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MOLECUAR COMPUTING METHODS FOR NATURAL LANGUAGE SYNTAX
Gemma Bel Enguix
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$$\forall\ (uu)^n = ((uu)^n, f^{\cdot n-1}),$$
$$\sigma = (s^n, f^{\cdot n-1}),$$
$$\omega = (s^n, f^{\cdot n-1}),$$
$$f^{\cdot 1} \ldots f^{\cdot n-2} =, ;\ f^{\cdot n-1} = g$$

And for bounder ghosts:

Being $u = svo$, g any bounder ghost $\neq$,:

$$\forall\ (u)^n = ((u)^n, f\star^{n-1}),$$
$$f\star^1 = g;\ f\star^2 \ldots f\star^{n-2} =, ;\ f \smile^{n-1} = and$$

8.6.6 Syntactic aspects

8.6.6.1 Category of splicing sentences

In spite of the differences we have just summed up, the working of connector and bounder ghosts is very similar. They are emergent ghosts, thus they act in blunt cuts with common friction groups. Connectors are universal emergent ghosts, whereas bounders are limited emergent ghosts which cannot link monofocal sequences.

What do emergent ghosts produce when appearing? It is certain that they produce compound syntactic structures. We do not want to call them with any of the present names because they do not match exactly. Let's say that the domain of connector ghosts corresponds to the domain of present *coordinate sentences* and to the structures with multiple subjects σ or multiple objects ω, ϖ. We simply name these structures of *connection*. The domain of bounder ghosts includes, however, what we usually name *adverbial subordinate sentences*, structures which we simply consider of *bind*.

CONNECTION + BINDING = SPLICING

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Now, splicing becomes a complex syntactic structure with strings or linking focus apart from being a molecular operation.

We have just deleted the traditional distinction between coordination and subordination. The truth is that such differentiation between coordinates and adverbials is made up according to logic criteria for the meaning of every specific ghost, and not according to syntactic criteria, which approach them strongly. This is such an important approach that the distinction among the different structures obtained by means of splicing almost becomes vague.

8.6.6.2 Permutations in connection and binding

Let's imagine a string x and a string y which are joined by means of connection. The outcome is $x \cdot y$. Given a complex string of this kind, it is always possible to carry out an equality which says:

$$x \cdot y = y \cdot x$$

So, connected strings can be twisted by changing the order of their elements.

Let's imagine now another string x and a string y joined by means of bind; so the final outcome is $x \star y$. Given a complex string of this kind, any equality that says the following can be carried out:

$$^{*}x \star y = y \star x$$

Whereas the connection is commutative, the bind it is not.
In order to carry out the equality, we must make use of this rule:

$$x \star y = \star\, y\, x$$

Thus, $f\star$ keeps the precedence with regard to the original element. Furthermore, it is possible to make a rule that says,

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$$x \star y \rightarrow y \star x$$

which can be applied any time, but it is necessary to state that it is not an equality.

Therefore, both rules are interchangeable, although $f\cdot$ does not allow the change of ghost from the central position that it occupies. Whereas $f\star$ is not fixed in the absolute place but in the original precedence of the ghost to obtain the same results as the permutation of elements of a connected series. On the other hand $f\star$ allows two kinds of movements, one of them as an equivalence and the other as an inversion.

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Chapter 9

Replication

9.1 Existing formalizations

Replication is defined as an operation based on effecting a cut on a string where another string fragmented in two sites is inserted. Therefore, replication, as we understand here, does not have anything to do with the process of copy of DNA that we have studied in chapter 2, but it is a kind of link very common in biology, which takes place when the inserted string is circular.

The biologic mechanism that reflects this process needs a staggered cut, and consequently the ends are sticker ones. However, in an analogous way to the application carried out by (Păun, Rozenberg & Salomaa, 1998) we think it is advisable to try this insertion among linear strings cut in such a way that produce blunt ends. In fact, it is an adjustment of splicing with the newness that a cut and a complex link are effected. It is obvious that the biologic referent is far away.

In order to carry out replication, it is necessary to define a string with a single cut where insertion will take place, and another with two cuts that limit the fragment which will be inserted inside the other. Adjusting the most prevalent terminology, we will name the fragment where insertion is carried out

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string x, the fragment which is cut in order to be inserted y and the resultant string z.

The operation is still marked with \$, which simply means mixing and the cut site is marked with #, whereas the replication sign is $\triangleright$. The result is always an only string. What is removed from the cut in the string y turns into unusable fragments, junk.

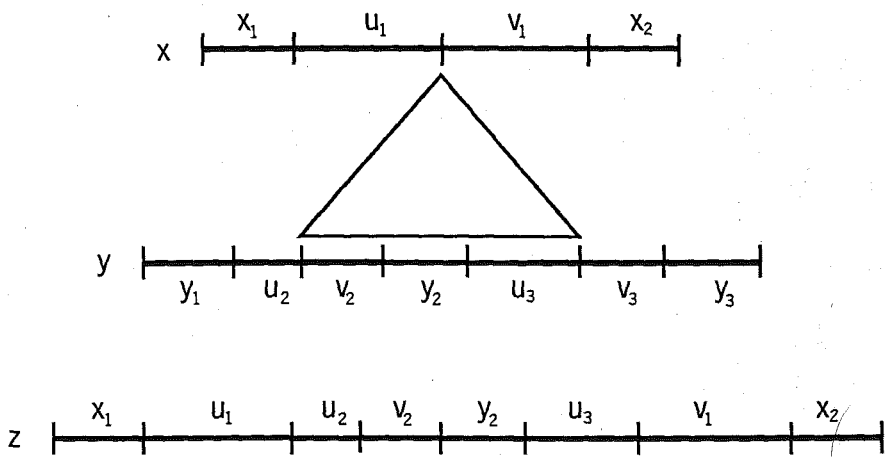

Figure 9.1: Replication

The formal description, carried out by the authors we have named previously, is the following:
for $x, y, z \in V^*$, C_i, $1 \leq i \leq$, finite subsets of $V^*\#V*$ and $1 \leq i \leq n$, we write

$$
\begin{aligned}
(x, y) \triangleright_i z \; iff \; & x = x_1u_1v_1x_2, \\
& y = y_1u_2v_2y_2u_3v_3y_3, \\
& z = x_1u_1v_2y_2u_3v_1x_2, \\
& \text{for } u_1\#v_1, u_2\#v_2, u_3\#v_3 \in C_i, \\
& \text{and } x_1, x_2, y_1, y_2, y_3 \in V^*.
\end{aligned}
$$

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Other interesting formalizations and applications of replication are found in (Mihalache & al., 1996) and (Mihalache & Salomaa, 1996).

9.2 Application of replication to basic stage strings

As we have done in splicing, now we propose to formulate rules that allow us to carry out this operation. Stage strings where we will apply them are basic.

Rules named *replication basic rules*, because they are the necessary and sufficient ones to apply the operation just one time to basic strings, are the following:

1) $x_1\varepsilon \mid sx_2$ / $\#s'\#$

2) $x_1\varepsilon \mid sx_2$ / $\#s'v'\#$

3) $x_1\varepsilon \mid sx_2$ / $\#s'v'o'\#$

4) $x_1\varepsilon \mid sx_2$ / $\#v'o'\#$

5) $x_1\varepsilon \mid sx_2$ / $\#o'\#$

6) $x_1\varepsilon \mid sx_2$ / $\#v'\#$

7) $x_1\varepsilon \mid sx_2$ / $\#s'\#$

8) $x_1\varepsilon \mid sx_2$ / $\#s'v'\#$

9) $x_1\varepsilon \mid sx_2$ / $\#s'v'o'\#$

10) $x_1\varepsilon \mid sx_2$ / $\#v'o'\#$

11) $x_1\varepsilon \mid sx_2$ / $\#o'\#$

12) $x_1\varepsilon \mid sx_2$ / $\#v'\#$

13) $x_1\varepsilon \mid sx_2$ / $\#s'\#$

14) $x_1\varepsilon \mid sx_2$ / $\#s'v'\#$

15) $x_1\varepsilon \mid sx_2$ / $\#s'v'o'\#$

16) $x_1\varepsilon \mid sx_2$ / $\#v'o'\#$

17) $x_1\varepsilon \mid sx_2$ / $\#o'\#$

18) $x_1\varepsilon \mid sx_2$ / $\#v'\#$

19) $x_1\varepsilon \mid sx_2$ / $\#s'\#$

20) $x_1\varepsilon \mid sx_2$ / $\#s'v'\#$

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21)

$x_1\varepsilon$	sx_2
$\#s'v'o'\#$	

22)

$x_1\varepsilon$	sx_2
$\#v'o'\#$	

23)

$x_1\varepsilon$	sx_2
$\#o'\#$	

24)

$x_1\varepsilon$	sx_2
$\#v'\#$	

In this formulation, we have taken the liberty of giving to string y only the right context of the left cut and the left context of the right cut, it is to say, the internal string.

