v, B \mapsto C\rangle} = \boxed{\langle x^1, A \mapsto D\rangle}$$

The original referent systems avoid these problems by means of the left–to–right ordering. Because there is no equivalent of this here, we shall have to impose restrictions. The first of these is made to ensure that we can identify a functor and an argument. If output names clash then one of the AHSs is an argument while the other is neither argument nor functor. In this case it is the AHS of the non–argument that loses its output name. Dually, if input names clash, it is the AHS of the non–functor that loses its input name.

DEFINITION 8. *Let ρ_1 and ρ_2 be referent systems. Then $\rho_1 \circ \rho_2$ is defined iff there is exactly one pair $\langle \nu_1, \nu_2\rangle \in \rho_1 \times \rho_2$ such that $\nu_1 \circ \nu_2$ is defined. $\langle \rho_1, \rho_2\rangle$ is called the* ***matching pair****. ρ_1 is called the* ***argument*** *of the merge if ν_1 is, otherwise we call ρ_1 the* ***functor****. Analogously with ρ_2.*

It is with the definition of the matching pair that we can define the merge in an unambiguous way. Suppose that ρ_1 is the functor. Then if both $\nu_1 \in \rho_1$ and $\nu_2 \in \rho_2$ have output name A, then ν_1 is left unchanged; the referent of ν_2 however loses its output name. That is, if $\nu_2 = \langle y, C \mapsto A\rangle$ then it is

[15] Note that merge is commutative only up to alphabetic variants.

transformed into $\langle y, C \mapsto \star \rangle$. If on the other hand v_1 and v_2 have the same input name, say B, the v_2 is left unchanged, and v_1 loses its input name. This defines $\rho_1 \circ \rho_2$. It is routine to check

PROPOSITION 9. *Let ρ_1 and ρ_2 be two basic referent systems. If $\rho_1 \circ \rho_2$ is defined, it is a basic referent system.*

Finally, we dock DRSs onto referents systems.

DEFINITION 10. *Let N be a set of names. A pair $\langle \rho, \Delta \rangle$ is called an N–* ***system*** *if ρ is a referent system over N and Δ a DRS.*

The merge of N–systems is defined as follows. The merge of ρ_1 and ρ_2 induces a mapping β_1 from the referents of ρ_1 into the set of referents of $\rho_1 \circ \rho_2$ and a mapping β_2 from the referents of ρ_2 into the set of referents of $\rho_1 \circ \rho_2$. Then we put $\iota_1(x) := x^1$ if x is a referent occurring in Δ_1 but not in ρ_1, and $\iota_1(x) := \beta_1(x)$ otherwise. Likewise, $\iota_2(x) := x^2$ if x occurs in Δ_2 but not in Δ_1, and $\iota_2(x) := \beta_2(x)$ otherwise. [16] Finally,

$$\langle \rho_1, \Delta_1 \rangle \circ \langle \rho_2, \Delta_2 \rangle := \quad \langle \rho_1 \circ \rho_2, \iota_1[\Delta_1] \cup \iota_2[\Delta_2] \rangle$$

This means simply that the referent systems dictate the naming of the referents which the DRSs use. If a renaming takes place under merge of the referent systems, that renaming is used as well for the corresponding DRSs.

4. The Stratal Uniqueness Law

We shall now show how RG can be incorporated into referent systems. In particular, the Stratal Uniqueness Law will be a special consequence of the conditions on referent systems, namely that no two argument handling statements may share an input name. We shall put $N := \{1, 2, 3\}$. The English verb bite has the following representation

/bite/
$\langle x, 1 \mapsto \star \rangle$ $\langle y, 2 \mapsto \star \rangle$
$\varnothing$
bite$'(x, y)$

This means that it takes a subject and an object. By the rules of English grammar, the subject must be to its left and the object to its right, and this is how they are identifiable. Therefore, in the sentence (4.1) a dog is inevitably

[16] Notice that we have not required that all referents of the DRSs occur in the referent systems. Of course, we must take care of them as well.

the subject, a cat the object. In (4.2) it is the reverse.

(4.1) A dog bites a cat.

(4.1) A cat bites a dog.

As we have ignored directionality, however, we cannot ensure the correct handling of the English example with this mechanism. We will instead turn to a language where order is less important, namely Latin. In Latin the verb is basically free to assume any position, and the same holds for the subject and object. We shall assume for simplicity that the function of marking something nominative is to give it the relation name 1, and to mark something accusative is to give it the relation name 2. (The details of this process are of no concern here. See (Kracht, 1999) for how this can be done.) Hence the Latin verb mordere (to bite) has the following form.

$$\begin{array}{c}
/\mathsf{mordere}/ \\
\hline
\multicolumn{1}{|c|}{\langle x, 1 \mapsto \star \rangle} \\
\multicolumn{1}{|c|}{\langle y, 2 \mapsto \star \rangle} \\
\hline
\multicolumn{1}{|c|}{\varnothing} \\
\hline
\multicolumn{1}{|c|}{\mathsf{bite}'(x, y)} \\
\hline
\end{array}$$

The lexical entry for Latin mordere is therefore not really different from that of bite (except for the phonological representation, of course). Both are transitive verbs.

Now, the referent system allows for the verb to state which of its referents is the subject and which the object. This allows an easy implementation of the idea of relation change through morphological elements. [17] Take for example passive. We assume that the morpheme PASS in Latin as in other languages has the following referent system.

$$\begin{array}{c}
/\textsc{pass}/ \\
\hline
\multicolumn{1}{|c|}{\langle x, 1 \mapsto 2 \rangle} \\
\hline
\multicolumn{1}{|c|}{\varnothing} \\
\hline
\multicolumn{1}{|c|}{\varnothing} \\
\hline
\end{array}$$

Notice that we assume passive to be semantically vacuous. Therefore, in the DRS section we have put the empty DRS, $[\varnothing : \varnothing]$. This implies that passive makes no direct semantic contribution. It simply changes the relations. What

[17] In fact, we need not assume that relation change comes about through adding a morpheme. It can be a clitic, an adposition or something else. However, we shall not go into the complications arising from that here.

happens if passive is applied to mordere? We get

$$\begin{array}{c}/\text{mordere}/\\ \hline \multicolumn{1}{|c|}{\langle x, 1 \mapsto \star\rangle} \\ \multicolumn{1}{|c|}{\langle y, 2 \mapsto \star\rangle} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \multicolumn{1}{|c|}{\text{bite}'(x,y)} \\ \hline \end{array} \circ \begin{array}{c}/\textsc{pass}/\\ \hline \multicolumn{1}{|c|}{\langle x, 1 \mapsto 2\rangle} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \end{array} = \begin{array}{c}/\text{morderi}/\\ \hline \multicolumn{1}{|c|}{\langle x^1, \star \mapsto \star\rangle} \\ \multicolumn{1}{|c|}{\langle y^1, 1 \mapsto \star\rangle} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \multicolumn{1}{|c|}{\text{bite}'(x^1,y^1)} \\ \hline \end{array}$$

We see that the former object is advanced to subject, and the former subject is now an anonymous variable, or a chômeur in relational terms. As is easily seen, the rule $1 \mapsto 2$ reflects the change from 2 to 1, and not conversely. Hence, an element inducing a relation change $\alpha \mapsto \beta$ is simply given the following structure:

$$\begin{array}{|c|} \hline \langle x, \beta \mapsto \alpha\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \end{array}$$

To give another example, we take dative shift in Bahasa Indonesia (see (Chung, 1983)). Dative shift in relational terms is 3–to–2 advancement. Consequently, its semantical structure is the following.

$$\begin{array}{c}/\text{meng-}/\\ \hline \multicolumn{1}{|c|}{\langle x, 2 \mapsto 3\rangle} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \end{array}$$

This morpheme makes the indirect object advance to the direct object status, whereby the former direct object is put en chômage. We can put these operations in sequence, applying passive after dative shift, for example. In all these cases, the results are as expected.

