

# Applicative and Combinatory Categorical Grammar: Analysis of the French Interrogative Sentences

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## Abstract

The Applicative and Combinatory Categorical Grammar (ACCG) (Biskri, Desclés, 1995) is included in the general three-level model of Applicative and Cognitive Grammar (Desclés, 1990). It connects the first level, that contains concatenated expressions of natural languages, and the second level, with applicative expressions that describe the functional semantic interpretation of the first level expressions. This paper is about a first work on the possibility of extending the ACCG model for the analysis of French interrogative sentences.

## 1. Introduction

Linguistic expressions of natural languages are concatenated linguistic units considered as operators or operands. The linguistic units are arranged according to French syntagmatic rules, here. The *functional semantic interpretation* of the expressions restores the internal operator-operand order owing to an *applicative expression*. The Universal Applicative Grammar (Shaumyan, 1987) is a two-level linguistic model for the natural language analysis. The Applicative and Cognitive Grammar (ACG) (Desclés, 1990) extends this model by adding a third cognitive level. The three analysis levels of the ACG are:

- the *morpho-syntactical configurations* level. It contains the linguistic expressions that we can directly observe in each particular natural language.
- the *logical and grammatical representations* level. It tries to draw the semiotic invariants of natural languages. The functional semantic interpretations are constructed here, in the shape of applicative representations.
- the *semantic and cognitive representations* level. Semantic cognitive schemes analyze the meanings of the second-level linguistic units.

*Categorical Grammars* make the connection between the first and the second level of the ACG. These models are typed applicative systems that verify if a linguistic expression is syntactically well-formed, and then construct

its functional semantic interpretation. They use the *fundamental operation of application* of an operator to an operand. The result is a new operand or a new operator. This operation can be repeated as many times as necessary to construct the linguistic expressions' functional semantic representation. This representation takes the shape of a bracket prefixed expression, where the operator is always on the left of its operand. For an automatic treatment, every linguistic unit receives a *syntactic functional type*. This type informs about the unit syntactic category, indicating if it acts like operand or operator, and in this case, with what sort of categories it can be combined. So we can do a calculus on the types without worrying about the associated linguistic units. This calculus verifies if a linguistic unit organisation is well-formed, and then constructs its functional semantic representation. The first Categorical Grammars appear with Ajdukiewicz's (1935) and Bar-Hillel's (1953) works. They take the dichotomy between complete-meaning *categorematic* expressions, and incomplete-meaning *syncategorematic* expressions, outlined by Husserl (1913) then Lesniewski (1922). We have here the difference between respectively the operand units and the operator units. Ajdukiewicz and Bar-Hillel's model of *simple Categorical Grammars* is called *AB system*. They have only one possible operation for the type calculus. Lambek (1958, 1961) developed a more important system for calculus on functional syntactic types. The simple Categorical Grammars aim is to verify for a particular natural language if a sentence is correct, using only two type reduction rules. If we obtain the *S (sentence)* type, the sentence is well-formed. With Bach's and Steedman's works, they construct in addition the functional semantic representation of these sentences. The Steedman's Combinatory Categorical Grammar (CCG) (1989) is an extension of the simple Categorical Grammars. It uses a *left to right incremental analysis* model, with powerful *combinatory rules*, lambda-calculus and unification method. The combinatory rules are semantic and syntactic at once. They allow the composition between two units. The Biskri's and Desclés's Applicative and Combinatory Categorical Grammar abandons the use of unification, and introduces the Curry's and Feys' combinatory logic and its combinators (Curry, Feys, 1958).

We will first develop the ACCG model working. We will then describe how to treat French interrogative sentences with this model.

## 2. Applicative and Combinatory Categorical Grammar

The *Applicative and Combinatory Categorical Grammar* has been made to improve the CCG system and to extend the set of sentences that can be analysed. It establishes a canonical association between Steedman's combinatory rules and Curry's combinators. This association implies a two steps processing in the ACCG:

- the ACCG *applicative and combinatory rules* verify the good syntactic connexion of the sentence while introducing combinators in the applicative representation.
- then the combinators are reduced to give the functional semantic interpretation of the sentence. This step is totally included in the ACG second level.