The result of applying replication or insertion of strings with blunt ends is:

RULE	x	\$	y	$\triangleright$	z
1	$x_1\varepsilon\#sx_2$	\$	$\#s'\#$	$\triangleright$	$x_1\varepsilon s's x_2$
2	$x_1\varepsilon\#sx_2$	\$	$\#s'v'\#$	$\triangleright$	$x_1\varepsilon s'v'sx_2$
3	$x_1\varepsilon\#sx_2$	\$	$\#s'v'o'\#'$	$\triangleright$	$x_1\varepsilon s'v'o'sx_2$
4	$x_1\varepsilon\#sx_2$	\$	$\#v'o'\#$	$\triangleright$	$x_1\varepsilon v'o'sx_2$
5	$x_1\varepsilon\#sx_2$	\$	$\#o'\#$	$\triangleright$	$x_1\varepsilon o'sx_2$
6	$x_1\varepsilon\#sx_2$	\$	$\#v'\#$	$\triangleright$	$x_1\varepsilon v'sx_2$
7	$x_1s\#vx_2$	\$	$\#s'\#$	$\triangleright$	$x_1ss'vx_2$
8	$x_1s\#vx_2$	\$	$\#s'v'\#$	$\triangleright$	$x_1ss'v'vx_2$
9	$x_1s\#vx_2$	\$	$\#s'v'o'\#$	$\triangleright$	$x_1ss'v'o'vx_2$
10	$x_1s\#vx_2$	\$	$\#v'o'\#'$	$\triangleright$	$x_1sv'o'vx_2$
11	$x_1s\#vx_2$	\$	$\#o'\#$	$\triangleright$	$x_1so'vx_2$
12	$x_1s\#vx_2$	\$	$\#v'\#$	$\triangleright$	$x_1sv'vx_2$
13	$x_1v\#ox_2$	\$	$\#s'\#$	$\triangleright$	$x_1vs'ox_2$
14	$x_1v\#ox_2$	\$	$\#s'v'\#$	$\triangleright$	$x_1vs'v'ox_2$
15	$x_1v\#ox_2$	\$	$\#s'v'o'\#$	$\triangleright$	$x_1vs'v'o'ox_2$
16	$x_1v\#ox_2$	\$	$\#v'o'\#$	$\triangleright$	$x_1vv'o'ox_2$
17	$x_1v\#ox_2$	\$	$\#o'\#$	$\triangleright$	$x_1vo'ox_2$
18	$x_1v\#ox_2$	\$	$\#v'\#$	$\triangleright$	$x_1vv'ox_2$
19	$x_1o\#\varepsilon x_2$	\$	$\#s'\#$	$\triangleright$	$x_1os'\varepsilon x_2$
20	$x_1o\#\varepsilon x_2$	\$	$\#s'v'\#$	$\triangleright$	$x_1os'v'\varepsilon x_2$

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RULE	x	\$	y	$\triangleright$	z
21	$x_1o\#\varepsilon x_2$	\$	$\#s'v'o'\#$	$\triangleright$	$x_1os'v'o'\varepsilon x_2$
22	$x_1o\#\varepsilon x_2$	\$	$\#v'o'\#$	$\triangleright$	$x_1ov'o'\varepsilon x_2$
23	$x_1o\#\varepsilon x_2$	\$	$\#o'\#$	$\triangleright$	$x_1oo'\varepsilon x_2$
24	$x_1o\#\varepsilon x_2$	\$	$\#v'\#$	$\triangleright$	$x_1ov'\varepsilon x_2$

This formalization, where each end has not yet been replaced by its specific value, shows in a graphic way the fundamental difference between splicing and replication. Splicing changes the whole right context of the string x into the right context of the string y, whereas replication keeps both contexts, right and left, of the string x, and only inserts a fragment of the string y. That is the reason why when we are working with basic strings, there are results obtained by means of replication which are the same, from a structural point of view, to those obtained by means of splicing. And when we are working with compound strings it is not like this in any case. Coincidences of results of both operations with basic stage strings are merely by chance.

After effecting replacements of ends by corresponding foci, the results are the following:

RULE	x	\$	y	$\triangleright$	z
1	$\#svo$	\$	$\#s'\#$	$\triangleright$	$s'svo$
2	$\#svo$	\$	$\#s'v'\#$	$\triangleright$	$s'v'svo$
3	$\#svo$	\$	$\#s'v'o'\#'$	$\triangleright$	$s'v'o'svo$
4	$\#svo$	\$	$\#v'o'\#$	$\triangleright$	$v'o'svo$
5	$\#svo$	\$	$\#o'\#$	$\triangleright$	$o'svo$
6	$\#svo$	\$	$\#v'\#$	$\triangleright$	$v'svo$
7	$s\#vo$	\$	$\#s'\#$	$\triangleright$	$ss'vo$
8	$s\#vo$	\$	$\#s'v'\#$	$\triangleright$	$ss'v'vo$
9	$s\#vo$	\$	$\#s'v'o'\#$	$\triangleright$	$ss'v'o'vo$

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RULE	x	\$	y	$\triangleright$	z
10	$s\#vo$	\$	$\#v'o'\#'$	$\triangleright$	$sv'o'vo$
11	$s\#vo$	\$	$\#o'\#$	$\triangleright$	$so'vo$
12	$s\#vo$	\$	$\#v'\#$	$\triangleright$	$sv'vo$
13	$sv\#o$	\$	$\#s'\#$	$\triangleright$	$svs'o$
14	$sv\#o$	\$	$\#s'v'\#$	$\triangleright$	$svs'v'o$
15	$sv\#o$	\$	$\#s'v'o'\#$	$\triangleright$	$svs'v'o'o$
16	$sv\#o$	\$	$\#v'o'\#$	$\triangleright$	$svv'o'o$
17	$sv\#o$	\$	$\#o'\#$	$\triangleright$	$svo'o$
18	$sv\#o$	\$	$\#v'\#$	$\triangleright$	$svv'o$
19	$svo\#$	\$	$\#s'\#$	$\triangleright$	$svos'$
20	$svo\#$	\$	$\#s'v'\#$	$\triangleright$	$svos'v'$
21	$svo\#$	\$	$\#s'v'o'\#$	$\triangleright$	$svos'v'o'$
22	$svo\#$	\$	$\#v'o'\#$	$\triangleright$	$svov'o'$
23	$svo\#$	\$	$\#o'\#$	$\triangleright$	$svoo'$
24	$svo\#$	\$	$\#v'\#$	$\triangleright$	$svov'$

9.3 Formal analysis of results

From the strings z we have just obtained, the following formal analysis can be carried out:

- About the kind of resulting strings:
  - Obviously, all the strings z are compound because we have inserted new foci to a basic string.
  - Replication is a very powerful operation because it never deletes, every string z is bigger than its preceding one.
  - Rules 1-7, 2-14, 3-21, 12-18, 10-22, 17-23 give structurally identical results but with different distribution of foci proceeding from x and

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y.

- Comparison with splicing results:

  - Only rules that cause two structurally equal strings have a parallel with splicing results (with basic rules), with which they correspond in the following way:

Splicing	**Replication**
5) $ss'v'o'$	1) $s'svo$
	7) $ss'vo$
9) $svs'v'o'$	2) $s'v'svo$
	14) $svs'v'o'$
13) $svos'v'o'$	3) $s'v'o'svo$
	21) $svos'v'o'$
10) $svv'o'$	12) $sv'vo$
	18) $svv'o$
14) $svov'o'$	10) $sv'o'vo$
	22) $svov'o'$
15) $svoo'$	17) $svo'o$
	23) $svoo'$

In spite of being exact in structure, these triplets are not in the distribution of elements proceeding from x and y, except for the pairs 9e) - 14r), 13e) - 21r), 14e) - 22r) i 15e) - 23r). We will name these last pairs *identical* and the remaining relations *analogous*. We will not nullify any of these rules because, as we have affirmed, when operating with compound strings splicing and replication have different results.