The other relational changes operate in a similar manner. No semantic change is induced, only the relations are reassigned. The different strata are therefore present in the various stages of the composition of the meaning. By applying more and more elements to the verb we proceed from one stratum to the next until we reach the final stratum. The STRATAL UNIQUENESS LAW is nothing but the requirement that any referent system take no more than one referent under a given name, a requirement that is constitutive of a referent system. Hence, the STRATAL UNIQUENESS LAW is automatically satisfied if we are working in the context of referent systems.

5. Stacking Referent Systems

As we have said in Section 2, there are syntactic rules which are sensitive not to the relations as they are in the final stratum but how they are in the initial stratum. The mechanism of the preceding section, however, does not allow to remember any relational assignment. As soon as passive has applied, the verb will forget that it has been a transitive verb and act just like any other intransitive verb. Indeed, the whole purpose of referent systems was to explain how new assignments of relations can push the established bearers of a relation out of service and en chômage. Forgetting previous relations is an integral part of the mechanism of referent system. So it would certainly be a mistake to introduce a special mechanism by which we remember the assignment at the initial stratum. It so turns out that this is anyway not necessary. Recall that the relational assignment at the initial stratum is said to be governed by the UAH. If two lexical entries have the same θ–grids, they shall end up with identical relation assignment. This suggests that if we have changed the relations but have kept a record of the θ–roles, we might still be able to recover the situation at the initial stratum. This is the road that we shall take here. Basically, we shall propose to insert an intermediate level into the representation that keeps a record of θ–roles. This level remains almost unchanged throughout the strata and therefore allows to access the initial stratum. The details differ from the proposals made in the literature in some important respects, though, as we shall see.

We have earlier established a referent system to take care of the grammatical relations. We shall now add *another* referent system to take care of the θ–grid. The resulting structure will be called a *stacked N–system*. It is structured as follows. It has three levels, the highest being the level of grammatical relations (GR–level), the middle the level of θ–roles (θ–level) and the lowest being the level of DRSs (DRS–level).

GR–level
θ–level
DRS–level

At the GR–level we find the referent systems as introduced in the previous sections. In the middle, we find similar referents, but this time the names are drawn from the set of θ–roles:

$$T := \{\text{ACT}, \text{EXP}, \text{LOC}, \text{THM}, \text{BEN}, \ldots\}$$

These labels correspond to the θ–roles of actor, experiencer, location, theme, and beneficiary. There are more θ–roles, but the set T is always finite. The referent system at the θ–level corresponds to the θ–grid. Otherwise, things remain the same. Now here is how the semantic structure for mordere will look like under these assumptions.

/mordere/
$\langle x, 1 \mapsto \star\rangle$ $\langle y, 2 \mapsto \star\rangle$
$\langle x, \textsc{agt} \mapsto \star\rangle$ $\langle y, \textsc{thm} \mapsto \star\rangle$
$\varnothing$
bite$'(x, y)$

This requires some comment. We assume that θ–roles are uniquely assigned just like grammatical relations. A sentence does not contain two experiencers for the same predicate, or two instruments. Therefore, we shall use the same mechanism of introducing and consuming θ–roles under merge as we did with grammatical relations. Consequently, we do not find $\langle x, \textsc{thm} \mapsto \textsc{thm}\rangle$ but rather $\langle x, \textsc{thm} \mapsto \star\rangle$. A noteworthy difference between the GR–level and the θ–level is that there can be no change of θ–role. Since this is an important feature of the system, let us highlight this.

Θ–Preservation Law. There are no AHSs which have the form $\langle x, \alpha \mapsto \beta\rangle$, where $\alpha \neq \beta$ and $\alpha, \beta \in T$.

It is this requirement that preserves the initial assignment of grammatical relations, though in disguised form.

The merge algorithm is somewhat tricky to define. It takes several steps. The first step is to find the matching pairs of the GR–level and the θ–level. We generally allow the overall merge to be defined if the following holds.

(a) There is at least one matching pair, either at the GR–level or at the θ–level.

(b) If there are two matching pairs, then the same structure is the functor in both levels.

(c) The merge procedure defined below succeeds.

A merge is *light* if there is only one matching pair.

So, let us take two such systems, $\mathfrak{S}_1 = \langle \rho_1, \rho'_1, \Delta_1\rangle$ and $\mathfrak{S}_2 = \langle \rho_2, \rho'_2, \Delta_2\rangle$. We define first the substitutions κ_1 and κ_2. If x is a referent of $\mathfrak{S}_1$ which does not occur in any matching pair, then $\kappa_1(x) := x^1$. Similarly, if x is a referent of $\mathfrak{S}_2$ which does not occur in any matching pair, then $\kappa_2(x) := x^2$. If x is a referent of $\mathfrak{S}_1$ that occurs in a matching pair then $\kappa_1(x) := x^1$, and if x is a referent of $\mathfrak{S}_2$ that occurs in a matching pair together with y of $\mathfrak{S}_1$ then $\kappa_2(x) := y^1$. This is the first step. Next we shall have to take care that the resulting structure becomes a referent system. The reason that it may fail to do so is that the substitutions of one level may interact with the substitutions of the other level if the merger is defined independently in both levels. Here is an example:

$$\begin{array}{|c|}\hline \langle x, \star \mapsto A\rangle \\ \hline \langle x, \star \mapsto \textsc{agt}\rangle \\ \hline \end{array} \circ \begin{array}{|c|}\hline \langle x, \star \mapsto B\rangle \\ \hline \langle x, \textsc{agt} \mapsto \star\rangle \\ \hline \end{array} = \begin{array}{|c|}\hline \langle x^1, \star \mapsto A\rangle \\ \langle x^1, \star \mapsto B\rangle \\ \hline \langle x^1, \star \mapsto \star\rangle \\ \hline \end{array}$$

In this case we do not end up with a referent system unless $A = B$. However, we may take recourse to the same measure that we used in defining the simple merge of the referent systems. In such cases, the AHS of the functor is kept and that of the argument is lost. In the present case we get

$$\begin{array}{|c|}\hline \langle x, \star \mapsto A\rangle \\ \hline \langle x, \star \mapsto \textsc{agt}\rangle \\ \hline \end{array} \circ \begin{array}{|c|}\hline \langle x, \star \mapsto B\rangle \\ \hline \langle x, \textsc{agt} \mapsto \star\rangle \\ \hline \end{array} = \begin{array}{|c|}\hline \langle x^1, \star \mapsto B\rangle \\ \hline \langle x^1, \star \mapsto \star\rangle \\ \hline \end{array}$$

To make this idea work, we have assumed (see condition (b) above) that the notions of functor and argument are the same on both levels.