In the ACCG model, the applicative and combinatory rules allow a *quasi-incremental analysis from left to right*, and the introduction of Curry's combinators allows a dynamic construction of the second-level applicative expressions. The ACCG contains also metarules to control the use of the type-raising rules that are used notably for the quasi-incremental analysis. We first describe the ACCG's type system. We then briefly introduce the combinatory logic's combinators. We finally present the rules and the metarules of the model.

### 2.1 The type system

Biskri and Desclés use the same notion of type, or category, as in the simple Categorical Grammars. The syntactic functional type system contains:

- Two constructive operators: / and \
- Basic types in finite number:  
*S* (*sentence*), sentence type  
*N* (*noun*), nominal phrase type  
*N\**, complete nominal phrase type (*N\** is a subset of *N*)  
*CONJD* and *CONJN*, respectively the distributive and the non-distributive conjunction types.

- Derived types, theoretically in infinite number, constructed with two rules:

basic types are types

if **X** and **Y** are types, then **X/Y** and **X\Y** are types.

In this paper, we use Steedman's notation: the operand type is always to the right of the constructive operator, and the result to the left. For example, **X\Y** is an operator type whose typed operand **Y** is positioned on the left of the operator. The result of the application to its operand is a unit with the type **X**.

### 2.2 The Combinatory Logic

With the combinatory logic, the ACCG doesn't need unification like in Steedman's model. The combinatory logic uses combinators, i.e. abstract operators that build compound operators using elementary or compound operators. The action of these combinators is described in *β-reduction* rules (Curry). These rules create a link between an expression with combinators, and an equivalent expression without combinators, without worrying about the unit meaning. We present some combinators used in the ACCG and there *β-reduction* rules:

- Composition combinator **B**: *β-reduction*: **B** f g x ≥ f (g x)
- Type-raising combinator **C\***: *β-reduction*: **C\*** X Y ≥ Y X
- permutation combinator **C**: *β-reduction*: **C** f y x ≥ f x y
- Substitution combinator **S**: *β-reduction*: **S** f g x ≥ f x (g x)
- Etc.

When they are used in the ACCG, the combinators are used in a typed applicative system: they are all typed.

### 2.3 Applicative Combinatory rules

In the notation, the symbol « - » notes the concatenation, and the square brackets [ ] note unit delimitation. The premises in each rule are typed concatenated linguistic units. The result is an applicative expression that can not be reduced anymore.

The ACCG model contains the both application rules of the simple Categorical Grammars.

$$\frac{[X/Y: u1]-[Y: u2]}{\text{-----}(>)} \quad \frac{[X: u1]-[Y\X: u2]}{\text{-----}(<)}$$

$$\frac{[X: (u1 u2)]}{\text{-----}(>)} \quad \frac{[Y: (u2 u1)]}{\text{-----}(<)}$$

We now present the ACCG applicative combinatory rules:

$$\frac{[X/Y: u1]-[Y/Z: u2]}{\text{-----}(>B)} \quad \frac{[X/Y: u1]-[Y\Z: u2]}{\text{-----}(>Bx)}$$

$$\frac{[X/Z: (B u1 u2)]}{\text{-----}(>B)}$$

$$\frac{[Y/Z: u1]-[X\Y: u2]}{\text{-----}(<B)} \quad \frac{[Y/Z: u1]-[X\Y: u2]}{\text{-----}(<Bx)}$$

$$\frac{[X/Z: (B u2 u1)]}{\text{-----}(<B)}$$

$$\frac{[(X/Y)\Z: u1]-[Y/Z: u2]}{\text{-----}(>S)} \quad \frac{[(X\Y)\Z: u1]-[Y/Z: u2]}{\text{-----}(>Sx)}$$

$$\frac{[X/Z: (S u1 u2)]}{\text{-----}(>S)}$$

$$\frac{[Y/Z: u1]-[(X\Y)\Z: u2]}{\text{-----}(<S)} \quad \frac{[Y/Z: u1]-[(X\Y)\Z: u2]}{\text{-----}(<Sx)}$$

$$\frac{[X/Z: (S u2 u1)]}{\text{-----}(<S)}$$

$$\frac{[X: u]}{\text{-----}(>T)} \quad \frac{[X: u]}{\text{-----}(>Tx)}$$

$$\frac{[Y/(Y\X): (C* u)]}{\text{-----}(>T)}$$

$$\frac{[X: u]}{\text{-----}(<T)} \quad \frac{[X: u]}{\text{-----}(<Tx)}$$

$$\frac{[Y/(Y\X): (C* u)]}{\text{-----}(<T)}$$

The *metarules* control when a type-raising rule has to be applied and choose which type-raising to apply.