- About ghosts:

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- There are ghosts in all resultant strings, except in 4z, 5z, 6z, 11z, 13z, 19z.
- All the arising ghosts are emergent –connector or bounder ones depending on the case– because it is an operation with blunt cuts.
- There is no rule where bounder ghosts arise and connector ghosts cannot due to the second ones being a universalization of the first ones, or the first ones being a restriction of the second ones. Connector ghosts can only arise in: 1), 7), 8), 9), 10), 12), 16), 17), 18), 22) , 23) i 24).). One or the other can arise in: 2), 3), 14), 20), 21). Finally, the rule 15) allows the combination of both ghosts in a single string.
- It is achieved for the first time the appearance of two ghosts by means of a single rule. They are different in 15), and the repeated connector ghost in 8), 9), 15), 16).
- Strings which do not allow ghosts are bad-shaped strings. They distinguish because there is, at least, a repeated focus that does not belong to any friction context as vo in $4z$, o in $5z$ and $11z$, v in $6z$, s in $13z$ and $19z$.

9.4 Formation and correctness criteria of z strings

9.4.1 Ghosts

Emergent, connector or bounder ghosts arise according to the same criteria and conditions expressed in 8.4.1, giving way to spliced structures –bound or connected ones.

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9.4.2 Correctness

In order to establish the correctness of a string made up by means of replication, we will formulate three conditions:

1. Do not contravene the agreement criteria and level assignment.
2. Possiblility in any linguistic situation.
3. To fulfill the precedence: $s \prec v \prec o$

The first two rules are the same previously given to test if a string achieved by means of splicing was correct or not. However, in splicing it is possible to achieve strings that do not fulfill the precedence. Nevertheless, in replication some of the structures z do not follow this criterion and, therefore, rules that cause these kind of strings will be directly labelled with *, which has not happened in splicing in any situation.

However, it is advisable to take into account that a friction context never breaks the precedence rule. In spite of this, distant friction groups, which we will find in replication and cannot be linked by means of a ghost, do.

In general, it can be said that every derived string from a replication rule that does not start from the focus s is a bad-shaped string.

9.5 Systematization and analysis of results

Now, we will go over rule by rule. Since we already know the functioning of ghosts, we will not stop to explain it and we also will not emphasize the strings readjustment rules if new ones fo noy occur. All those strings with results that we have already explained in the splicing section do not deserve our attention either, but we will only point the steps that must be accomplished to reach the string z and give examples of its functioning.

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We will classify the rules in four groups:

- Rules which have a structurally *identical* or *analogous* result to some operation of strict splicing.
- Rules which have as a result a *bad-shaped* string.
- Rules which have as a result a string with a *double ghost.*
- Rules which have as a result a string with a friction group with *filter.*

9.5.1 Rules which have a structurally identical or analogous result to some operation of strict splicing

9.5.1.1 Addition $s + s$

This result is achieved by means of 1) and 7), which are analogous to the splicing rule 5) –see 8.5.2.1– and are configurated by means of the same laws of readjustment:

i. Connector ghost $f\cdot$ between the friction groups (s) $(s') \rightarrow (s \cdot s')$.

ii. Addition s + s by means of the table 8.4 or 8.7.

iii. Creation of a structure σ.

iiii. Therefore, $PN_{v_z} = PN_\sigma$

Rule 1

$$\begin{array}{llllll} \#svo & \$ & \#s'\# & \triangleright & s'svo & \rightarrow \\ & & & \triangleright & (s' \cdot s)vo & \rightarrow \\ & & & \triangleright & \sigma_{PN} v_{PN(\sigma)} o & \end{array}$$

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Rule 7

$$\begin{array}{lllll} s\#vo & \$ & \#s'\# & \triangleright & ss'vo & \rightarrow \\ & & & \triangleright & (s \cdot s')vo & \rightarrow \\ & & & \triangleright & \sigma_{PN}v_{PN(\sigma)}o & \end{array}$$

Example 45

 # En Joan escriu una carta $ # La Maria # compra un llibre ▷ La Maria i en Joan escriuen una carta

John is writing a letter $ # Mary is buying # a book ▷ Mary and John are writing a letter

Example 46

En Joan # escriu una carta $ #La Maria # compra un llibre ▷ En Joan i la Maria escriuen una carta

John # is writing a letter $ #Mary # is buying a book ▷ John and Mary are writing a letter

9.5.1.2 Addition $o + o$

Whereas rule 23) is identical to 15) of splicing –see 8.5.2.2–, and, therefore, works exactly with the same conditions, 17) is only analogous. It will be advisable to analyse if the different configuration of foci in each one can influence in the formation of correct strings.

The final result of the string z depends on $\exists l \parallel l \in \ell(v), l \in^{-} \ell(o), l \in^{-} \ell(o')$. Consequently, we will give the results according to the fulfillment of this condition or not:

9.5.1.2 a) $\exists \mathbf{l} \parallel \mathbf{l} \in \ell(\mathbf{v}), \mathbf{l} \in^{-} \ell(\mathbf{o}), \mathbf{l} \in^{-} \ell(\mathbf{o}')$

In this case, the process already known is the following:

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i. Appearance of $f\cdot$ between the friction groups (o) $(o) \rightarrow (o \cdot o)$.

ii. Creation of a structure ω.

Rule 23

$$\begin{array}{lllll} svo\# & \$ & \#o'\# & \triangleright & svoo' \rightarrow \\ & & & \triangleright & sv(o \cdot o')_l \rightarrow \\ & & & \triangleright & sv\omega \end{array}$$

Rule 17

$$\begin{array}{lllll} sv\#o & \$ & \#o'\# & \triangleright & svo'o \rightarrow \\ & & & \triangleright & sv(o' \cdot o)_l \rightarrow \\ & & & \triangleright & sv\omega \end{array}$$

As it can be seen in:

Example 47

En Joan escriu # una carta $ La Maria compra # un llibre # ▷ En Joan escriu un llibre i una carta

`John is writing # a letter $ Mary is buying # a book # ▷ John is writing a book and a letter`

9.5.1.2 b) $\nexists \mathbf{l} \parallel \mathbf{l} \in \ell(\mathbf{v}), \mathbf{l} \in^{-} \ell(\mathbf{o}), \mathbf{l} \in^{-} \ell(\mathbf{o}')$

This time, the process is:

i. The appearance of $f\cdot$ between the friction groups (o) (o) is impossible.

ii. Optional creation of a structure ϖ.

Rule 23

$$\begin{array}{lllll} svo\# & \$ & \#o'\# & \triangleright & svoo' \rightarrow \\ & & & \triangleright & sv\varpi \end{array}$$

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Rule 17

$$sv\#o \quad \$ \quad \#o'\# \quad \triangleright \quad svo'o \quad \rightarrow$$
$$\triangleright \quad sv\varpi$$

With the results we see in 48 for 23) and in 49 for 17).

Example 48

En Joan escriu una carta # $ La Maria viu # a Barcelona # ▷
En Joan escriu una carta a Barcelona

`John is writing a letter # $ Mary lives # in Barcelona # ▷`
`John is writing a letter in Barcelona`

Example 49

En Joan escriu # una carta $ La Maria viu # a Barcelona # ▷
En Joan escriu a Barcelona una carta

`John is writing # a letter $ Mary lives # in Barcelona # ▷`
`*John is writing in Barcelona a letter`

From where it is clearly considered that only the identical rule to 5) of splicing gives exactly the same results because rule 17, which is analogous, does not work in languages of strict order such as English although it can continue being kept in languages of very free order such as Catalan. Therefore, one can conclude that the parity of levels among foci s of x and y is universally imposed in replication but not in splicing.

9.5.1.3 Addition $v + v$

They give as a result the addition $v+v$ the replication rules 12) and 18) which are analogous to 10) of splicing –see 8.5.2.3. The final structure of the string will depend on $\exists l \parallel l \in \ell(v), l \in \ell(v'), l \in^{-} \ell(o)$. So, we will start from the fulfillment or not of this condition.

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9.5.1.3 a) $\exists \mathbf{l} \parallel \mathbf{l} \in \ell(\mathbf{v}), \mathbf{l} \in \ell(\mathbf{v}'), \mathbf{l} \in^{-} \ell(\mathbf{o})$

For both rules, 12) and 18), it is fulfilled:

i. Appearance of ghost $f\cdot$ in the friction context $(v)\ (v) \rightarrow (v \cdot v)$.

ii. Osmosis $PN(v_y) = PN(v_x)$.

iii. Creation of the structure ξ.

