Psycholinguistically-based Selection of Analyses in IPS and FIPS

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1   Introduction

It has often been noted that one of the main drawbacks of non-deterministic NL-parsing lies in the exponentially growing number of alternatives that can be computed for a given sentence. Moreover, if non-determinism gives the parser some degree of robustness, it goes against the basic requirements of NL-parsing, namely efficiency and parsimony. Last but not least, a completely non-deterministic parser could hardly be dubbed "psychologically plausible", as computing all possible interpretations for a sentence makes it difficult to model the systematic interpretation preferences that have been shown to hold in human processing.

If determinism constitutes the most radical solution to efficiency and some well-known psychological-plausibility problems such as conscious garden-path effects (see a.o. Marcus 1980, Milne 1988, Berwick & Weinberg 1984), various forms of limited non-determinism have also been proposed in the literature to constrain the production of alternatives and to yield the correct analysis for a given sentence as efficiently and parsimoniously as possible. For instance, preferred analyses can be derived from specific attachment constraints like the *Minimal Attachment* and *Late Closure* strategies in the sequential model defended by Frazier 1978, or from a given complexity metrics via a ranking mechanism, as suggested by Gibson 1991. Just like Frazier's and Gibson's models, the interactive parsing model under development at the LATL relies on limited non-determinism. However, it differs from Frazier's processing model in its objectives, that are not strictly psycholinguistic but also practical. More precisely, psycholinguistic knowledge is being integrated into an implemented parser that underlies various practical applications such as an automatic translation system, for instance. It also differs from Gibson's model in that the strategies used to determine the rank of concurrent analyses are not strictly based on complexity and processing-overload considerations.

In the present technical report, I discuss the various strategies underlying the ranking device that is associated in IPS and FIPS (henceforth F/IPS) with a parallel treatment of alternatives to achieve limited non-determinism. Specifically, in cases of ambiguity, all alternatives are computed and the preferred analysis is defined as such on the basis of attachment properties of the relevant structures (*e.g.* functional *vs.* subcategorized complementation) or of psycholinguistic data incorporated — when available — into the system (*e.g.* PP-attachment). All alternatives are then ranked according to these preferences. At this point, no preference is computed in case of lexical ambiguities, but ranking could be established either on the basis of occurrence frequencies or according to the type of attachment allowed by a given reading.

F/IPS being an interactive parser, the user can be asked for clarification at any choice point in parse. However, in order to increase speed and efficiency (*i.e.* to avoid potentially unnecessary queries at each choice point in the parse), interaction with the user takes place either when the number of concurrent analyses has passed a pre-set threshold and makes the system inefficient (in the so-called *delayed-interaction mode*), or when some ambiguity could not be solved on-line. To facilitate interaction, a default value is associated with the preferred analyses selected as sketched above, and the user is presented with an ordered list of alternatives.

As to the delayed-interaction mode, there will be cases where the ambiguity that currently makes the number of alternatives spill over the pre-set threshold could have been prevented from occurring if some other ambiguity upstream had been solved first; interaction should then address the ambiguity upstream and not the one that actually triggered the interaction. For that reason, it is necessary to store momentarily disregarded choice points[1] for later use,

After a brief recall of the essential features of F/IPS that have been described in previous *Notes techniques*, I discuss some of the preferences that are used to rank alternatives, and how these preferences can be derived from the parsing algorithm as well as from heuristics in the case of preferences that require non-syntactic expertise.

2 F/IPS (Brief description)

F/IPS is an interactive, GB-based parsing model with a parallel treatment of alternatives. It has been developed in two versions — French and English — that underlay an interactive translation system (for a detailed description, see Wehrli 1992, and Laenzlinger & Wehrli 1991 for the French version).

A central feature of this parsing model is that structures are constructed incrementally, which follows from a specific parsing algorithm dubbed the "right corner algorithm" (see Wehrli 1992 for details). According to this algorithm, the system attempts an immediate integration of incoming material (a maximal projection based on new input) into the existing structure in the left context of the new constituent.