We shall make this clear by concrete examples. The role of ρ_1 and ρ_2 will be as before. The intermediate referent system, however, will now contain AHSs that specify the θ–role of the referents. The structure for a subject NP is now as follows: [18]

$$\begin{array}{c} /\mathsf{lupus}/ \\ \begin{array}{|c|}\hline \langle x, \star \mapsto 1\rangle \\ \hline \langle x, \star \mapsto \textsc{agt}\rangle \\ \hline \{x\} \\ \hline \mathsf{wolf}'(x) \\ \hline \end{array}\end{array}$$

We take it that the nominative case is responsible for adding the θ–role as well as the grammatical relation. How it does that is of no immediate concern, suffice it to say that it can do so using the same mechanisms (see (Kracht, 1999)). Now let us merge the two structures:

$$\begin{array}{c} /\mathsf{lupus}/ \\ \begin{array}{|c|}\hline \langle x, \star \mapsto 1\rangle \\ \hline \langle x, \star \mapsto \textsc{agt}\rangle \\ \hline \{x\} \\ \hline \mathsf{wolf}'(x) \\ \hline \end{array}\end{array} \circ \begin{array}{c} /\mathsf{mordet}/ \\ \begin{array}{|c|}\hline \langle x, 1 \mapsto \star\rangle \\ \langle y, 2 \mapsto \star\rangle \\ \hline \langle x, \textsc{agt} \mapsto \star\rangle \\ \langle y, \textsc{thm} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \mathsf{bite}'(x, y) \\ \hline \end{array}\end{array} = \begin{array}{c} /\mathsf{lupus\ mordet}/ \\ \begin{array}{|c|}\hline \langle x^1, \star \mapsto \star\rangle \\ \langle y^2, 2 \mapsto \star\rangle \\ \hline \langle x^1, \star \mapsto \star\rangle \\ \langle y^2, \textsc{thm} \mapsto \star\rangle \\ \hline \{x^1\} \\ \hline \mathsf{wolf}'(x^1) \\ \mathsf{bite}'(x^1, y^2) \\ \hline \end{array}\end{array}$$

First, we look for a matching pair in the GR–level. This consists of $\langle x, \star \mapsto 1\rangle$ of the left hand structure and $\langle x, 1 \mapsto \star\rangle$ of the right hand structure. (By

[18] Latin has no determiners, so lupus can either mean *wolf*, *the wolf* or *a wolf*. In this case we treat it as meaning *a wolf*. This is of course only for illustration.

definition (see Page 16), the right hand structure is the functor.) Next we look at the θ–level. Here we find the matching pair $\langle x, \star \mapsto \text{AGT}\rangle$ and $\langle x, \text{AGT} \mapsto \star\rangle$. This defines the same substitution on the referents, so we end up with the following embddings:

$$\kappa_1 : x \mapsto x^1, \qquad \kappa_2 : x \mapsto x^1, y \mapsto y^2$$

If merge is defined in this way, a verb is born in the initial stratum with its θ–grid, which it keeps throughout all strata, simply because relational change cannot access the θ–grid. Let us see therefore how passive is first of all formulated, and second how it acts on the new structures.

$$\begin{array}{c} /\text{PASS}/ \\ \hline \multicolumn{1}{|c|}{\langle x, 1 \mapsto 2\rangle} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \end{array}$$

Now, merging this representation with the one for mordere gives

$$\begin{array}{|c|} \multicolumn{1}{c}{/\text{mordere}/} \\ \hline \langle x, 1 \mapsto \star\rangle \\ \langle y, 2 \mapsto \star\rangle \\ \hline \langle x, \text{AGT} \mapsto \star\rangle \\ \langle y, \text{THM} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \text{bite}'(x, y) \\ \hline \end{array} \circ \begin{array}{|c|} \multicolumn{1}{c}{/\text{PASS}/} \\ \hline \langle x, 1 \mapsto 2\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \varnothing \\ \hline \end{array} = \begin{array}{|c|} \multicolumn{1}{c}{/\text{morderi}/} \\ \hline \langle x^1, \star \mapsto \star\rangle \\ \langle y^1, 1 \mapsto \star\rangle \\ \hline \langle x^1, \text{AGT} \mapsto \star\rangle \\ \langle y^1, \text{THM} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \text{bite}'(x^1, y^1) \\ \hline \end{array}$$

This is an instance of light merge. There is only one matching pair, at the GR–level. So, while the assignment of relations has been changed, the assignment of θ–roles has remained constant.

Now, granted that the θ–grid remains constant, how can we formulate the rules of syntax that refer to, say, the 1 of the initial stratum? If we want to do that, we shall have to say in which way we can identify the initial subject in the θ–grid. Obviously, we would do it in the same way as the assignment of relations has been done in the initial stratum, but exactly how is that done? On that point, however, the literature is not particularly clear. The strongest hypothesis would be that there is a one–to–one mapping between θ–roles and relations. If that is so, we should expect that the subject is restricted to the actors. However, the most popular assumption is that grammatical relations are assigned on a relative rank basis. At the initial stratum the θ–role of highest actor likeness is assigned 1. 2 is assigned to the θ–role that is most like an undergoer. If the latter hypothesis is correct we can implement the syntactic processes that refer to the initial stratum only with great difficulty. We shall endorse here the stronger view, namely that there is a partial function from the set of θ–roles to the set of relations. In particular, actors are initial 1s and themes are initial 2s. If we are to believe the literature, experiencers are also initial 1s.

So far we have shown how to integrate arguments that the verbs subcategorize for, but we need to make room for adjuncts as well. Furthermore, it is necessary to account for the fact that the θ–grid can be extended by certain morphemes (for example the beneficiary morpheme in Kinyarwanda, see next section). Therefore, we shall change the apparatus once more. We shall use events in the semantics. So, rather than $\mathsf{bite}'(x, y)$ we shall now write

$$\mathsf{bite}'(e); \mathsf{agt}'(e) \doteq x; \mathsf{thm}'(e) \doteq y$$

The semantics of the verbs are now as follows. [19]

/mordere/
$\langle e, \star \mapsto \mathrm{P}\rangle$ $\langle x, 1 \mapsto \star\rangle$ $\langle y, 2 \mapsto \star\rangle$
$\langle x, \textsc{agt} \mapsto \star\rangle$ $\langle y, \textsc{thm} \mapsto \star\rangle$
$\varnothing$
$\mathsf{bite}'(e)$; $\mathsf{agt}'(e) \doteq x$; $\mathsf{thm}'(e) \doteq y$.

This says that there is an event of biting, whose agent is x and whose theme is y. Now, it may be thought that the θ–roles are redundant in presence of the semantical functions ben', thm' etc. This, however, is not so. First, elements that occur in the θ–grid are obligatorily expressed, while those appearing in the semantics need not be. Second, the set of roles that occur in T is different from the set of functions appearing in the semantics. For example, in the semantics there are functions that yield the source or target of emission in a communication event, the mover in a movement event and so on. There are no corresponding actant roles for these functions. For a defense of this picture see (Van Valin and LaPolla, 1997). Now, the argument status of an NP is stated three times: in the semantics, at the θ–level and at the GR–level. This is more than necessary. Indeed, we shall simplify the system to reduce unnecessary redundancy. (Van Valin and LaPolla, 1997) argue that the θ–roles are predictable from the semantic roles. Hence, the semantics already contains all necessary information about the θ–grid apart from the information about which relations must be expressed in the sentence. This information is

[19] Now we are making use of the relation P, which stands for predicate. So, a transitive verb consumes two nominal arguments bearing the relations 1 and 2 and produces a predicate.

contained in the θ–grid. Now, consider once more a subject which has been demoted to a chômeur. We have previously used the θ–grid to account for the fact that the subject chômeur can still identify itself with some role in the predicate, since the θ–grid contains the information that there once was, say, an actor. Now that this information is replicated (in more detail even) in the semantics, it is unnecessary to keep that in the θ–grid. What is more, if we assume that the θ–grid contains those arguments that are obligatorily expressed, we do not want the θ–grid to contain the actor any more. We propose therefore that if an actor is made a subject, it will lose its θ–status as an actor. We express this in the following condition.

> Disjointness. In a lexical structure, a referent must be anonymous in either the GR–level or the θ–level.

Notice that Disjointness does not talk about functional elements. In fact, it should not, for these elements have the power to lift a referent from one level to another, which means that the referent cannot be anonymous in any of the levels.