Rule12

$$\begin{array}{lllll} s\#vo & \$ & \#v'\# & \triangleright & sv'vo & \rightarrow \\ & & & \triangleright & s(v' \cdot v)_l o & \rightarrow \\ & & & \triangleright & s\xi o & \end{array}$$

Rule 18

$$\begin{array}{lllll} sv\#o & \$ & \#v'\# & \triangleright & svv'o & \rightarrow \\ & & & \triangleright & s(v \cdot v')_l o & \rightarrow \\ & & & \triangleright & s\xi o & \end{array}$$

Example 50

En Joan # escriu una carta $ *La Maria # compra # un llibre* $\triangleright$
En Joan compra i escriu una carta

`John # is writing a letter` $ `Mary # is buying # a book` $\triangleright$
John is buying and writing a letter.

Example 51

En Joan escriu # una carta $ *La Maria # compra # un llibre* $\triangleright$
En Joan escriu i compra una carta

`John is writing # a letter` $ `Mary # is buying # a book` $\triangleright$
`John is writing and buying a letter`

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9.5.1.3 b) $\nexists \mathbf{l} \parallel \mathbf{l} \in \ell(\mathbf{v}), \mathbf{l} \in \ell(\mathbf{v}'), \mathbf{l} \in^{-} \ell(\mathbf{o})$.

The process is the same for 12) and 18):

i. Appearance of the ghost $f\cdot$ in the friction context $(v)\ (v) \rightarrow (v \cdot v)$.

ii. Osmosis $PN(v_y) = PN(v_x)$.

iii. No creation of the structure ξ.

This mechanism that is applied in the same way to these two rules produces, nevertheless, strings which respond in a different way to the correctness criteria. Rule 12) continues causing suitable results always when: $\odot \in \ell(v_y)$. Then:

Rule 12

$$s\#vo \quad \$ \quad \#v'\# \quad \triangleright \quad sv'vo \quad \rightarrow$$
$$\triangleright \quad sv' \cdot vo$$

Example 52

En Joan # escriu una carta $ *La Maria # canta # una cançó* ▷
En Joan canta i escriu una carta
`John # is writing a letter` $ `Mary # is singing # a song` ▷
John is singing and writing a letter.

Whereas 18) always makes wrong strings:

Rule 18

$$sv\#o \quad \$ \quad \#v'\# \quad \triangleright \quad svv'o \quad \rightarrow$$
$$\triangleright \quad *sv \cdot v'o$$

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Example 53

En Joan escriu # una carta $ La Maria # viu# a Barcelona $\triangleright$
**En Joan escriu i viu una carta*

`John is writing # a letter $ Mary # lives # in Barcelona` $\triangleright$
`*John is writing and lives a letter`

9.5.1.4 Addition $sv + sv$

The concatenation of the friction group (sv) in string z supports the appearance of a connector $f\cdot$ or bounder $f\star$ ghost. Whereas rule 14) is identical to 9) of splicing –see 8.5.2.4–, rule 2) is analogous. This difference of order will not cause, however, divergent results.

The readjustment of foci of the string z is very simple, and consists of an only step:

i. Appearance of ghost $f\cdot$ or $f\star$ in the friction context $(sv)\ (sv) \rightarrow (sv) \smile (sv)$

Since the appearance of $f\cdot$ or $f\star$ will not have any implication in the correctness of z, we will pay attention mainly to another fact that affects this condition: $\odot \in \ell(v)$ in the first friction group.

9.5.1.4 a) $\odot \in \ell(\mathrm{v})$ in the first friction group.

Rule 2

$$\begin{array}{llll} \#svo\ \$ & \#s'v'\# & \triangleright & s'v'svo \quad \rightarrow \\ & \text{a)} & \triangleright & s'v' \cdot svo \\ & \text{b)} & \triangleright & s'v' \star svo \end{array}$$

According to the examples 54 and 55.

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Rule 14

$$\begin{array}{lllll} sv\#o & \$ & \#s'v'\# & \triangleright & svs'v'o \quad \rightarrow \\ & & \text{a)} & \triangleright & sv \cdot s'v'o \\ & & \text{b)} & \triangleright & sv \star s'v'o \end{array}$$

As it can be seen 56 and 57.

Example 54

a) *En Joan escriu # una carta* $ *#La Maria compra # un llibre* ▷
En Joan escriu i la Maria compra una carta

`John is writing # a letter $ # Mary is buying # a book ▷`
`John is writing and Mary is buying a letter`

Example 55

b) *En Joan escriu # una carta* $ *#La Maria compra # un llibre* ▷
En Joan escriu perquè la Maria compra una carta

`John is writing # a letter $ # Mary is buying # a book ▷`
`John is writing because Mary is buying a letter`

Example 56

a) *# En Joan escriu una carta* $ *#La Maria compra # un llibre* ▷
La Maria compra i en Joan escriu una carta

`# John is writing a letter $ #Mary is buying # a book ▷`
`Mary is buying and John is writing a letter`

Example 57

b) *# En Joan escriu una carta* $ *#La Maria compra # un llibre* ▷
La Maria compra perquè en Joan escriu una carta

`# John is writing a letter $ #Mary is buying # a book ▷`
`Mary is buying because Jonn is writing a letter`

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9.5.1.4 b) $\odot \notin \ell(\mathrm{v})$ in the first friction group.

Then, none of the results obtained with either of the two rules is correct:

Regla 2

$$\begin{array}{lllll} \#svo & \$ & \#s'v'\# & \triangleright & s'v'svo \quad \rightarrow \\ & & \text{a)} & \triangleright & *s'v' \cdot svo \\ & & \text{b)} & \triangleright & *s'v' \star svo \end{array}$$

As it is shown in the example 58.

Rule 14

$$\begin{array}{lllll} sv\#o & \$ & \#s'v'\# & \triangleright & svs'v'o \quad \rightarrow \\ & & \text{a)} & \triangleright & *sv \cdot s'v'o \\ & & \text{b)} & \triangleright & *sv \star s'v'o \end{array}$$

As it is checked in the example 59.

Example 58

b) # *En Joan escriu una carta* $ #*La Maria fa* # *soroll* ▷
**La Maria fa perquè en Joan escriu una carta*
`John is writing a letter` $ # `Mary is making` # `noise` ▷
`*Mary is making because John is buying a letter`

Example 59

b) *En Joan fa* # *soroll* $ #*La Maria compra* # *un llibre* ▷
**En Joan fa perquè la Maria compra una carta*
`John is making` # `noise` $ # `Mary is buying` # `a book` ▷
`*John is making because Mary is buying a letter`

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9.5.1.5 Addition $vo + vo$

As all the rules that cause results with an addition of elements, 10) and 22) have a referent in 14) of splicing –see 8.5.2.5–. Whereas 22) is identical to 14), 10) is analogous.

The friction context (vo) (vo) only allows the appearance of $f\cdot$, taking into account that it happens without any kind of restriction. The fact that the link is so universal entails that 22) as well as 10), in spite of its distributional differences, have exact results to 14) of splicing relating to the strings readjustment.

The process of cohesion of the rule is the following:

i. Appearance of $f\cdot$ between the friction groups (vo) $(vo) \rightarrow (vo) \cdot (vo)$.

ii. Osmosis: $PN(v_y) = PN(v_x)$.

Rule 10

$$s\#vo \quad \$ \quad \#v'o'\#' \quad \triangleright \quad sv'o'vo \quad \rightarrow$$
$$\triangleright \quad sv'o' \cdot vo$$

Rule 22

$$svo\# \quad \$ \quad \#v'o'\# \quad \triangleright \quad svov'o' \quad \rightarrow$$
$$\triangleright \quad svo \cdot v'o'$$

Example 60

En Joan # escriu una carta $ Aquestes noies # compren un llibre # ▷

En Joan compra un llibre i escriu una carta

`John # is writing a letter $ These girls # are buying a book # ▷`

`John is buying a book and writing a letter`

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Example 61

En Joan escriu una carta # $ La Maria #compra un llibre # ▷ En Joan escriu una carta i compra un llibre

`John is writing a letter # $ Mary # is buying a book # ▷ John is writing a letter and buying a book`

9.5.1.6 Addition $svo + svo$

3) is analogous to 13) of splicing, whereas 21) is identical, without having any repercussion in the string z because readjustment does not exist in any of these rules. z is consolidated only with:

i. Appearance of $f \smile$ in the friction context $(svo)\ (svo) \rightarrow (svo) \smile (svo)$.

where $f \smile$ can be $f\cdot$ or $f\star$. In such a way that the rule could be rewritten $x \cdot y$ o $y \star x$.