When more than one attachment can be performed, attachments are ordered according to their type (attachment as functional complement < subcategorized complement < adjunct < non-attachment), and the resulting structures receive a corresponding rank.

Also, the parser computes chains relating extraposed elements (*wh*-words, extraposed NPs, *etc.*) to an empty category in argument or adjunct position. Such chains are computed on-line for all alternative analyses, and termination is attempted at each step of the parse, so that structures supporting the shortest chains are preferred over other structures (to satisfy the *Minimal Chain Principle* proposed by DeVincenzi 1991).

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[1]These are choice points where an interaction could have taken place but has not, either in the delayed-interaction mode or in the autonomous mode in the case the end of the sentence has been reached and there are more than one analysis for the sentence. The exact mechanisms that keep track of these overseen interaction points are discussed elsewhere (cf. Walther 1993).

3 Ranking strategies

In F/IPS, alternatives are ordered not only to limit non-determinism and to simulate (some of the) processing preferences exhibited by humans — so as to achieve some level of psycholinguistic plausibility — but also to facilitate interaction with the user by presenting her with default values for the preferred analyses.

The various strategies used to determine preferences discussed in this section remain the same, no matter if interaction takes place on-line (at each choice point or in the delayed-interaction mode) or after parsing (when an ambiguity has not been solved on-line).

For most ambiguities, the preferred analysis — generally identified as such on the basis of available psycholinguistic data — can be directly derived from the implemented parsing strategies. Such strategies include for instance an attachment-type hierarchy (functional complement < subcategorized complement < adjunct < non-attachment, cf. section 3.1), a strong notion of locality (cf. section 3.2), and a gap-hunting mechanism that tries to deposit traces into the structure as early as possible (cf. section 3.3).

In other cases, though, when the resolution of the ambiguity requires non-syntactic knowledge, as for PP-attachment or for attachment of a relative clause to a complex noun phrase, for instance, the preferred analysis is computed according to psycholinguistically-based strategies and presented to the user as the default analysis in a ranked list (cf. section 3.4).

3.1 Attachment-type hierarchy

3.1.1 Functional *vs.* subcategorized complement

Consider the input sentence given in (1) below:

(1) Elles ont emmené tous les enfants au cinéma.
    they$_{fem}$ have brought all$_{masc}$ the children to the theater

When *tous* (a determiner) is parsed, a DP is projected (following Abney 1986) and immediately attached (among other possibilities) as a complement to *emmener*. The difficulty arises when *les* is parsed, because it also projects to a DP and as such, it can be attached as a functional complement to *tous* (as in (2)a), added to the list of complement of the verb (as in (2)b), or it can even remain unattached (as in (2)c):

(2)a. ... [$_{VP}$ emmené [$_{DP}$ tous [$_{DP}$ les]]]

  b. ... [$_{VP}$ emmené [$_{DP}$ tous] [$_{DP}$ les]]

  c. ... [$_{VP}$ emmené [$_{DP}$ tous]] [$_{DP}$ les]

The preferred reading for a *tous les* sequence, namely (2)a, follows directly from the parsing strategy, according to which attachment as functional complement is ranked higher than attachment as a (subcategorized) complement or non-attachment.

The attachment of a non-finite verb to an auxiliary is another instance of functional attachment. This type of functional complementation is specified in the lexicon as exemplified in (3)a,b for *tous* "all" and *avoir* "have" respectively:

(3)a. **tous:** Det, __ DP [+definite, +plural]

   b. **avoir:** Aux, __ VP [−finite, +past]

3.1.2   Subcategorized complement *vs.* non-attachment

The well-known case of attachment ambiguity illustrated in (4) has often been discussed as a typical case of Right Association (Kimball 1973), of Late Closure (Frazier 1978), or as a supporting evidence for the look-ahead mechanism (Marcus 1980), among others:

(4)a. While John was mending the sock fell off his lap.

   b. ... [$_{VP}$ mending [$_{DP}$ the sock] ...]

   c. ... [$_{VP}$ mending] [$_{TP}$ [$_{DP}$ the sock] ...]