Let us take u1 and u2, linguistic units in the concatenated expression « u1-u2 » (Biskri, Desclés, 1995):

**Metarule 1:** If u1 has type  $N^*$  and u2 has type  $(Y \setminus N^*)/Z$ , then we apply the forward type-raising ( $>T$ ) to u1:

$[N^*: u1 \rightarrow Y/(Y \setminus N^*): (C^* u1)]$

**Metarule 2:** If u1 has type  $X$  and u2 has type  $(Y \setminus X)/Z$ , then we apply the forward type-raising ( $>T$ ) to u1:

$[X: u1 \rightarrow Y/(Y \setminus X): (C^* u1)]$

**Metarule 3:** If u2 has type  $N^*$  and u1 has type  $(Y \setminus N^*) \setminus X$ , then we apply the backward type-raising ( $<T$ ) to u2:

$[N^*: u2 \rightarrow Y \setminus (Y \setminus N^*): (C^* u2)]$

**Metarule 4:** If u2 has type  $N^*$  and u1 has type  $Y/S$ , then we apply the forward type-raising ( $>T$ ) to u2:

$[N^*: u2 \rightarrow S/(S \setminus N^*): (C^* u2)]$

These metarules have to produce types that can be used in an applicative combinatory rule.

## 2.4 Quasi-incremental analysis and Structural reorganization

The applicative combinatory rules allow to use a *quasi-incremental strategy from left to right*, that solves the *spurious ambiguity* problem that is when several analyses lead to the same functional semantic interpretation for an unambiguous sentence. But sometimes we need an *intelligent backtracking*, to analyse backward modifiers for example. Biskri purposes a *structural reorganization*. The principle is to decompose the constituent already constructed in two components whose one of them may be combined with the backward modifier (Biskri, Desclés, 1995).

The operation of structural reorganization has two steps:

- The reorganization of the constituent. We reduce the combinators. At each time, two sub-categories are constructed. We test if one of these sub-categories can be combined with the backward modifier. We repeat the process until the test is positive.
- The decomposition of the category, using two rules that are the opposite of the applicative rules ( $>$ ) and ( $<$ ):

$[X: (u1 u2)]$                        $[X: (u1 u2)]$   
-----( $>dec$ )                      -----( $<dec$ )  
 $[X/Y: u1]-[Y: u2]$                $[Y: u2]-[X \setminus Y: u1]$

The choice of the rule to apply depends on the operator syntactic type, and more precisely on its constructive operator direction.

These points are illustrated in the analysis of the interrogative sentences. For more explanations, see Biskri (1995).

## 3. French interrogative sentences analysis with the ACCG

Applicative and Combinatory Categorical Grammar already analyses a lot of French sentences. We will tempt to extend this model in order to analyse the French interrogative sentences.

There are different question types:

- The Yes/No questions with set phrases: (1) *Y a-t-il des réductions? (Is it reductions?)*

- The Yes/No questions that begin with a verb: (2) *Acceptez-vous les animaux? (Do you accept animals?)*
- The Yes/No questions without alteration of the French canonical order of the units, with eventually the presence of a clitic: (3) *Le bus arrive-t-il bientôt? (The bus is it arriving soon?)*
- The Wh-questions on a facultative complement of the verb: (4) *A quelle heure ferme le musée? (At what time is the museum closing?)*
- The Wh-questions on an obligatory complement of the verb: (5) *Comment s'appelle ce bâtiment? (What is the name of this building?)*

Even if they are numerous, we will not analyse here sentences with impersonal expressions, in order to make the analysis easier. These cases are analysed in Rossi (2007). We make the hypothesis, that the interrogative sentences including impersonal expressions can be analysed with the rules we will see here, by analysing the impersonal expression content. The problem is not only to verify the syntactic form of the sentences, but more to build the good functional semantic interpretation of these interrogative sentences.

We first discuss the interrogative sentence type, we indicate then the use that we do of the metarules and of the contextual exploration method. We finally describe how to analyse the different question types.

### 3.1 Interrogative sentence type

The only stable indication of the French interrogative mode is the question mark “?”, always at the end of the sentence. This punctuation has to be considered like the other units. We are here in a types system, so we assign a specific type to this unit. The general sentence type is  $S$ . Questions are sentences with an interrogative mode in addition. So, we attribute to the interrogative sentences the type:  $S_{int}$ , considered like a subset of  $S$ . To obtain this type, we assign to the question mark “?” the type  $S_{int} \setminus S$ .