Rule 3

$$\begin{array}{llll} \#svo \ \$ \ \#s'v'o'\#' & \triangleright & s'v'o'svo & \rightarrow \\ & \triangleright & (s'v'o') \smile (svo): & \\ \quad a) & \triangleright & y \cdot x & \\ \quad b) & \triangleright & y \star x & \end{array}$$

According to the exemples 62 and 63.

Rule 21

$$\begin{array}{llll} svo\# \ \$ \ \#s'v'o'\#' & \triangleright & svos'v'o' & \rightarrow \\ & \triangleright & (svo) \smile (s'v'o'): & \\ \quad a) & \triangleright & x \cdot y & \\ \quad b) & \triangleright & x \star y & \end{array}$$

Results that 64 and 65 reflect.

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Example 62

a) # *En Joan escriu una carta* $ #*La Maria compra un llibre* # ▷
La Maria compra un llibre i en Joan escriu una carta
`John is writing a letter` $ #`Mary is buying a book` # ▷
`Mary is buying a book and John is writing a letter`

Example 63

b) # *En Joan escriu una carta* $ #*La Maria compra un llibre* # ▷
La Maria compra un llibre perquè en Joan escriu una carta
`John is writing a letter` $ #`Mary is buying a book` # ▷
`Mary is buying a book because John is writing a letter`

Example 64

a) *En Joan escriu una carta* # $ #*La Maria compra un llibre* # ▷
En Joan escriu una carta i la Maria compra un llibre
`John is writing a letter` # $ #`Mary is buying a book` # ▷
`John is writing a letter and Mary is buying a book`

Example 65

b) *En Joan escriu una carta* # $ #*La Maria compra un llibre* # ▷
En Joan escriu una carta perquè la Maria compra un llibre
`John is writing a letter` # $ #`Mary is buying a book` # ▷
`John is writing a letter because Mary is buying a book`

9.5.2 Rules that have as a result ill-formed strings

One of the main differences between replication and splicing is that the last method does not have any rule that systematically produces ill-formed strings. However, there exist rules in replication whose results must be marked with an asterisk from the very beginning. This is due to some of the following two facts or to the combination of both of them:

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- Resultant strings z do not begin with s.
- Friction groups are far away. We have already pointed out that friction groups are the only elements to which it is allowed to impose over precedence thanks to the action of ghosts.

9.5.2.1 Distant friction context $(vo)(vo)$

This distant context is only found in rule 4). Since both groups vo are separated by an s, friction context does not exist. That is the reason why the appearance of a ghost is impossible with which values PN of v' do not have any referent for the agreement.

$4z$ is a ill-formed string.

Rule 4

$$\#svo \quad \$ \quad \#v'o'\# \quad \triangleright \quad {}^{*}v'o'svo$$

Example 66

\# *En Joan escriu una carta* \$ *La Maria #compra un llibre #* ▷
**Comprar un llibre en Joan escriu una carta*

\# `John is writing a letter` \$ `Mary #is buying a book #` ▷
**To buy a book John is writing a letter*

9.5.2.2 Distant friction context (o) (o)

Rules 5) and 11) show this malformation in their resultant string z. As in the previous example, (o) (o) do not form friction context because they are separated by sv, foci that prevent the appearance of the ghost.

Rule 5

$$\#svo \quad \$ \quad \#o'\# \quad \triangleright \quad {}^{*}o'svo$$

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Example 67

En Joan escriu una carta $ *La Maria compra* # *un llibre* # ▷
**Un llibre en Joan escriu una carta*

`John is writing a letter` $ `Mary is buying` # `a book` # ▷
`*A book John is writing a letter`

Rule 11

$$s\#vo \quad \$ \quad \#o'\# \quad \triangleright \quad {}^{*}so'vo$$

Example 68

En Joan # *escriu una carta* $ *La Maria compra* # *un llibre* # ▷
**En Joan un llibre escriu una carta*

`John` # `is writing a letter` $ `Mary is buying` # `a book` # ▷
`*John a book is writing a letter`

9.5.2.3 Distant friction context (v) (v)

In spite of the power of foci v in 6), they cannot exceed the presence of s among them because this last one is not a filter focus in any case.

Rule 6

$$\#svo \quad \$ \quad \#v'\# \quad \triangleright \quad {}^{*}v'svo$$

Example 69

En Joan escriu una carta $ *La Maria* # *compra* # *un llibre* ▷
**Comprar en Joan escriu una carta*

`John is writing a letter` $ `Mary` # `is buying` # `a book` ▷
`*To buy John is writing a letter`

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9.5.2.4 Distant friction context (s) (s)

If we solely rely on the rule that a string must start on the focus s it would be correct. However, the presence of v between (s) (s) prevents the appearance of the ghost which causes that the results of rules 13) and 19) are always incorrect.

Rule 13

$$sv\#o \quad \$ \quad \#s'\# \quad \triangleright \quad *svs'o$$

Example 70

En Joan escriu # una carta $ *#La Maria # compra un llibre* ▷
**En Joan escriu la Maria una carta*

`John is writing # a letter $ # Mary # is buying a book ▷`
`*John is writing Mary a letter`

Rule 19

$$svo\# \quad \$ \quad \#s'\# \quad \triangleright \quad *svos'$$

Example 71

En Joan escriu una carta # $ *#La Maria # compra un llibre* ▷
**En Joan escriu una carta la Maria*

`John is writing a letter # $ # Mary # is buying a book ▷`
`*John is writing a letter Mary`

9.5.3 Rules that have as a result strings with double ghosts

Besides mal-formations, there is a set of rules which, applied to basic stage strings, cause a new result with respect to the splicing ones. The important

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innovation is the appearance of two ghosts at the same time that, given the friction contexts, must both be emergent ones.

Strings z that we will now analyze show a double addition, although sometimes readjustments that each one entails affect the other one and the results cannot be presented as a simple gathering of the frictions we have seen in 9.5.1.

These are structures of great complexity concerning the internal relations among foci which enter in a combinatory multiplication creating difficulty in controlling the correlation of terminal strings.

9.5.3.1 Friction contexts $(s)(s)$ / $(v)(v)$

Rule 8) is the only one that offers the combination of friction contexts $(s)(s)$ / $(v)(v)$. In one and in the other, $f\cdot$ only fits. As we have already seen several times, the formation of multiple subjects does not cause any problem. However, consecutive foci v do.

We will distinguish in the results of 8) if $l||l \in \ell(v_x), l \in \ell(v_y), l \in^{-} \ell(o_x)$ exists or not.

9.5.3.1 a) $\exists \mathbf{l}||\mathbf{l} \in \ell(\mathbf{v_x}), \mathbf{l} \in \ell(\mathbf{v_y}), \mathbf{l} \in^{-} \ell(\mathbf{o_x})$

Then, the resultant of the application of the rule and the readjustment process of the string until arriving to the final result is:

i. Appearance of connector ghosts between $(s)(s) \rightarrow (s \cdot s)$ and $(v)(v) \rightarrow (v \cdot v)$.

ii. Formation of σ, with values PN taken from $s \cdot s$.

iii. Formation of the group ξ.

iv. Osmosis: $PN(\xi) = PN(\sigma)$

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Rule 8

$$\begin{array}{llllll} s\#vo & \$ & \#s'v'\# & \triangleright & ss'v'vo & \rightarrow \\ & & & \triangleright & s \cdot s'v' \cdot vo & \rightarrow \\ & & & \triangleright & \sigma_{PN}\xi o & \rightarrow \\ & & & \triangleright & \sigma_{PN}\xi_{PN(\sigma)}o & \end{array}$$

Example 72

En Joan # escriu una carta $ #La Maria compra # un llibre ▷ En Joan i la Maria compren i escriuen una carta

`John # is writing a letter $ # Mary is buying # a book ▷ John and Mary are buying and writing a letter`

9.5.3.1 b) $\nexists \mathbf{l} \| \mathbf{l} \in \ell(\mathbf{v_x}), \mathbf{l} \in \ell(\mathbf{v_y}), \mathbf{l} \in^{-} \ell(\mathbf{o_x})$

Then, it is required that $\odot \in \ell(v_y)$. If it is so, the process of consolidation of the string is the following:

i. Appearance of connector ghosts between $(s)(s) \rightarrow (s \cdot s)$ and $(v)(v) \rightarrow (v \cdot v)$.

ii. Formation of σ, with values PN taken from $s \cdot s$.

iii. Osmosis: $PN(v_x, v_y) = PN(\sigma)$

Rule 8

$$\begin{array}{llllll} s\#vo & \$ & \#s'v'\# & \triangleright & ss'v'vo & \rightarrow \\ & & & \triangleright & s \cdot s'v' \cdot vo & \rightarrow \\ & & & \triangleright & \sigma_{PN}v'vo & \rightarrow \\ & & & \triangleright & \sigma_{PN}v'_{PN(\sigma)}v_{PN(\sigma)}o & \end{array}$$

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Example 73

En Joan # escriu una carta $ #La Maria parla # del temps ▷
En Joan i la Maria parlen i escriuen una carta

`John # is writing a letter $ # Mary is talking # about the weather ▷`
`John and Mary are talking and writing a letter`

On the contrary case, if $\odot \notin \ell(v_y)$, then the result is not correct and the strings readjustement cannot be carried out.