According to the various strategies proposed in the literature, the preferred analysis for the segment *mending the sock* (unpunctuated or with punctuation untreated) is the one given in (4)b, where the DP *the sock* is attached as a complement to the verb *mend*. The garden path effect that has been shown to obtain (longer reading times in the disambiguating region *fell, cf.* Frazier & Rayner 1982) is due to the fact that the correct analysis (4)c is actually the locally (at the syntactic level) unpreferred one.

Again, the preference here derives straightforwardly from the parsing strategy, since attachment as subcategorized complement ((4)b) is ranked higher than non-attachment or attachment as specifier ((4)c). Therefore, in such a case, the default analysis proposed to the user will be (4)b. Note that when the system is dealing in a delayed-interaction mode with a very heavy DP (say with a relative clause attached, *etc.*), the preferred analysis will be confirmed by subsequent ranking operations, so that the correct analysis can be recovered only at high cost — which seems to correspond to the intuitions of the speakers.

To my knowledge, there are no experimental data available for French. For the sake of simplicity, I will assume that the same strategy holds for French, so that the preferred continuation for a sentence like (5)a will be (5)b (compatible with the attachment of *deux kilomètres* as an object of *courir*) and not (5)c:

(5)a. Depuis qu'il court régulièrement deux kilomètres...
      since he jogs regularly 2 kilometers

   b. Anselme a perdu 12 kilos.
      A. has lost 12 kilos

   c. lui semblent une bien courte distance.
      to-him seem like a very short distance

Again, nothing specific needs to be stipulated here, as the preference for an attachment as complement over an attachment as specifier is embedded in the parser. For reasons of psycholinguistic plausibility, though, an on-line message mentioning the reanalysis (or rather the preference switch) could be displayed.

Caveat In most cases, especially in French, the LC-ambiguity can be solved on the basis of the presence or absence of a comma between the V and the following DP. However, this is not always true, so that it does not seem reasonable to assume that this type of ambiguity will disappear by itself as soon as a proper treatment of punctuation will have been implemented.

3.1.3 Complement *vs.* adjunct

The fact that the preferred reading for the fragment (6)a is the declarative-clause reading given in (6)b and not the relative-clause reading (6)c is experimentally documented in Frazier & Rayner 1982:

(6)a. John will tell the guy (that) Mary ...

   b. ... [$_{VP}$ tell [$_{DP}$ the guy] [$_{CP}$ (that) [$_{TP}$ Mary ...]]]

   c. ... [$_{VP}$ tell [$_{DP}$ [the guy] [$_{CP}$ (that) [$_{TP}$ Mary ...]]]]

In IPS, the preference for (6)b over (6)c can be derived from the preference for an attachment as subcategorized complement (therefore for the declarative-clause reading) over attachment as adjunct, since the system first tries to satisfy subcategorization requirements of heads.

When the continuation to (6)a allows on-line disambiguation, say like (7)a, that confirms the declarative-clause reading, or (7)b, that forces the unpreferred relative-clause reading, no interaction will take place unless the number of alternatives passes the tractability threshold:

(7)a. ... has bought a new bike.

   b. ... has met yesterday that he should buy a new bike.

However, when the continuation does not allow on-line disambiguation (like (8)a), the user will be presented with a ranked list of alternatives, in which the declarative-clause reading (8)b will be ranked higher than the relative-clause reading (8)c and taken as the default:

(8)a. ... knows all the secrets of the trade.

   b. [$_{TP}$ John will [$_{VP}$ tell [$_{DP}$ the guy] [$_{CP}$ (that) [$_{TP}$ Mary knows all the secrets of the trade]]]]

   c. [$_{TP}$ John will [$_{VP}$ tell [$_{DP}$ [the guy] [$_{CP}$ (that) [$_{TP}$ Mary knows *t*]]] [$_{DP}$ all the secrets of the trade]]]

For the time being, I will admit that the same strategy holds for French as well, so that the preferred continuation for (9)a should be (9)b and not (9)c:

(9)a. J'ai répondu au conservateur que mes toiles intéressaient
     I have answered to the curator that my paintings interested

   b. ... une autre galerie.
     another gallery

    c. ...que j'étais d'accord de les prêter pour un mois.
       that I was ready to lend them for one month

Given the attachment-type hierarchy, the declarative-clause reading (attachment of the CP as a complement) is preferred over the relative-clause reading (attachment of the CP as an adjunct) for the segment *que mes toiles intéressaient* in (9)a. Therefore, the continuation (9)b that is compatible with this preference should not cause any processing difficulties. The continuation (9)c, on the contrary, is compatible only with the unpreferred relative-clause reading (in order for the sentence to be grammatical, naturally), so that preferences must be switched for the relevant segment.[2]

The same preference is expected to occur when the subordinate clause is embedded under a noun that can take a declarative clause as object. For English, Gibson (1991:113) compares (10)a and (10)b (from Fodor 1985) and concludes that there is no conscious difference between (10)a (relative-clause reading) and (10)b (declarative-clause reading) in terms of processing difficulties:

(10)a. The report that the president sent to us helped us make the decision.

    b. The report that the president sent the troops to combat depressed me.

The same lack of contrast seems to hold for the French sentences corresponding to (10)a and (10)b given in (11)a and (11)b respectively:

(11)a. Le fait que le président veut discuter demain lui a été rapporté
       The fact that the president wants to discuss tomorrow has been reported to him
       par un journaliste espagnol.
       by a Spanish journalist.

    b. Le fait que le président veut discuter demain du nouveau sous-marin nucléaire
       The fact that the president wants to discuss tomorrow the new nuclear submarine
       dérange les journalistes espagnols.
       disturbs the Spanish journalists.

However, "lack of conscious difficulty" is far from meaning "lack of difficulty". Therefore, I will admit that for (10)–(11) as well as for (6)–(9), the preferred reading for the subordinate clause is the declarative reading — up to the point, naturally, where this reading is no longer compatible with the data.

As the preference for attachment as argument (declarative-clause reading) over attachment as adjunct (relative-clause reading) is incorporated in the system, the correct prediction for (11)can be directly derived from the parsing strategy (as long as nouns that are normally associated with an argument structure are actually specified as such in the lexicon). Thus, the default value will be "declarative", while the relative-clause option receives a lower ranking. In the case the preference for the declarative-clause reading becomes incompatible with the data, then the system should display a message stating `CP xyz reanalyzed as a relative clause within DP xyz`. If the ambiguity could not be solved on-line, the alternatives should be ordered as "declarative-1, relative-2".

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[2]Note that if the V *intéressaient* in (9)a were replaced by a potentially transitive **and** intransitive verb, the continuation (9)c would be compatible with the analysis of the relevant segment as a declarative-clause (based on the intransitive reading of the verb), as some kind of juxtaposed coordinate complement.

Special French   There are contexts in French in which past participle agreement can be used as an advanced disambiguation clue to distinguish between declarative-clause (DC) reading (no agreement) and object-relative-clause (RC) reading (agreement possibly visible). The emphasized segment in (12)a, where there is zero- or no agreement on *reçu* is ambiguous and the continuations given in (12)b and (12)c are both possible; on the contrary, the only possible continuation for (13)a is (13)c, that is compatible with the (unpreferred) RC reading of the emphasized segment:

(12)a. Cunégonde devra préciser sur le formulaire rose *qu'elle a reçu la semaine dernière*
   C. will have to specify on the pink form that she has received last week

   b. ...l'intégralité de son salaire.
   the whole of her salary.

   c. ...qu'elle n'a pas gagné plus de 100.000 francs.
   that she hasn't earned more than 100.000 francs.

(13)a. Cunégonde devra préciser sur le*s* formulaire*s* rose*s qu'elle a reçus la semaine dernière*
   C. will have to specify on the pink form that she has received$_{m,pl}$ last week

   b. *...l'intégralité de son salaire.

   c. ...qu'elle n'a pas gagné plus de 100.000 francs.