### 3.2 Contextual exploration and metarules

The contextual exploration is a method to identify semantic values in a text. It distinguishes two unit types: the *indicator* and the *marks*. The *indicator* contains the semantic of what is searched: quotations, encounters, etc. The *marks* are here to remove ambiguities. The contextual exploration concerns a particular research space, for example the sentence, the paragraph, etc.

In Categorical Grammars, metarules are a restrictive contextual exploration, because the context explored is limited to the units contiguous to the indicator. We will extend the use of contextual exploration to the space of the entire sentence in the ACCG, to perform the analysis of the French interrogative sentences. So we verify at the beginning of the analysis if the sentence is finished by a question mark “?”. If the question mark is present, all the rules for the question analysis can be applied. On the other case, no question rule is applied. Some phenomenon in the sentence is only used in interrogative sentences. The

contextual exploration introduced in the metarules forbids these constructions in declarative sentences, but not in interrogative sentences. If there is a question mark at the end of the sentence, the indicator, and we detect a phenomenon specific to questions, so we are in an interrogative sentence, and we can apply metarules for questions.

We will now present the metarules necessary to analyse the French interrogative sentences.

Let us take u1 and u2 in the concatenated expression « u1-u2 ».

**Metarule ?1:** If u1 has type (S\X)/Y and u2 has type X, and the question mark “?” appears at the end of the sentence, then we apply the rule (>C) to u1:

[(S\X)/Y: u1 → (S/Y)\X: (C u1)]

**Metarule ?2:** If u1 has type Y and u2 has type (S\X)/Y, and the question mark “?” appears at the end of the sentence, then we apply the rule (<?1>) to u2:

[(S\X)/Y: u2 → (S/X)\Y: u2]

**Metarule ?3:** If u1 has type X\Y and u2 has type Y or Y/N, and the question mark “?” appears at the end of the sentence, then we apply the rule (<?2>) to u1:

[X\Y: u1 → X/Y: u1]

These metarules are used in the following analyses.

### 3.3 Analysis of the interrogative sentences

We will now see how to analyse the different types of question that we draw.

**Wh-questions.** The Wh-questions are about one element of the sentence. This component can be a facultative or an obligatory complement of the verb. In these questions, the component that is the center of the question is at the first position. Then there is the verb and its other complements.

The Wh-questions can concern an *obligatory complement of the verb*. In general, they concern the verb complement that is not the subject: the object, the attribute, etc. In the functional semantic representation, the subject is the second operand of the verb, and the object is the first. The units order in these questions is inversed regarding to the French canonical order. We observe the order: Object-Verb-Subject. We have to create a rule that indicates the order changes by inverting the application orientation of the verb’s constructive operators. This rule is applied only if the following unit has N\* type, to prove that it is the subject of the verb. This condition is contained in the *metarule ?2*. We infer the rule:

[(S\X)/Y: u]  
-----(<?1>)  
[(S/X)\Y: u]

We analyse the sentence (5) *Comment s’appelle ce bâtiment?* (What is the name of this building?)

1 [N\*: comment]-[(S\N\*)/N\*: s’appelle]-[N\*/N: ce]-[N: bâtiment]-[S<sub>int</sub>\S: ?] *types attribution*

2 [N\*: comment]-[(S\N\*)/N\*: s’appelle]-[N\*/N: ce]-[N: bâtiment]-[S<sub>int</sub>\S: ?] (<?1>)

3 [S/N\*: (s’appelle comment)]-[N\*/N: ce]-[N: bâtiment]-[S<sub>int</sub>\S: ?] (<)

4 [S/N: (B (s’appelle comment) ce)]-[N: bâtiment]-[S<sub>int</sub>\S: ?] (>B)

5 [S: ((B (s’appelle comment) ce) bâtiment)]-[S<sub>int</sub>\S: ?] (>)

6 [S<sub>int</sub>: (? ((B (s’appelle comment) ce) bâtiment))] (<)

7 [S<sub>int</sub>: (? ((B (s’appelle comment) ce) bâtiment))]

8 [S<sub>int</sub>: (? ((s’appelle comment) (ce bâtiment)))] B

In the analysis, the line “-----” indicates the passage to the second level of the ACG, the logical and grammatical representation level.