9.5.3.2 Friction contexts (s) (s) / (vo) (vo)

Rule 9) presents a solution that generates the emergency of two ghosts, both of them connectors, among the friction groups (s) (s) / (vo) (vo). In one as well as in the other, their appearance is universal, therefore:

i. Appearance of $f\cdot$ between $(s)(s) \rightarrow (s \cdot s)$ and $(vo)(vo) \rightarrow (vo \cdot vo)$.

ii. Creation of σ.

iii. $PN(v_y) = PN(\sigma)$.

iv. Osmosis: $PN(v_x) = PN(v_y)$.

Rule 9

$$\begin{array}{llll} s\#vo \;\; \$ \;\; \#s'v'o'\# & \triangleright & ss'v'o'vo & \rightarrow \\ & \triangleright & s \cdot s'v'o' \cdot vo & \rightarrow \\ & \triangleright & \sigma v'o' \cdot vo & \rightarrow \\ & \triangleright & \sigma_{PN} v'_{PN(\sigma)} o' \cdot v_{PN(\sigma)} o & \end{array}$$

Example 74

En Joan # escriu una carta $ #La Maria compra un llibre# ▷
En Joan i la Maria compren un llibre i escriuen una carta

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John # is writing a letter $ # Mary is buying a book# ▷
John and Mary are buying a book and writing a letter

9.5.3.3 Friction contexts $(sv)(sv)$ / $(o)(o)$

Rule 15), which causes the friction groups (sv) (sv) / (s) (o) is probably the one with the most interesting result with basic stage strings. The final disposition of foci makes possible the appearance of two ghosts at the same time that can be either connector or bounder - connector ghosts because the friction context (sv) (sv) allows both of them. We will take our base from the hypothesis that $\odot \in \ell(v_x)$. On the contrary case, the result is always incorrect.
Although $\odot \in \ell(v_x)$ is fulfilled, there can also be two possibilities for $(o' \cdot o)$: that $l \parallel l \in \ell(v_y)$ $l \in \ell(o_y)$, $l \in \ell(o_x)$, exists or that such condition is not fulfilled. Let's begin with the affirmative case.

9.5.3.3 a) $\exists \mathbf{l} \parallel \mathbf{l} \in \ell(\mathbf{v_y}),\ \mathbf{l} \in \ell(\mathbf{o_y}),\ \mathbf{l} \in \ell(\mathbf{o_x})$

Then the rule is solved:

i. Appearance of ghosts, $f\cdot, f\cdot$, or $f\star, f\cdot$ in the contexts $(s)(s) \rightarrow (s \smile s)$, $(o)(o) \rightarrow (o \smile o)$.

ii. Creation of the group ω

Rule 15

$$
\begin{array}{llllll}
sv\#o & \$ & \#s'v'o'\# & \triangleright & svs'v'o'o & \rightarrow \\
 & & & \triangleright & sv \smile s'v'o' \cdot o & \rightarrow \\
 & & & \triangleright & sv \smile s'v'\omega: & \\
 & & \text{a)} & \triangleright & sv \cdot s'v'\omega & \\
 & & \text{b)} & \triangleright & sv \star s'v'\omega &
\end{array}
$$

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Example 75

a) *En Joan escriu # una carta* $ *#La Maria compra un llibre #* $\triangleright$
En Joan escriu i la Maria compra un llibre i una carta
`John is writing # a letter` $ `# Mary is buying a book #` $\triangleright$
`John is writing and Mary is buying a book and a letter`

Example 76

b) *En Joan escriu # una carta* $ *#La Maria compra un llibre #* $\triangleright$
En Joan escriu perquè la Maria compra un llibre i una carta
`John is writing # a letter` $ `# Mary is buying a book #` $\triangleright$
`John is writing because Mary is buying a book and a letter`

9.5.3.3 b) $\nexists \mathbf{l} \parallel \mathbf{l} \in \ell(\mathbf{v_y}),\ \mathbf{l} \in \ell(\mathbf{o_y}),\ \mathbf{l} \in \ell(\mathbf{o_x})$

Then, it is needed that $L \in^{-} \ell(o_x)$ and, due to that, a ghost cannot arise linking two structures o denoted by a different level, creation of ϖ. Having to count with the following process:

- Appearance of $f\cdot$ or $f\star$ between $(sv)(sv) \rightarrow (sv \smile sv)$.
- Creation of the group ϖ

Rule 15

$$
\begin{array}{llll}
sv\#o & \$ \quad \#s'v'o'\# & \triangleright & svs'v'o'o \quad \rightarrow \\
 & & \triangleright & sv \smile s'v'o'o \quad \rightarrow \\
 & & \triangleright & sv \smile s'v'\varpi: \\
 & \text{a)} & \triangleright & sv \cdot s'v'\varpi \\
 & \text{b)} & \triangleright & sv \star s'v'\varpi
\end{array}
$$

Example 77

a) *En Joan parla # per la tele* $ *#La Maria compra un llibre #* $\triangleright$

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En Joan parla i la Maria compra un llibre per la tele

`John is talking # on television $ # Mary is buying a book #` ▷

`John is talking and Mary is buying a book on television`

Example 78

b) En Joan parla # per la tele $ #La Maria compra un llibre # ▷

En Joan parla perquè la Maria compra un llibre per la tele

`John is talking # on television $ # Mary is buying a book #` ▷

`John is talking because Mary is buying a book on television`

9.5.3.4 Friction contexts $(v)(v)$ / $(o)(o)$

Resultant strings obtained by means of 16) also show two friction contexts $(v)(v)$, $(o)(o)$. Only connector ghosts can arise among these groups. Besides, if the two foci (o) that will make the context, do not have in common any level, which is compatible with foci (v), then the emergence of the second ghost gets blocked. There are two conditions in order that the final result is a well-shaped string:

1. For $(v_x \cdot v_y)$ the following must be accomplished:

   (a) $\odot \in \ell(v) \vee$

   (b) $\exists l \mid l \in \ell(v_x),\ l \in \ell(v_y),\ l \in^{-} \ell(o_y)$

2. Relating to $o_x o_y$ it is advisable that $\exists l \mid l \in^{-} \ell(o_x),\ l \in^{-} ell(o_y)$

From all the solutions that can arise from different combinations of these conditions, we will only pay attention to those two that have as a result correct strings:

a) $l(v_x) = l(v_y) \ \rightarrow\ l(o_x) = l(o_y)$

b) $l(v_x) \neq l(v_y),\ l(o_x) \neq l(o_y),\ \odot \in \ell(v_x),\ L \in^{-} \ell(o_x)$

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9.5.3.4 a) $\mathbf{l(v_x) = l(v_y) \rightarrow l(o_x) = l(o_y)}$

Then it follows:

i. Appearance of ghosts $f\cdot$ between the two friction contexts $(v)(v) \rightarrow (vv)$, $(o)(o) \rightarrow (o \cdot o)$.

ii. Creation of the structure ξ where, by osmosis $PN(\xi) = PN(v_x)$.

iii. Creation of ω.

Rule 16

$$\begin{array}{llllll} sv\#o & \$ & \#v'o'\# & \triangleright & svv'o'o & \rightarrow \\ & & & \triangleright & sv \cdot v'o' \cdot o & \rightarrow \\ & & & \triangleright & s\xi\omega & \rightarrow \\ & & & \triangleright & s\xi_{PN(s)}\omega & \end{array}$$

As we see in 79.

Example 79

En Joan escriu # una carta $ La Maria # compra un llibre # ▷ En Joan escriu i compra un llibre i una carta

`John is writing # a letter $ Mary # is buying a book # ▷` *John is writing and buying a book and a letter*

9.5.3.4 b) $\mathbf{l(v_x) \neq l(v_y),\ l(o_x) \neq l(o_y),\ \odot \in \ell(v_x)\ L \in^{-} \ell(o_x)}$

Then it follows:

i. Appearance of ghost $f\cdot$ between the friction group $(v)(v) \rightarrow (v \cdot v)$.

ii. Blockade to the appearance of ghosts in $(o)(o)$.

iii. By osmosis, $PN(v_y) = PN(v_x)$.

iv. Creation of ϖ.