Now, if Disjointness is assumed, why do we not simply fuse the two levels into one, and use both sets of names indiscriminately? Technically, this is feasible. However, the present structures allow for two referents to be shared, one at the GR–level and one at the θ–level, which would otherwise be excluded. This is itself is not enough of a reason reason since in principle referent systems allow any number of shared referents. We have stipulated that they are only allowed to share one variable. We have argued that this is correct. Now, if Disjointness does not hold, it can occur that two referents are shared. If we fuse the levels, this means that we have to restrict the number of shared referents to two. But it would be rather odd to require that the limit is two rather than any other number, while the restriction to one shared referent per level seems to be well–motivated.

We shall now outline the scenario of relational changes that occur in the life of a predicate, in our case a verb. It starts out with only the semantics being specified. There is a single referent mentioned, and it is the event variable e. This variable is not quantified over.

/mord-/
$\langle e, \star \mapsto \mathrm{P}\rangle$
$\varnothing$
$\varnothing$
bite′(e).

The first cycle installs the θ–roles. Theme–installment is done by merging with the following structure:

$$\begin{array}{c} /\textsc{thm–i}/ \\ \hline \multicolumn{1}{|c|}{\langle e, \mathrm{P} \mapsto \mathrm{P}\rangle} \\ \hline \multicolumn{1}{|c|}{\langle x, \textsc{thm} \mapsto \star\rangle} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \multicolumn{1}{|c|}{\mathsf{thm}'(e) \doteq x} \\ \hline \end{array}$$

It is worthwhile looking at this merge in detail.

$$\begin{array}{|c|} \multicolumn{1}{c}{/\mathsf{mord}\text{-}/} \\ \hline \langle e, \star \mapsto \mathrm{P}\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \mathsf{bite}'(e) \\ \hline \end{array} \circ \begin{array}{|c|} \multicolumn{1}{c}{/\textsc{thm–i}/} \\ \hline \langle e, \mathrm{P} \mapsto \mathrm{P}\rangle \\ \hline \langle x, \textsc{thm} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \mathsf{thm}'(e) \doteq x \\ \hline \end{array} = \begin{array}{|c|} \multicolumn{1}{c}{/\mathsf{mord}\text{-}/ + /\textsc{thm-i}/} \\ \hline \langle e^1, \star \mapsto \mathrm{P}\rangle \\ \hline \langle x^2, \textsc{thm} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \mathsf{bite}'(e^1); \\ \mathsf{thm}'(e^1) \doteq x^2. \\ \hline \end{array}$$

The reader may also check the following. If the semantics of mordere contains the formula $\mathsf{thm}'(e) \doteq y$, then after merge we will have the lines $\mathsf{thm}'(e^1) \doteq y^1$ and $\mathsf{thm}'(e^1) \doteq x^2$. By the laws of predicate logic we can deduce $y^1 \doteq x^2$, and therefore these two referents must always denote the same thing. Hence, by pure logic, it does not matter at all whether the semantics contains the theme argument already or whether it is added by the installment. Technically, however, the latter option is cleaner, giving only the bare minimal semantics to the verb mordere.

The first cycle is completed when the installments are done. The θ–grid is complete. The second cycle is the promotional cycle. Here, bearers of θ–roles are promoted into bearers of grammatical relations. An example is beneficiary advancement:

$$\begin{array}{c} /\textsc{ben–a}/ \\ \hline \multicolumn{1}{|c|}{\langle x, 2 \mapsto \star\rangle} \\ \hline \multicolumn{1}{|c|}{\langle x, \star \mapsto \textsc{ben}\rangle} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \multicolumn{1}{|c|}{\mathsf{ben}'(e) \doteq x} \\ \hline \end{array}$$

(Notice that this does not comply with Disjointness. This therefore qualifies it as a functional element.) After the promotions are completed, the relational changes can take place.

This scenario is found also in (Van Valin and LaPolla, 1997). Van Valin and LaPolla also show how the process itself is regulated. For if the θ–role installments are left by themselves, any verb can appear with any θ–grid. This is not what is observed. We assume therefore that verbs are marked for which installments are obligatory and which ones are optional. [20] For our purposes

[20] See also (Kracht, 1999) for an extensive treatment of such issues.

we can just assume that the verb comes out of the lexicon with all necessary installments having operated.

6. A Worked Example: Relational Change in Kinyarwanda

In this section we will demonstrate the utility of the concepts and analyses by way of giving some examples. We shall use Kinyarwanda as our main target. Our analysis is based on (Dryer, 1983). However, we shall note a problem with the analysis given in that paper and point to a possible solution. Kinyarwanda is a head marking language (for example, there are no cases) and it has a rich verbal morphology. It has in addition to subject agreement (which is a prefix) a number of suffixes, which indicate relational change. As we shall see, they form a rather heterogeneous class from a semantic point of view. The first suffix is glossed as BEN and has the form -i or -er. [21] It signals the presence of a beneficiary. It is not an advancement sign. We give it therefore the following semantics:

$$\begin{array}{c} /\text{BEN}/ \\ \hline \multicolumn{1}{|c|}{\langle e, \text{P} \mapsto \text{P}\rangle} \\ \hline \multicolumn{1}{|c|}{\langle x, \text{BEN} \mapsto \star\rangle} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \multicolumn{1}{|c|}{\mathsf{ben}'(e) \doteq x} \\ \hline \end{array}$$

Notice that BEN introduces the beneficiary on the level of θ–roles.

The next element is the one glossed as PASS. It has the form -w. According to Dryer, the passive has three functions: the advancement of 2 to 1, the advancement of 3 to 1 and the advancement of beneficiaries to 1. In our view, however, the third must be distinguished from the first two. It is not an advancement in the same sense. From our point of view, it introduces the beneficiary into the highest level of semantics, thus giving it a relation in the proper sense. We will continue however to call it beneficiary advancement. The analysis of 2–to–1 and 3–to–1 are by now obvious. The semantics of beneficiary advancement (lets call it B-PASS) is the following.

$$\begin{array}{c} /\text{B-PASS}/ \\ \hline \multicolumn{1}{|c|}{\langle x, 1 \mapsto \star\rangle} \\ \hline \multicolumn{1}{|c|}{\langle x, \star \mapsto \text{BEN}\rangle} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \multicolumn{1}{|c|}{\varnothing} \\ \hline \end{array}$$

This means that if it attaches to a verb, the event referents are shared on the main level and the beneficiary on the lower level, on condition that the event

[21] According to our terminology, it should now be called BEN–I, but we shall use the established name here.

has a beneficiary. If that is so, the beneficiary is promoted by passive to the upper level, that of the relations.

The last in our series is locative introduction. There is a suffix, glossed here as LOC, which takes two forms, -ho and -mo (with different meaning). Its function is to advance a locative to direct object: [22]

/LOC/
$\langle x, 2 \mapsto \star \rangle$
$\langle x, \star \mapsto \text{LOC} \rangle$
$\varnothing$
$\varnothing$

Now consider the following examples.