In the first step, the contextual exploration indicates us that we are in an interrogative sentence, with the “?”. The first unit has type N\*, and the second unit is an operator that waits for an N\* unit on its right. We are in the case of the *metarule ?2*, so we apply the (<?1>) rule to the second unit, inverting its constructive operators.

The Wh-questions about the subject are particular. They are indicated by the pronoun *qui* (*who*). This pronoun is closely bound to the verb. It receives the type: S/(S\N\*), like the subject clitic. We take the example of the sentence (6) *Qui nettoie la salle?* (*Who is cleaning the room?*).

1 [S/(S\N\*): qui]-[(S\N\*)/N\*: nettoie]-[N\*/N: la]-[N: salle]-[S<sub>int</sub>\S: ?] *types attribution*

2 [S/N\*: (B qui nettoie)]-[N\*/N: la]-[N: salle]-[S<sub>int</sub>\S: ?] (>B)

3 [S/N: (B (B qui nettoie) la)]-[N: salle]-[S<sub>int</sub>\S: ?] (>B)

4 [S: ((B (B qui nettoie) la) salle)]-[S<sub>int</sub>\S: ?] (>)

5 [S<sub>int</sub>: (? ((B (B qui nettoie) la) salle))] (<)

6 [S<sub>int</sub>: (? ((B (B qui nettoie) la) salle))]

7 [S<sub>int</sub>: (? ((B qui nettoie) (la salle)))] B

8 [S<sub>int</sub>: (? (qui nettoie (la salle)))] B

The Wh-questions can also concern a *facultative complement of the verb*. We can not analyse this type of questions with a *transitive verb*, because of the problem of the forward modifiers, not completely analysed in the ACCG. The problem does not exist with the sentences with *intransitive verbs*. We just have to indicate that the operand of the verb appears to its right. The following rule describes this phenomenon:

[X\Y: u]  
-----(<?2>)  
[X/Y: u]

Example: (4) *A quelle heure ferme le musée?* (*At what time is the museum closing?*)

1 [(S/S)/N\*: à]-[N\*/N: quelle]-[N: heure]-[S\N\*: ferme]-[N\*/N: le]-[N: musée]-[S<sub>int</sub>\S: ?] *types attribution*

2 [(S/S)/N: (B à quelle)]-[N: heure]-[S\N\*: ferme]-[N\*/N: le]-[N: musée]-[S<sub>int</sub>\S: ?] (>B)

3 [S/S: ((B à quelle) heure)]-[S\N\*: ferme]-[N\*/N: le]-[N: musée]-[S<sub>int</sub>\S: ?] (>)

4 [S\N\*: (B ((B à quelle) heure) ferme)]-[N\*/N: le]-[N: musée]-[S<sub>int</sub>\S: ?] (>Bx)

5 [S/N\*: (B ((B à quelle) heure) ferme)]-[N\*/N: le]-[N: musée]-[S<sub>int</sub>\S: ?] (<?2>)

6 [S/N: (B (B ((B à quelle) heure) ferme) le)]-[N: musée]-[S<sub>int</sub>\S: ?] (>B)

7 [S: ((B (B ((B à quelle) heure) ferme) le) musée)]-  
[S<sub>int</sub>\S:?) (>)  
8 [S<sub>int</sub>: (? ((B (B ((B à quelle) heure) ferme) le) musée))]  
(<)

9 [S<sub>int</sub>: (? ((B (B ((B à quelle) heure) ferme) le) musée))]  
10 [S<sub>int</sub>: (? ((B ((B à quelle) heure) ferme) (le musée)))] B  
11 [S<sub>int</sub>: (? (((B à quelle) heure) (ferme (le musée))))] B  
12 [S<sub>int</sub>: (? ((à (quelle heure)) (ferme (le musée))))] B

In the step 4, the analysis can not continue. But, we can apply the *metarule* ?3. The contextual exploration finds the question mark at the end of the sentence. The first unit is an operator that waits for an N\* unit to its left. This unit is on the right in questions. So we apply the (<?2>) rule.

**Yes/No questions.** In the Yes/No questions, the interrogation is about the entire sentence. There are three possibilities to express a Yes/No question.