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Rule 16

$$\begin{array}{lllll} sv\#o \quad \$ \quad \#v'o'\# & \triangleright & svv'o'o & \rightarrow \\ & \triangleright & sv \cdot v'o'o & \rightarrow \\ & \triangleright & sv \cdot v'\varpi & \rightarrow \\ & \triangleright & svv'_{PN(v)}\varpi & \end{array}$$

Example 80

En Joan parla # per la tele $ *La Maria # compra un llibre #* ▷ *En Joan parla i compra un llibre per la tele*

`John is talking # on television` $ `Mary # is buying a book #` ▷ *John is writing and buying a book on television*

9.5.4 Rules that have as a result a string with a friction group with filter

For the first time, we are in front of a friction context with filter. The combination of foci that cause this phenomenon does not have to correlate in splicing. Therefore, we examine for the first time syntactic results that can be caused.

9.5.4.1 Friction context $(sv)o(sv)$

The friction group (sv), as well as (v), are extremely powerful, whereas o is a focus that does not obstruct friction among contexts placed in one and another site. That is the reason why a ghost can arise here, and besides, due to the features of the friction group, it can be connector(a), or bounder (b), with the only requirement that $\odot \in \ell(v_y)$.

If the condition $\odot \in \ell(v_y)$, is fulfilled, then the process of readjustment of foci within the string z is that easy:

i. Appearance of the ghost between the two friction groups $((sv)o)(sv) \rightarrow (svo \smile sv)$

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Rule 20

$$\begin{array}{llll} svo\# & \$ & \#s'v'\# & \triangleright \quad svo \smile s'v': \\ & & \text{a)} & \triangleright \quad svo \cdot s'v' \\ & & \text{b)} & \triangleright \quad svo \star s'v' \end{array}$$

Example 81

a) *En Joan escriu una carta # $ #La Maria compra # un llibre* ▷
En Joan escriu una carta i La Maria compra

`John is writing a letter # $ # Mary is buying # a book` ▷
`John is writing a letter and Mary is buying`

Example 82

b) *En Joan escriu una carta # $ #La Maria compra # un llibre* ▷
En Joan escriu una carta perquè La Maria compra

`John is writing a letter # $ # Mary is buying # a book` ▷
`John is writing a letter because Mary is buying`

9.5.4.2 Friction context $(v)o(v)$

Rule 24), which causes this friction context with filter, works essentially as rule 20), with the requirement that $\odot \in \ell(v_y)$, but with two differences:

- Only a connector ghost can be applied.
- Necessity of osmosis.

Therefore, if condition $\odot \in \ell(v_y)$, is fulfilled, then in order that z is a well-shaped string it is necessary:

i. Appearance of ghost $f\cdot$ between the two friction groups $((v)o)(v) \rightarrow (v)o \cdot (v)$

ii. Osmosis: $PN(v_y) = PN(v_x)$

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Rule 24

$$svo\# \quad \$ \quad \#v'\# \quad \triangleright \quad svo \cdot v' \quad \rightarrow$$
$$\triangleright \quad svo \cdot v'_{PN(v)}$$

Example 83

En Joan escriu una carta # $ *La Maria* # *compra* # *un llibre* ▷ *En Joan escriu una carta i compra*

John is writing a letter # $ Mary # is buying # a book ▷ John is writing a letter and buying

9.6 Conclusions

9.6.1 Final rules

RULE	x	$	y	▷	z	
1	$\#svo$	$	$\#s'\#$	▷	$\sigma v_{PN(\sigma)} o$	
2	$\#svo$	$	$\#s'v'\#$	▷	a) $s'v' \smile svo$	iff $\odot \in \ell(v_y)$
				▷	b) $^*s'v' \smile svo$	iff $\odot \notin \ell(v_y)$
3	$\#svo$	$	$\#s'v'o'\#'$	▷	$s'v'o' \smile svo$	
4	$\#svo$	$	$\#v'o'\#$	▷	$^*v'o'svo$	
5	$\#svo$	$	$\#o'\#$	▷	$^*o'svo$	
6	$\#svo$	$	$\#v'\#$	▷	$^*v'svo$	
7	$s\#vo$	$	$\#s'\#$	▷	$\sigma v_{PN(\sigma)} o$	
8	$s\#vo$	$	$\#s'v'\#$	▷	$\sigma \xi o$	iff $\exists l \parallel l \in \ell(v_x)$, $l \in \ell(v_y)$, $l \in \ell(o_x)$
				▷	$\sigma v'_{PN(\sigma)} v_{PN(\sigma)} o$	iff $\nexists l \parallel l \in \ell(v_x)$, $l \in \ell(v_y)$, $l \in \ell(o_x)$
9	$s\#vo$	$	$\#s'v'o'\#$	▷	$\sigma v'_{PN(\sigma)} o' v_{PN(\sigma)} o$	
10	$s\#vo$	$	$\#v'o'\#'$	▷	$sv'o' \cdot vo$	
11	$s\#vo$	$	$\#o'\#$	▷	$^*so'vo$	

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RULE	x	\$	y	$\triangleright$	z	
12	$s\#vo$	\$	$\#v'\#$	$\triangleright$	$s\xi o$	iff $\exists l \mid l \in \ell(v_x)$, $l \in \ell(v_y)$, $l \in^- \ell(o_x)$
				$\triangleright$	$sv'vo$	iff $\nexists l \mid l \in \ell(v_x)$, $l \in \ell(v_y)$, $lin^-\ell(o_x)$, $\odot \in \ell(v_y)$
13	$sv\#o$	\$	$\#s'\#$	$\triangleright$	$^*svs'o$	
14	$sv\#o$	\$	$\#s'v'\#$	$\triangleright$	$sv \smile s'v'o$	iff $\odot \in \ell(v_x)$
				$\triangleright$	b) $^*sv \smile s'v'o$	iff $\odot \notin \ell(v_x)$
15	$sv\#o$	\$	$\#s'v'o'\#$	$\triangleright$	$sv \smile s'v'\omega$	iff $\exists l \mid l \in \ell(v_y)$, $l \in^- \ell(o_y)$, $l \in^- \ell(o_x)$
				$\triangleright$	$sv \smile s'v'\varpi$	iff $\nexists l \mid l \in \ell(v_y)$, $l \in^- \ell(o_y)$, $l \in^- \ell(o_x)$
16	$sv\#o$	\$	$\#v'o'\#$	$\triangleright$	a) $s\xi\omega$	iff $l(v_x) = l(v_y) \rightarrow l(o_x) = l(o_y)$
				$\triangleright$	b) $svv'\varpi$	iff $l(v_x) \neq l(v_y), l(o_x) \neq l(o_y)$, $\odot \in \ell(v_x), L \in^- \ell(o_x)$
17	$sv\#o$	\$	$\#o'\#$	$\triangleright$	$sv\omega$	iff $\exists l \mid l \in \ell(v_x)$, $l \in^- \ell(o_x)$, $l \in^- \ell(o_y)$
				$\triangleright$	$sv\varpi$	iff $\nexists l \mid l \in \ell(v_x)$, $l \in^- \ell(o_x)$, $l \in^- \ell(o_y)$
18	$sv\#o$	\$	$\#v'\#$	$\triangleright$	$s\xi o$	iff $\exists l \mid l \in \ell(v_x)$, $l \in \ell(v_y)$, $l \in^- \ell(o_x)$
				$\triangleright$	$^*svv'o$	iff $\nexists l \mid l \in \ell(v_x)$, $l \in \ell(v_y)$, $l \in^- \ell(o_x)$
19	$svo\#$	\$	$\#s'\#$	$\triangleright$	$^*svos'$	
20	$svo\#$	\$	$\#s'v'\#$	$\triangleright$	$svo \smile s'v'$	iff $\odot \in \ell(v_y)$
21	$svo\#$	\$	$\#s'v'o'\#$	$\triangleright$	$svo \smile s'v'o'$	
22	$svo\#$	\$	$\#v'o'\#$	$\triangleright$	$svo \cdot v'o'$	
23	$svo\#$	\$	$\#o'\#$	$\triangleright$	$sv\omega$	iff $\exists l \mid l \in \ell(v_x)$, $l \in^- \ell(o_x)$, $l \in^- \ell(o_y)$
				$\triangleright$	$sv\varpi$	iff $\nexists l \mid l \in \ell(v_x)$, $l \in^- \ell(o_x)$, $l \in^- \ell(o_y)$
24	$svo\#$	\$	$\#v'\#$	$\triangleright$	$svo \cdot v'$	iff $\odot \in \ell(v_y)$

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9.6.2 Ghosts

In this chapter we have learnt or checked new ideas about ghosts:

- In replication, there are ghosts that act in friction contexts with filter.
- There can be more than one ghost in a resultant string caused by a single operation.
- Two kinds of different ghosts can be obtained in a single operation.