(6.1)	Íntebe	y-iicar-i-w-é-ho	umugabo	n-uúmwáana.
	chair	it-sit-BEN-PASS-ASP-LOC	man	by-child
	The chair was sat on for the man by the child			
(6.2)	Umugabo	y-iicar-i-w-é-ho	íntebe	n-uúmwáana.
	man	he-sit-BEN-PASS-ASP-LOC	chair	by-child
	The man was sat-on-the-chair-for by the child			

Let us ignore the agreement prefix as well as the aspect marker (glossed as ASP). What is striking about these sentences is that passive applies to what seems to be an intransitive verb in both cases. This seems to be in violation of the principles of relational grammar. However, notice that the same happens in English. The verb to sit on (sic!) can be passivized. The key to the solution is to analyze the locative advancement as making an intransitive verb into a transitive one, which can subsequently be passivized. In English, locative advancement takes the form of preposition incorporation (which is not visible in writing, however). While these facts might still be puzzling for relational grammar, because it would have to explain why passive applies to an intransitive verb that is later made transitive, the present semantics has no such problems. We start with the verb to sit (θ–role installments have already

[22] The treatment of locative phrases in this paper is highly superficial. However, nothing of substance is gained if the semantics would be made more explicit at this point.

taken place):

$$\begin{array}{c} \text{/iicar/} \\ \begin{array}{|c|}\hline \langle e, \star \mapsto \textsc{p}\rangle \\ \langle x, 1 \mapsto \star\rangle \\ \hline \langle y, \textsc{loc} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \mathsf{act}'(e) \doteq x; \\ \mathsf{loc}'(e) \doteq y; \\ \mathsf{sit}'(e). \\ \hline \end{array} \end{array}$$

Next we apply BEN:

$$\begin{array}{c} \text{/iicar/} \\ \begin{array}{|c|}\hline \langle e, \star \mapsto \textsc{p}\rangle \\ \langle x, 1 \mapsto \star\rangle \\ \hline \langle y, \textsc{loc} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \mathsf{act}'(e) \doteq x; \\ \mathsf{loc}'(e) \doteq y; \\ \mathsf{sit}'(e). \\ \hline \end{array} \end{array} \circ \begin{array}{c} /\textsc{ben}/ \\ \begin{array}{|c|}\hline \langle e, \textsc{p} \mapsto \textsc{p}\rangle \\ \hline \langle x, \textsc{ben} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \mathsf{ben}'(e) \doteq x \\ \hline \end{array} \end{array} = \begin{array}{c} \text{/iicar-i/} \\ \begin{array}{|c|}\hline \langle e^1, \star \mapsto \textsc{p}\rangle \\ \langle x^1, 1 \mapsto \star\rangle \\ \hline \langle x^2, \textsc{ben} \mapsto \star\rangle \\ \langle y^1, \textsc{loc} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \mathsf{act}'(e^1) \doteq x^1; \\ \mathsf{ben}'(e^1) \doteq x^2; \\ \mathsf{loc}'(e^1) \doteq y^1; \\ \mathsf{sit}'(e^1). \\ \hline \end{array} \end{array}$$

In a second step we attach PASS. There are now two choices. We may consider this as beneficiary advancement (called B-PASS) or as 2–to–1 advancement. (3–to–1 advancement is also possible at this stage, but leads to an incomplete sentence, since a 3 gets introduced that is never discharged.)

Let us take the first option. Then we get

$$\begin{array}{c} \text{/iicar-i/} \\ \begin{array}{|c|}\hline \langle e^1, \star \mapsto \textsc{p}\rangle \\ \langle x^1, 1 \mapsto \star\rangle \\ \hline \langle x^2, \textsc{ben} \mapsto \star\rangle \\ \langle y^1, \textsc{loc} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \mathsf{act}'(e^1) \doteq x^1; \\ \mathsf{ben}'(e^1) \doteq x^2; \\ \mathsf{loc}'(e^1) \doteq y^1; \\ \mathsf{sit}'(e^1). \\ \hline \end{array} \end{array} \circ \begin{array}{c} /\textsc{b-pass}/ \\ \begin{array}{|c|}\hline \langle x, 1 \mapsto \star\rangle \\ \hline \langle x, \star \mapsto \textsc{ben}\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \end{array} \end{array} = \begin{array}{c} \text{/iicar-i-w/} \\ \begin{array}{|c|}\hline \langle e^{11}, \star \mapsto \textsc{p}\rangle \\ \langle x^{11}, \star \mapsto \star\rangle \\ \langle x^{21}, 1 \mapsto \star\rangle \\ \hline \langle x^{21}, \star \mapsto \star\rangle \\ \langle y^{11}, \textsc{loc} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \mathsf{act}'(e^{11}) \doteq x^{11}; \\ \mathsf{ben}'(e^{11}) \doteq x^{21}; \\ \mathsf{loc}'(e^{11}) \doteq y^{11}; \\ \mathsf{sit}'(e^{11}). \\ \hline \end{array} \end{array}$$

(According to Proposition 11 it is safe if we drop anonymous referents from any of the lists. In order not to overload the notation, we shall therefore typically drop anonymous referents from the referent systems after merge.) We ignore ASP. Next we add LOC (and also the subject agreement marker, whose effect we shall ignore):

$$\begin{array}{c} \text{/iicar-i-w-é/} \\ \begin{array}{|c|}\hline \langle e^{11}, \star \mapsto \text{P}\rangle \\ \langle x^{21}, 1 \mapsto \star\rangle \\ \hline \langle y^{11}, \text{LOC} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \text{act}'(e^{11}) \doteq x^{11}; \\ \text{ben}'(e^{11}) \doteq x^{21}; \\ \text{loc}'(e^{11}) \doteq y^{11}; \\ \text{sit}'(e^{11}). \\ \hline \end{array} \end{array} \circ \begin{array}{c} \text{/LOC/} \\ \begin{array}{|c|}\hline \langle x, 2 \mapsto \star\rangle \\ \hline \langle x, \star \mapsto \text{LOC}\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \end{array} \end{array} = \begin{array}{c} \text{/y-iicar-i-w-é-ho/} \\ \begin{array}{|c|}\hline \langle e^{111}, \star \mapsto \text{P}\rangle \\ \langle x^{211}, 1 \mapsto \star\rangle \\ \langle y^{111}, 2 \mapsto \star\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \text{act}'(e^{111}) \doteq x^{111}; \\ \text{ben}'(e^{111}) \doteq x^{211}; \\ \text{sit}'(e^{111}); \\ \text{loc}'(e^{111}) \doteq y^{111}. \\ \hline \end{array} \end{array}$$

Thus we get a transitive verb whose subject is the beneficiary and whose object is the location. This is exactly sentence (6.2).

Now let us take the other route, and assume that PASS is 2–to–1 advancement. Here we find that attaching PASS directly to the verb is impossible. This is so since it tries to advance a referent that is not found in the GR–level of the verb. Merge fails:

$$\begin{array}{c} \text{/iicar-i/} \\ \begin{array}{|c|}\hline \langle e^{1}, \star \mapsto \text{P}\rangle \\ \langle x^{1}, 1 \mapsto \star\rangle \\ \hline \langle x^{2}, \text{BEN} \mapsto \star\rangle \\ \langle y^{1}, \text{LOC} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \text{act}'(e^{1}) \doteq x^{1}; \text{ben}'(e^{1}) \doteq x^{2}; \\ \text{loc}'(e^{1}) \doteq y^{1}; \text{sit}'(e^{1}). \\ \hline \end{array} \end{array} \circ \begin{array}{c} \text{/PASS/} \\ \begin{array}{|c|}\hline \langle x, 1 \mapsto 2\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \varnothing \\ \hline \end{array} \end{array} = \;??$$

However, there is another way of composing the structure. Namely, ignoring ASP and the agreement marker, we shall first compose LOC and PASS:

$$\begin{array}{c} \text{/PASS/} \\ \begin{array}{|c|}\hline \langle x, 1 \mapsto 2\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \varnothing \\ \hline \end{array} \end{array} \circ \begin{array}{c} \text{/LOC/} \\ \begin{array}{|c|}\hline \langle x, 2 \mapsto \star\rangle \\ \hline \langle x, \star \mapsto \text{LOC}\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \end{array} \end{array} = \begin{array}{c} \text{/w-é-ho/} \\ \begin{array}{|c|}\hline \langle x^{1}, 1 \mapsto \star\rangle \\ \hline \langle x^{1}, \star \mapsto \text{LOC}\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \end{array} \end{array}$$