Some questions contain a *set phrase at the beginning* of the sentence, like: *est-ce (is it), est-ce que, y a-t-il (is there)*. We consider these expressions like set phrases because when we use these expressions, we don't carry about the meaning of every word, but we consider the meaning of all the expression, that is « this is a question about... ».

The analysis of these sentences depends on the type assigned to the set phrases. « est-ce que » is an operator that waits for an operand with the type S on the right. We assign to the unit « est-ce que » the type S/S. « est-ce » (« is it ») and « y a-t-il » (« is there ») are operators that wait for an operand with the type N\* to the right. They receive the type S/N\*. This is the question mark “?” at the end of the sentence which indicates that this is a question, of type S<sub>int</sub>. These constructions have to be more precisely analyzed. We can assign them a particular type, but we have to study more precisely the implications of this decision, in term of compatibility between S and S<sub>int</sub> types. We analyse the sentence: (1) *Y a-t-il des réductions? (Is it reductions?)*

1 [S/N\*: Y a-t-il]-[N\*/N: des]-[N: réductions]-[S<sub>int</sub>\S:?)  
*types attribution*  
2 [S/N: (B Y a-t-il des)]-[N: réductions]-[S<sub>int</sub>\S:?) (>B)  
3 [S: ((B Y a-t-il des) réductions)]-[S<sub>int</sub>\S:?) (>)  
4 [S<sub>int</sub>: (? ((B Y a-t-il des) réductions))] (<)

5 [S<sub>int</sub>: (? ((B Y a-t-il des) réductions))]  
6 [S<sub>int</sub>: (? (Y a-t-il (des réductions)))] B

The Yes/No questions can be signalized with the *inversion of the subject*, and the verb in first position. The French canonical order of the linguistic units is Subject-Verb-Object (SVO). In this type of questions the order is Verb-Subject-Object (VSO). We have to build rules to account for two phenomena:

- The inversion of the operands order. We have to introduce the permutation combinator C. that inverse the two arguments of the operator. The rule (>C) is:  
[(S\X)/Y: u]  
-----(>C)  
[(S/Y)\X: (C u)]

- The position of the subject, at the right of the verb, like in the Wh-questions on a facultative complement, with the same <?2> rule, to take into account this frequent interrogative phenomenon. Here is the analysis of (2) *Acceptez-vous les animaux? (Do you accept animals?)*

1 [(S\N\*)/N\*: acceptez]-[N\*: vous]-[N\*/N: les]-[N: animaux]-[S<sub>int</sub>\S:?)  
*types attribution*  
2 [(S\N\*)/N\*: (C acceptez)]-[N\*: vous]-[N\*/N: les]-[N: animaux]-[S<sub>int</sub>\S:?) (>C)  
3 [(S\N\*)/N\*: (C acceptez)]-[N\*: vous]-[N\*/N: les]-[N: animaux]-[S<sub>int</sub>\S:?) (< ?2>)  
4 [S/N\*: ((C acceptez) vous)]-[N\*/N: les]-[N: animaux]-[S<sub>int</sub>\S:?) (>)  
5 [S/N: (B ((C acceptez) vous) les)]-[N: animaux]-[S<sub>int</sub>\S:?) (>B)  
6 [S: ((B ((C acceptez) vous) les) animaux)]-[S<sub>int</sub>\S:?) (>)  
7 [S<sub>int</sub>: (? ((B ((C acceptez) vous) les) animaux))] (<)

8 [S<sub>int</sub>: (? ((B ((C acceptez) vous) les) animaux))]  
9 [S<sub>int</sub>: (? (((C acceptez) vous) (les animaux)))] B  
10 [S<sub>int</sub>: (? ((acceptez (les animaux)) vous))] C

In the first step, the unit « [(S\N\*)/N\*: acceptez] », is waiting for two units of type N\*. But the two N\* units are inverted. We see with the contextual exploration, that there is a “?” in the right context. So we are in the case of the *metarule* ?1, and we apply the permutation rule (>C) that modifies the orientation of the constructive operators, and inverse the position of the operands, at the step 2. The subject is at the right of the verb. We are in the case of the *metarule* ?3, and we change the orientation of the constructive operator to apply first, at the step 3.

Finally, the Yes/No questions can be indicated *only by the presence of the question mark “?”*. If they contain a transitive verb, they are close to another question type that takes the order: Object-Verb-Subject. For example, the sentence *La gare est proche? (The station is near?)* is close to *Où est la gare? (Where is the station?)*. There is interference between the two types. We found no solution to this problem. So, our system can not analyze these Yes/No questions with transitive verb.