9.6.3 Comparison of syntactic results obtained by means of splicing and replication

Sentences that can be generated by means of splicing and replication are the same ones: solely all the spliced operations of a language, whichever they are. Therefore, replication does not carry anything with respect to splicing in relation to the syntactic phenomena that it can cover, but it is a mechanism that generates complex sentences in a very clearly different way.

Summarizing, we can say than splicing and replication differ in:

- Replication is much more powerful that splicing because:
  - every resultant string z increases in length with respect to the previous one. That fact did not happen in splicing which was able to create resultant strings equal to stage strings, or even shorter ones,
  - in a single operation of replication, sentences with two links can be generated,
  - There exist friction contexts with filter.
- Replication is more dangerous than splicing because:

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  - operating with basic strings, some of their rules generate systematically incorrect strings,
  - complexity, in strings' readjustment rules, when they present two ghosts, is notable.

- Splicing is a clearly recombinant method, whereas replication is close to insertion.

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Chapter 10

Controlled Splicing

10.1 Theoretical bases: methods with meaning preservation

The idea which controlled splicing is based on is the construction of operations that preserve the meaning of stage strings . It is to say, taking $\bowtie$ as a symbol of the operation, it is necessary that given two stage strings x and y:

$$\text{meaning } \bowtie_{(x,y)} = \text{meaning } x + \text{meaning } y$$

Occasionally, arbitrary systems carry out this premise: if we apply a splicing rule $o\#\varepsilon\$\varepsilon\#s$ to two strings $x = svo$ and $y = s'v'o'$, then $z = svo \cdot s'v'o'$ clearly preserves the meaning. But there is no way to achieve the adjustment of all the results.

To introduce a recombination method that insures the fulfillment of the previous rule, we have no alternative but dispensing with arbitrariness.

Then, the cut by means of recognition is introduced. It takes place when stage strings have an element in common; otherwise the process does not become activated. As we already know that $\mathcal{S} \cap \mathcal{O} = \mathcal{I}$, it may occur that

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some focus s is equal to some focus o. Instead, as $\mathcal{V} \cap (\mathcal{S} \cup \mathcal{O}) = \varnothing$, then any focus belonging to $\mathcal{V}$ cannot exist which is equal to any other $\notin \mathcal{V}$. We are not referring to foci belonging to the domain of the same variable but equal foci. It is to say, foci $\in \mathcal{U}$, which we name equal, must have the same elements and in the same order. For instance, in Catalan the phrase *el noi* (`the boy`) $\in \mathcal{S}$ and *el noi* (`the boy`)$\in \mathcal{O}$ is an equal focus belonging to $\mathcal{I}$ that may coincide in two x, y different strings. When formalizing, we will only denote $s = o'$ because we have not detailed the analysis of internal structures of phrases, and foci are only syntagmatic types. In order that a focus $u \in (\mathcal{S} \cup \mathcal{O})$ is considered equal to another $u' \in \mathcal{S} \cup \mathcal{O}$, it is advisable that $PN(u) = PN(u')$. Therefore, the focus *el noi* (`the boy` is not equal to *els nois* (`the boys`).

In order that a focus $u \in \mathcal{V}$ is considered equal to focus u' in $\mathcal{V}$ it is advisable that $TPN(u) = TPN(u')$. We have introduced the parameter time in the focal agreement. It means that *dormo* (`sleep`) is not equal to *dormia* (`slept`) because T does not have the same values in both foci. In the same way, *dorm* (`sleeps`) is not equal to *dormen* (`sleep`) because there is not coincidence in PN.

From what we have said, it follows that the existence of two types of systems are necessary with preservation of meaning:

- Central systems: in which there is coincidence among foci belonging to $\mathcal{V}$ in the strings x and y.

- Lateral systems: in which there can be equality among foci belonging to $\mathcal{S} \cup \mathcal{O}$ in the strings x and y.

Both methods have still another essential difference, the kind of cut.

- Central systems: coincidence causes a complex blunt cut on the right and on the left of v.

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- Lateral systems: coincidence causes a staggered simple cut of 1 in depth.

Therefore, we can distinguish two operations:

- **Controlled splicing**: complex links of blunt cut by means of recognition of v, which correspond to central systems.
- **Sticker links**: simple links with staggered cut by means of recognition of foci $\mathcal{S} \cup \mathcal{V}$, which are based on lateral systems.

In this chapter we will analyse controlled splicing, which is included within splicing. In the next chapter [11] we will consider sticker structures which take part of cohesive systems.

The goal of controlled splicing is the formation of multiple subjects and objects.

10.2 Formalization

Up to now, there is not any genetical model that helps to formalize this operation, neither has it been expressed by Computer Science because it is not possible to construct computational systems with meaning.
Controlled splicing is defined as follows:
for two linguistic strings $x = s_1, v_1, o_1$, $y = s_2 v_2 o_2$, $x, y \in \mathcal{U}^*$ a rule r : if $v_1 = v_2 \rightarrow \bowtie_{x,y}$ and a symbol $\bowtie \notin \mathcal{U}^*$:

$$\begin{aligned} (x,y) \bowtie_r z \quad \text{iff} \quad & x = s_1 v_1 o_1 \\ & y = s_2 v_2 o_2 \\ & z = s_1 s_2 v_1 o_1 o_2 \\ & z \in \mathcal{U}^* \end{aligned}$$

The graphic representation is the following:

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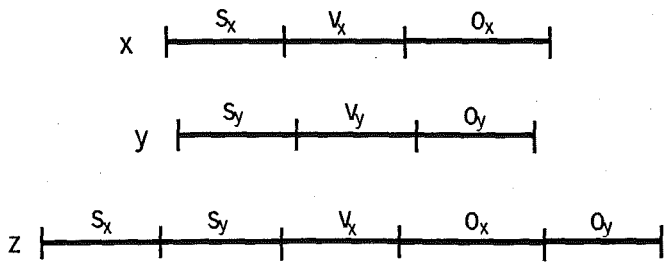

Figure 10.1: controlled splicing

10.3 Features of controlled splicing

10.3.1 Kinds of cut

In the controlled splicing, the cut applied to a string has three essential features:

1. It is caused by recognition of v.
2. It is blunt.
3. It is complex.

The cut is only caused by the coincidence of a focus in two different strings. In controlled splicing systems the recognition takes place among foci belonging to $\mathcal{V}$. If this condition is carried out, then the rule starts acting and causes a blunt cut in the sides of v:

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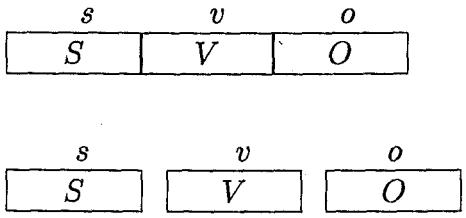

Figure 10.2: Complex cut by recognition of v within a ULPS

As we see in 10.2, the string is absolutely divided, setting apart $\begin{pmatrix} v \\ V \end{pmatrix}$ without cutting any pole. This fact allows us to work on strings without it being necessary to refer to poles, because a variable always corresponds to every focus.

Obviously, it is also a complex mechanism due to:

$$\text{Cut}\begin{pmatrix} v \\ V \end{pmatrix} = \text{Cut}\begin{pmatrix} s \\ S \end{pmatrix} + \text{Cut}\begin{pmatrix} o \\ O \end{pmatrix}$$

10.3.1.1 Extension of the recognition

Controlled splicing operations only work if $v_x = v_y$. However, the recognition may be extended to foci s and o. For instance, if $v_x = v_y$, $PN(v_{x,y}) = 1s$ then $s_x = s_y$. Therefore, considering the existence of cut systems by recognition of sv is compulsory. Due to the fact that extension to foci $\in \mathcal{S}$ is compulsory, we will also accept it for foci $\in \mathcal{O}$. Nevertheless, it is always necessary that $v_x = v_y$: if this condition is not carried out, then no operation is impossible. So, there are three kinds of recognition between two strings x, y:

- recognition of v,
- recognition of sv,
- recognition of vo,