This complex is merged with y-iicar-i:

$$\begin{array}{c}\text{/y-iicar-i/}\\ \begin{array}{|c|}\hline \langle e^1, \star \mapsto \textsc{p}\rangle \\ \langle x^1, 1 \mapsto \star\rangle \\ \hline \langle x^2, \textsc{ben} \mapsto \star\rangle \\ \langle y^1, \textsc{loc} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \text{act}'(e^1) \doteq x^1; \\ \text{ben}'(e^1) \doteq x^2; \\ \text{loc}'(e^1) \doteq y^1; \\ \text{sit}'(e^1). \\ \hline \end{array}\end{array} \circ \begin{array}{c}\text{/w-é-ho/}\\ \begin{array}{|c|}\hline \langle x^1, 1 \mapsto \star\rangle \\ \hline \langle x^1, \star \mapsto \textsc{loc}\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \end{array}\end{array} = \begin{array}{c}\text{/y-iicar-i-w-é-ho/}\\ \begin{array}{|c|}\hline \langle e^{11}, \star \mapsto \textsc{p}\rangle \\ \langle x^{11}, \star \mapsto \star\rangle \\ \langle y^{11}, 1 \mapsto \star\rangle \\ \hline \langle x^{21}, \textsc{ben} \mapsto \star\rangle \\ \hline \varnothing \\ \hline \text{act}'(e^{11}) \doteq x^{11}; \\ \text{ben}'(e^{11}) \doteq x^{21}; \\ \text{loc}'(e^{11}) \doteq y^{11}; \\ \text{sit}'(e^{11}). \\ \hline \end{array}\end{array}$$

We get an intransitive sentence, in which the subject is the location. This may be surprising, since the sentence looks just like a transitive sentence. However, as Dryer observes, what looks like an object in Kinyarwanda can be either a 2, 3 or a beneficiary. Here are some examples, showing a 3 (in (6.3)) and a beneficiary (in (6.4)). (The examples are directly without alterations from (Dryer, 1983).)

(6.3)	Yohaâni	y-oher-er-eje	Maríya	ibárúwa
	Yohani	he-send-BEN-ASP	Maria	letter
	John sent a letter to Mary.			
(6.4)	Umukoôbwa	a-ra-som-er-a	umuhuûngu	igitabo
	girl	she-PRES-read-BEN-ASP	boy	book
	The girl is reading the book for the boy.			

Thus, the referent systems are capable of analysing the relational change even when the order of suffixes is not as would be expected. However, this possibility is bought at a price: we cannot proceed strictly left–to–right.

There are two points that are worth noting. The semantics of the verb to sit contains a locational variable. If it did not contain that variable, this analysis would not go through. We are convinced that this is the right approach, but more evidence needs to be adduced. An additional point is the following. Notice that the present proposal makes the following prediction. If a verb is simply transitive (i. e. has no beneficiary nor 3) then the effect of passive is to advance the object to subject. We shall expect that LOC makes a transitive sentence with the location being the direct object, not the subject. We expect therefore that if merge is strictly left associative (6.6) is grammatical while (6.5) is not. This is contrary to fact (see (Dryer, 1983)):

(6.5)	Ishuûri	ry-oohere-j-w-é-ho	igitabo	n-úmwáalímu.
	school	it-send-ASP-PASS-ASP-LOC	book	by-teacher
	The school was sent the book to by the teacher.			
(6.6)	*Igitabo	cy-oohere-j-w-é-ho	ishuûri	n-úmwáalímu.
	book	it-send-ASP-PASS-ASP-LOC	school	by-teacher
	The book was sent to the school by the teacher.			

This is not a problem of the referent systems alone but also for the RG analysis. Notice namely that if the relational changes were analyzed on an inside out basis, we must expect that the direct object is promoted, not the locational object. What we must assume therefore is that locative advancement happens before passive is applied. We note that the same must be assumed for English. [23]

(6.7)	The teacher	was	sent	the book	to
		3SG.PAST	send-PASS		LOC
	by the director.				

In the present framework there is an alternative analysis, which we have outlined above. We combine LOC and PASS before the whole complex is merged with the transitive verb.

$$\begin{array}{c}\text{/ry-oohere-j/}\\ \boxed{\begin{array}{c}\langle e, \star \mapsto \text{P}\rangle\\ \langle x, 1 \mapsto \star\rangle\\ \langle y, 2 \mapsto \star\rangle\end{array}}\\ \boxed{\langle z, \text{LOC} \mapsto \star\rangle}\\ \boxed{\varnothing}\\ \boxed{\begin{array}{c}\text{act}'(e) \doteq x;\\ \text{thm}'(e) \doteq y;\\ \text{goal}'(e) \doteq z;\\ \text{send}'(e).\end{array}}\end{array} \circ \begin{array}{c}\text{/w-é-ho/}\\ \boxed{\langle x^1, 1 \mapsto \star\rangle}\\ \boxed{\langle x^1, \star \mapsto \text{LOC}\rangle}\\ \boxed{\varnothing}\\ \boxed{\varnothing}\end{array} = \begin{array}{c}\text{/ry-oohere-j-w-é-ho/}\\ \boxed{\begin{array}{c}\langle e^1, \star \mapsto \text{P}\rangle\\ \langle x^1, \star \mapsto \star\rangle\\ \langle y^1, 1 \mapsto \star\rangle\end{array}}\\ \boxed{\langle z^1, \text{BEN} \mapsto \star\rangle}\\ \boxed{\varnothing}\\ \boxed{\begin{array}{c}\text{act}'(e^1) \doteq x^1;\\ \text{ben}'(e^1) \doteq z^1;\\ \text{goal}'(e^1) \doteq y^1;\\ \text{send}'(e^1).\end{array}}\end{array}$$

The referent systems do not forbid this analysis. This would make (6.5) grammatical, but does not show why (6.6) is in fact ungrammatical. Further work must be done here.

[23] That the example below is not an instance of movement alone but actually of passive is shown by the phrase by the director. In our view the stranded preposition is incorporated abstractly into the verb (locative advancement) whereby the object the book is made into a chômeur. We shall not give detailed evidence for this view here.

7. On Being A Chômeur

The main difference between the present proposal and RG is the treatment of chômeurs. It is our proposal to equate the notion of a chômeur with a referent that is anonymous at both levels. That this complies with the intuitions is shown by the following fact.

PROPOSITION 11. *Let N be a referent system which does not contain an AHS for x, and let M be an arbitrary referent system. Put $N^+ := N \cup \{\langle x, \star \mapsto \star\rangle\}$. Then the following holds.*

1. *$N^+ \circ M$ is defined iff $N \circ M$ is defined, and moreover in this case*

$$N^+ \circ M = N \circ M \cup \{\langle x^1, \star \mapsto \star\rangle\}\,.$$

2. *$M \circ N^+$ is defined iff $M \circ N$ is defined, and moreover in this case*

$$M \circ N^+ = M \circ N \cup \{\langle x^2, \star \mapsto \star\rangle\}\,.$$

This means that if a referent x is anonymous, it does not matter whether or not the AHS for x is dropped from the referent system N. It is straightforward to verify that a merge of two semantic structures does not depend on the explicit listing of anonymous referents.