The same holds for CPs embedded under nouns; in (14)a, past participle agreement forces the RC reading, while in (14)b, the lack of agreement confirms the DC reading:

(14)a. L'idée que Javotte a développé*e* dans son dernier livre empêche Anselme de dormir.
   The idea$_f$ that J. has developed$_f$ in her last book prevents A. from sleeping.

   b. L'idée que Javotte a développé un nouveau système de guidage pour fusée
   The idea$_f$ that J. has developed$_0$ a new command system for rockets
   empêche Anselme de dormir.
   prevents A. from sleeping.

There are no experimental data available yet as to whether the human processing system makes use of agreement as an advanced disambiguation clue or not. I will assume the parser to take agreement into account every it is relevant. Thus, every agreement is visible (plural and feminine forms), it should be used to construct the correct RC reading or to recover the unpreferred RC reading (in case alternatives had already been ranked).

The problem arises when agreement is "missing" or underspecified (either by mistake, or because it is masculine singular, or in speech processing — when the dialect is such that *rencontré* (*met$_{masc}$*) and *rencontrée* (*met$_{fem}$*) are not phonetically distinct). In this case, the lack of agreement on the past participle will be taken as a confirmation for the DC reading (the default value). As a consequence, the (correct) RC reading remains unavailable (having received very low ranking) or the system outputs a wrong analysis or no analysis at all — which is not satisfying.

I propose to deal with such an over-efficiency of the filtering device by using a robustness parameter that has to be set independently from the "level-of-interaction" parameter but interacts with it as follows: In the fully-interactive mode, when the user is consulted and

chooses the RC reading even though the lack of agreement would have indicated DC reading, the system points out lack of agreement as a mistake and suggests the proper correction. In the delayed-interaction mode, zero agreement is taken as an indication for DC reading (default value) and also as an erroneous version of RC reading with the appropriate flags.[3] When interaction takes place, the RC reading is presented as the unpreferred interpretation, and the system indicates the possibility of a mistake.

In this perspective, agreement is taken as an early disambiguation clue, while lack of (or zero) agreement does not really contribute to disambiguation. Potentially, this stands in contradiction with the notions of efficiency and parsimony, according to which ambiguities should be solved as early as possible. but practically, this treatment of syntactically-relevant mistakes allows more robust parsing — which can be desirable.

Such a treatment could be extended to other constructions involving past participle agreement and anteposed direct objects, for instance left-dislocations like *Marie, il l'a aidé/e* (*Mary, he him/her-has helped$_{0/fem}$*), where agreement makes *l'* (and thus *Marie*) an argument of *aider*, while zero agreement indicates that *l'* is actually *him* and that *Marie* is not an argument of *aider* but rather the addressee.

3.2   Low Attachment

Traditionally, cases of so-called "low attachment" are treated as instances of LC in the spirit of Frazier 1978, or according to some version of the "Recency Principle" proposed by Gibson 1991. By means of the LC strategy, in a temporary ambiguity, the current element is attached into the last treated XP.[4] In (15)a below, for instance, the PP *to Mary* is attached to the DP *the letter* rather than to the VP, even though the verb *give* requires such a PP.[5] As a consequence, the continuation to (15)a given in (15)b (compatible with the low attachment of *to Mary*) is preferred over the one given in (15)c (that forces the PP *to Mary* to be interpreted as an argument of *give*):

(15)a. John gave the books, the picture, the report and the letter to Mary...

  b. to Bill.

  c. before leaving the country.

The main difficulty here lies in the fact that this type of PP-attachment stands in apparent contradiction with the preference discussed below (cf. section 3.4.1), according to which a PP attaches to VP rather than to a preceding DP. However, it could be argued that in (15)a, *letter* is a noun associated with an argument structure, which could determine the low attachment — as the attachment of an argument to a local head.