We need no particular rule to analyze Yes/No questions only indicated by the question mark, with an intransitive verb. A clitic can be introduced after the verb, to remember the French question characteristic: the inversion of the subject. The clitic is bound to the verb, so its type is: (S\N\*)(S\N\*). We analyse the sentence: (3) *Le bus arrive-t-il bientôt? (The bus is it arriving soon?)*

1 [N\*/N: le]-[N: bus]-[S\N\*: arrive]-[(S\N\*)(S\N\*): -t-il]-  
[(S\N\*)(S\N\*): bientôt]-[S<sub>int</sub>\S:?)  
*types attribution*  
2 [N\*: (le bus)]-[S\N\*: arrive]-[(S\N\*)(S\N\*): -t-il]-  
[(S\N\*)(S\N\*): bientôt]-[S<sub>int</sub>\S:?) (>)  
3 [S: (arrive (le bus))]-[(S\N\*)(S\N\*): -t-il]-  
[(S\N\*)(S\N\*): bientôt]-[S<sub>int</sub>\S:?) (<)  
4 [N\*: (le bus)]-[S\N\*: arrive]-[(S\N\*)(S\N\*): -t-il]-  
[(S\N\*)(S\N\*): bientôt]-[S<sub>int</sub>\S:?) (<dec)  
5 [N\*: (le bus)]-[S\N\*: (-t-il arrive)]-[(S\N\*)(S\N\*):  
bientôt]-[S<sub>int</sub>\S:?) (<)

6 [S: ((-t-il arrive) (le bus))]-[(S\N\*)(S\N\*): bientôt]-[S<sub>int</sub>\S:?] (<)  
 7 [N\*: (le bus)]-[S\N\*: (-t-il arrive)]-[(S\N\*)(S\N\*): bientôt]-[S<sub>int</sub>\S:?] (<dec)  
 8 [N\*: (le bus)]-[S\N\*: (bientôt (-t-il arrive))]-[S<sub>int</sub>\S:?] (<)  
 9 [S: ((bientôt (-t-il arrive)) (le bus))]-[S<sub>int</sub>\S:?] (<)  
 10 [S<sub>int</sub>: (? ((bientôt (-t-il arrive)) (le bus)))] (<)

-----  
 11 [S<sub>int</sub>: (? ((bientôt (-t-il arrive)) (le bus)))]

**Rules used in the French interrogative sentence analysis.** We sum up here the rules that we draw to analyse the interrogative sentences.

Rule for Yes/No questions with inversion of the subject:

[(S\X)\Y: u]  
 -----(>C)

[(S\Y)\X: (C u)]

Rule for Wh-questions about an obligatory complement of the verb:

[(S\X)\Y: u]  
 -----(<?1>)

[(S\X)\Y: u]

Rule for Wh-questions on a facultative complement of the verb and Yes/No questions with inversion of the subject:

[X\Y: u]  
 -----(<?2>)

[X\Y: u]

#### 4. Conclusion

There are some researches about the interrogative sentences using models near to the Categorical Grammars, but not really with (the Categorical Grammars). In this paper, we studied the French interrogative sentences with the Applicative and Combinatory Categorical Grammar of Desclés and Biskri that takes place in the general model of the Applicative and Cognitive Grammar of Desclés. For this, we introduce a new type  $S_{int}$  that indicates a subset of sentences with an interrogative mode. We add also rules to translate the changes in the French units' canonical order. It doesn't necessarily introduce a combinator. We add new metarules to control the application of these rules. We also introduce the use of the contextual exploration method that is developed independently of the Categorical Grammars. It extends the context of the metarules to all the units and not only to the contiguous units. This work has been implemented with success in the Caml language, to improve its fiability. In this system, there is a function that control if the question mark is present. If that's true, then we look at the questions metarules to eventually apply.

To treat completely the questions, other works about backward modifiers, clitics and impersonal expressions (Lazarov, 2007) has to be integrated to this work. The subordination and the infinitives have to be analysed in a quasi-incremental case. In the future, the ACCG has to be extended to treat even more sentences. Finally, we succeed to connect the interrogative sentences of the ACG first level with their functional semantic representation of the logical and grammatical representation level. We have to

search now how to analyse these representations of the second level in the third cognitive level of the ACG.

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