This proposal differs from the RG analysis in one important respect. RG proposes to grant the chômeur a specific relation, namely the relation of a chômeur. Moreover, there are distinct kinds of chômeurs depending on the relation they had before. The subject chômeur created by passive bears the relation denoted by $\widehat{1}$. An object chômeur bears the relation $\widehat{2}$. And so on. The disadvantage of this position has been pointed out earlier: it is by mere fiat that we disallow a chômeur to enter the picture again. While there are enough ways to promote beneficiaries or locations into term status, we must explicitly ban chômeurs from ever being promoted again. Further, suppose that there is such a notion as a chômeur relation $\widehat{1}$. Then what happens the next time another subject is turned en chômage? What is the relation into which the previous subject chômeur is thrown when the new subject chômeur enters the scene? RG says, this can't happen. This is stated as a law, the 1 Advancement Exclusiveness Law. However, there are certain things to be said. First, it does not appear to be valid. Ed Keenan has pointed out to me that Lithuanian and Turkish do allow double passives and therefore violate this law. Second, even if this evidence would turn out to be false, a similar case arises with the category of an object–chômeur. The inner logic of the whole theory makes it highly implausible that 'chômeur' is a grammatical relation of some sort. Too much would have to be sacrificed to allow for that.

Indeed, we have earlier argued that it is not even necessary. Assuming general principles that project the θ–grid as well as the grammatical relations from the root (as (Van Valin and LaPolla, 1997) have outlined and which partly follows from the UAH) we always have a record of the initial stratum at our disposal. If we want to revive the initial subject, this is possible. However, things do not come easy.

In order to pull up the initial 1, we need to access it at the semantics. All we have there at our disposal is the functions act′, exp′ etc. We are therefore committed to the belief that the initial 1 is equatable with a specific set of semantic functions. This is the position we have taken earlier, though it is not at all unproblematic. Despite this, let us see how on the basis of this assumption the referent systems can be put to work. Here is a possible analysis of English by:

$$\begin{array}{c} \text{/by/} \\ \begin{array}{|c|}\hline \langle e, \mathrm{P} \mapsto \mathrm{P}\rangle \\ \langle x, 2 \mapsto \star\rangle \\ \hline \varnothing \\ \hline \varnothing \\ \hline \mathsf{agt}'(e) \doteq x \\ \hline \end{array} \end{array}$$

(Notice that the preposition by asks for a complement that bears the 2–relation. This we think is a plausible assumption, though not a view proposed in the literature on RG. We shall not go into the ramifications of this proposal. Let us only mention that it implies the complement to have accusative case.) This structure, if combined with, say, a dog, produces

$$\begin{array}{c} \text{/by/} \\ \begin{array}{|c|}\hline \langle e, \mathrm{P} \mapsto \mathrm{P}\rangle \\ \langle x, 2 \mapsto \star\rangle \\ \hline \mathsf{agt}'(e) \doteq x \\ \hline \varnothing \\ \hline \varnothing \\ \hline \end{array} \end{array} \circ \begin{array}{c} \text{/a dog/} \\ \begin{array}{|c|}\hline \langle x^1, \star \mapsto 2\rangle \\ \hline \varnothing \\ \hline \{x^1\} \\ \hline \mathsf{dog}'(x^1) \\ \hline \end{array} \end{array} = \begin{array}{c} \text{/by a dog/} \\ \begin{array}{|c|}\hline \langle e^1, \mathrm{P} \mapsto \mathrm{P}\rangle \\ \langle x^1, \star \mapsto \star\rangle \\ \hline \varnothing \\ \hline \{x^1\} \\ \hline \mathsf{agt}'(e); \doteq x^1 \\ \mathsf{dog}'(x^1). \\ \hline \end{array} \end{array}$$

We notice that a chômeur need not be a PP. In Tagalog, a subject–chômeur is realized by a genitive NP. Similarly with object chômeurs. In English and German the object chômeur is an NP in accusative case, and so 3–to–2 advancement (dative shift) seems to produce a double object construction.

Now, a chômeur of a verb is a constituent that gets identified with an anonymous referent (though this can be done only indirectly, as we have just seen). It is therefore indistinguishable from a typical adjunct. It therefore seems that chômeurs could in principle be reintegrated into the relational level just like adjuncts (for example beneficiaries in Kinyarwanda). Therefore, the present proposal does not distinguish clearly enough between oblique relations and chômeurs. We believe, however, that no such distinction can be successfully maintained. Instead we shall argue that the principles of RG must anyway be further restrained to cover the facts, and that such restrictions will imply that chômeurs cannot be reintegrated into the relational level. Consider by way of example passive. There is nothing that prevents us from iterating passive. For example, take a transitive verb like to read in Kinyarwanda. Suppose we first passivize, then apply locative advancement and finally passivize again. Then we get a clause which is intransitive, with a subject that is the location, having two chômeurs. Yet, to our knowledge such a construction is not possible in Kinyarwanda (see also the discussion above).

There is another point where RG seems to fare less favourably than referent systems, namely with respect to the Motivated Chômage Law (MCL). While in RG we must postulate this as a law, in referent systems it is naturally complied with. And this is not because it does not happen that something is put en chômage but because when it happens it serves a totally different purpose, namely argument saturation. Recall the basic scenario of merge:

$$\langle x, A \mapsto B\rangle \circ \langle y, B \mapsto C\rangle = \langle x^1, A \mapsto C\rangle$$

If x is put en chômage through this merge then this is so only if $A = C = \star$. But this kind of situation we have met very often: for example, a verb being combined with a nominal argument. So, putting en chômage directly happens here very openly but for an honest purpose: to trade an element of the subcategorization frame for a real argument.

Now, there are instances of violation of the MCL that are worth mentioning to see that there is an issue here. Postal has claimed in (Postal, 1977) that antipassive is not simply the rule that moves the object en chômage. Rather, it is 1–to–2 retreat followed by passive. To see how it works, let us take a verb and first apply 2–to–1 retreat:

$$\boxed{\begin{array}{l}\langle x, 1 \mapsto \star\rangle \\ \langle y, 2 \mapsto \star\rangle\end{array}} \quad \circ \quad \boxed{\langle x, 2 \mapsto 1\rangle} \quad = \quad \boxed{\begin{array}{l}\langle x^1, 2 \mapsto \star\rangle \\ \langle y^1, \star \mapsto \star\rangle\end{array}}$$

In the next step we apply passive:

$$\boxed{\begin{array}{l}\langle x^1, 2 \mapsto \star\rangle \\ \langle y^1, \star \mapsto \star\rangle\end{array}} \quad \circ \quad \boxed{\langle x, 1 \mapsto 2\rangle} \quad = \quad \boxed{\begin{array}{l}\langle x^{11}, 1 \mapsto \star\rangle \\ \langle y^{11}, \star \mapsto \star\rangle\end{array}}$$

The net effect of this maneuver is the change

$$\begin{bmatrix} 1 \\ 2 \end{bmatrix} \mapsto \begin{bmatrix} 1 \\ \star \end{bmatrix}$$

Obviously, this cannot be formulated as a single–step rule, for penalty of violating the MCL. One might ask why one does not simply give up the MCL instead. This is shown not to solve the problem. For the subject of the antipassive construction has object qualities, which it would not have if it would never have been an object at some stratum. Hence, for independent reasons it is argued that the subject of the antipassive was at some stratum an object. If that is so, then the proposed solution is the easiest one, and the MCL holds anyhow. However, it appears that there are also other legal instances of self–induced chômage, namely through insertion of a dummy. The role of dummies is not only to fill a syntactic position when grammar needs one which the semantics fails to provide (in impersonal verbs), but a dummy can also push an element out of its relation that appears overtly. (Such is the case also with ascensions.) For example, in Hungarian, sentences are rarely found in preverbal position. Instead, a demonstrative is put into preverbal position instead, and the sentence appears at the end.

(7.6) Azt mondta János hogy nem akar menni.
This said John that he does not want to go.
John said that he didn't want to go.

A similar phenomenon is found in German. A different instantiation of unmotivated chômage is noun incorporation. As the data of (Baker, 1996) show, Mohawk verbs display double agreement, with subject and object. However, if the object is incorporated the verb becomes intransitive. We would like to propose an analysis whereby the incorporated noun saturates the 2–relation, feeding itself into the argument position. To see this notice first that the object is expressed as an incorporated noun as well as an overt constituent. So we may alternatively see this as object agreement.

(7.7) Shaʔtéku ni-kuti rabahbót wa-hʌ-[i]tsy-a-hnínu-ʔ ki
eight PART-ZPS bullhead FACT-MsS-fish-∅-buy-PUNC this
rake-ʔniha
my-father
My father bought eight bullheads.

Notice that the object (which we claim to be a chômeur) may be absent.

(7.8) Uwári ʌ-ye-nakt-anúhweʔ-neʔ ne Sak rao-nákt-aʔ.
Mary FUT-FsS-bed-∅-like-PUNC NE Sak MsP-bed-NSF
Mary likes Sak's bed.

That we do not, however, have a case of object agreement is shown by the following data. If the noun is not incorporated, it may also be realized by an object agreement marker. The object agreement is expressed together with subject agreement by a single morpheme. This morpheme is obligatorily absent if the noun is incorporated, and presumably obligatory if the incorporated noun is absent.

(7.9) Shako-núhweʔ-s ne owiráʔa.
MsS.SpO-like-HAB NE baby

(7.10) Ra-wir-a-núhweʔ-s.
MsS-baby-∅-likes-HAB

(7.11) *Shako-wir-a-núhweʔ-s
MsS.3PO-baby-∅-like-HAB
He likes babies.

The object agreement marker cannot be added. Taking the presence of object agreement as a test for the presence of a 2 we see that noun incorporation puts the 2 en chômage.

In sum, there seems to be no need for postulating the MOTIVATED CHÔMAGE LAW. It automatically follows from the way things are implemented into referent systems.

After having reconstructed Relational Grammar in terms of referent systems, it is worthwile to see which principles of RG are now accounted for, and which ones are not. The STRATAL UNIQUENESS LAW is obviously a consequence of the way in which referent systems are set up. The OBLIQUE LAW follows from the fact that θ–assignment cannot be changed. Obviously, however, in our formulation there is a violation of the OBLIQUE LAW just in case a nominal is put en chômage. While in RG this means that it assumes a different relation (namely, the chômeur relation, which is not oblique), here it means that the associated referent falls into anonymity. Many other laws must be accounted for in a different way, such as the FINAL 1 LAW, the 1–ADVANCEMENT EXCLUSIVENESS LAW and the NUCLEAR DUMMY LAW. However, let us note that RG not only proposes laws on possible clause structure and possible relation changes, but also asserts that laws of grammar are sensitive to the various relations that an element bears during the derivation. We have seen that at any stage of the derivation, two strata can be accessed: the initial stratum and the current one. It is claimed in the literature (e. g. (Davies, 1986)) that some grammatical processes are sensitive to relations borne at intermediate strata. Yet, cases of such sensitivity are rare, and it might well be that they can be accounted for in one or the other way using referent systems. However, this needs careful investigation.

8. Conclusion

In this paper we have outlined a semantics that deals with the mechanics of grammatical relations. Many details still have to be fitted into it (such as case and agreement). However, we have demonstrated elsewhere that this can be done in a similar way (see (Kracht, 1999)). We hope that the discussion in this paper has shown that referent systems provide an ideal tool for doing natural language semantics. Moreover, it became apparent that RG operates with the same principles and intuitions as referent systems. We believe that this similarity points to some fundamental aspect of human language processing that still needs to be explored in full depth.

References

Baker, M. C.: 1996, *The Polysynthesis Parameter*, Oxford Studies in Comparative Syntax. Oxford University Press.

Beaver, D.: 1995, 'Presupposition and assertion in dynamic semantics'. Ph.D. thesis, Centre for Cognitive Science, Edinburgh.

Chung, S.: 1983, 'An Object–Creating Rule in Bahasa Indonesia'. In: D. M. Perlmutter (ed.): *Studies in Relational Grammar, Vol. 1*. Chicago and London: The Chicago University Press, pp. 219 – 271.

Davies, W.: 1986, *Choctaw Verb Agreement and Universal Grammar*, Studies in Natural Language and Linguistic Theory. Dordrecht: Kluwer.

Davies, W. D.: 1984, 'Antipassive: Choctaw Evidence for a Universal Characterization'. In: D. M. Perlmutter and C. G. Rosen (eds.): *Studies in Relational Grammar, Vol. 2*. Chicago and London: The Chicago University Press, pp. 331 – 376.

Dryer, M. S.: 1983, 'Indirect Objects in Kinyarwanda Revisited'. In: D. M. Perlmutter (ed.): *Studies in Relational Grammar, Vol. 1*. Chicago and London: The Chicago University Press, pp. 129 – 140.

Harris, A. C.: 1984, 'Inversion as a Universal Rule of Grammar: Georgian Evidence'. In: D. M. Perlmutter and C. G. Rosen (eds.): *Studies in Relational Grammar, Vol. 2*. Chicago and London: The Chicago University Press, pp. 259 – 291.

Heim, I.: 1983, 'On the projection problem for presuppositions'. In: M. Barlow and D. Flickinger, D. Westcoat (eds.): *Proceedings of the 2nd West Coast Conference on Formal Linguistics*. Stanford University, pp. 114 – 126.

Kamp, H. and U. Reyle: 1993, *From Discourse to Logic, Introduction to Modeltheoretic Semantics of Natural Language, Formal Logic and Discourse Representation Theory*. Dordrecht: Kluwer.

Kracht, M.: 1999, 'Agreement Morphology, Argument Structure and Syntax'. Unpublished manuscript.

Perlmutter, D. M. and P. M. Postal: 1983, 'Some Proposed Laws of Basic Clause Structure'. In: D. M. Perlmutter (ed.): *Studies in Relational Grammar, Vol. 1*. Chicago and London: The Chicago University Press, pp. 81 – 128.

Perlmutter, D. M. and P. M. Postal: 1984, 'The 1–Avancement Exclusiveness Law'. In: D. M. Perlmutter and C. G. Rosen (eds.): *Studies in Relational Grammar, Vol. 2*. Chicago and London: The Chicago University Press, pp. 81 – 125.

Postal, P. M.: 1977, 'Antipassive in French'. In: *Proceedings of the Seventh Annual Meeting of the North–East Linguistics Society*. Cambridge, Massachussetts, MIT. reprinted in: *Linguisticae Investigationes I*, 333 – 374.

Rosen, C. G.: 1984, 'The Interface between Semantic Rules and Initial Grammatical Relations'. In: D. M. Perlmutter and C. G. Rosen (eds.): *Studies in Relational Grammar, Vol. 2*. Chicago and London: The Chicago University Press, pp. 38 – 77.

Tesnière, L.: 1982, *Éléments de Syntaxe Structurale*. Paris: Éditions Klicksieck, 4th edition.

van Eijck, J.: 1995, 'Presuppositions and dynamic logic'. In: M. Kanazawa, C. Piñón, and H. de Swart (eds.): *Papers from the Second CSLI Workshop in Logic, Language and Computation*. CSLI.

Van Valin, R. D. and J. LaPolla, Randy: 1997, *Syntax. Structure, meaning and function*, Cambridge Textbooks in Linguistics. Cambridge University Press.

Vermeulen, K. F. M.: 1995, 'Merging without Mystery or: Variables in Dynamic Semantics'. *Journal of Philosophical Logic* **24**, 405 – 450.

Vermeulen, K. F. M. and A. Visser: 1996, 'Dynamic bracketing and discourse representation'. *Notre Dame Journal of Formal Logic* **37**, 321 – 365.