The hypothesis that low attachment can be seen as attachment of an argument to a local head is supported by sentences like (16), in which the DP *the book* is first analyzed as the object of *read* and not as the (obligatory) object of *give*:

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[3]This is so for plurals and/or feminine antecedents, while with masculine singular potential antecedents, the selection device assigns the RC reading a lower ranking but does not set the mistake flag.

[4]Actually, in Frazier's framework, LC is ordered after *Minimal Attachment*.

[5]In the model of the *Sausage Machine* (Frazier & Fodor 1978), LC follows here from the fact that the VP node, once passed over to the higher processing level, has become unavailable as an attachment site.

(16) Sue gave the man who was reading the book.   (= Gibson (1991:140(324a)))

The same strategy seems to hold for French. As illustrated in (17), the continuation to (17)a given in (17)b (compatible with the low attachment strategy) is less problematic than the one given in (17)c (that forces the DP [$_{DP}$ le livre...] to be attached to the matrix verb):

(17)a. Javotte donnera à l'homme qui lit *le livre sur les baleines paru l'an dernier...*
J. will give to the man who reads the book on whales published last year

b. un autre volume de la même collection.
another volume of the same collection.

c. chez Bordas.
by Bordas.

Such preferences could be derived directly from a strong notion of locality, so that in all cases, attachment of an argument to a *local* head (possibly a theta-assigner) would be preferred. Thus, whenever possible, the current XP would be attached as a (functional or subcategorized) complement to the local head.

In the case of a local ambiguity that can be solved on-line, the complement is obligatory for one of the several heads, which implies a preference switch if the correct head is not the local one; a message stating `XP xyz reanalyzed as an argument of head xyz` could be displayed. In cases where the complement is optional for all concurring heads, the system should be able to deal with the global ambiguity, to output several ranked analyses (with "low attachment-1, high attachment-2...n"), and to leave it up to the semantico-pragmatic component of the system and/or to the user to disambiguate.

3.3   Active Filler Strategy and Minimal Chain Principle

The *Active Filler Strategy* (henceforth AFS) that is postulated to determine the identification of gaps in $\overline{\text{A}}$-relations (see Frazier & Flores d'Arcais 1989 and Frazier & Clifton 1989 for experimental evidence) can be seen as a consequence of the application of the *Minimal Chain Principle* (henceforth MCP) (DeVincenzi 1991), that states that the processing system prefers shorter chains to longer ones. Thus, according to the AFS, the processor tries to deposit (*wh-*)traces into the first possible position, without waiting to see whether this position is actually available or not. (This strategy is presented as a valid alternative to the "gap as last resort" strategy proposed by Fodor 1978 and to the lexical-preference model discussed by Ford, Bresnan & Kaplan 1982, see for instance Frazier 1987 for discussion.)[6]

For a sentence like (18), AFS predicts that the system will first try to deposit a trace as an object of the matrix V *promise* (t_1), then as an object of the verb *give* (t_2), and eventually as an object of the preposition *to* (t_3):

(18) Who did John promise t_1 to give t_2 a book to t_3?

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[6]The hypothesis that traces exist has received strong support from various experimental data. See for instance Crain & Fodor 1985 and Stowe 1986 for the filled-gap effect (reading-time data), Garnsey *et al.* 1989 and Tanenhaus *et al.* 1989 for on-line plausibility effects (ERPs data), and Nicol & Osterhout (in Nicol 1988) for priming effects after any potentially transitive verb.

In the case of the ambiguous sentence given in (19)a, in which the indirect object is optional for both the matrix and the embedded verb, AFS causes the interpretation of the *wh*-element as an argument of the matrix V to be preferred — as the contrast between (19)b (weak filled-gap effect) et (19)c (stronger filled-gap effect) indicates:

(19)a. Who did John promise ___$_1$ to write ___$_2$ a letter?

   b. Who did John promise ___ to write Mary a letter?

   c. Who did John promise Mary to write ___ a letter?

It cannot be argued that this contrast is dictated by lexical preferences, since both (20)a and (20)b present a (strong) filled-gap effect, regardless of the fact that the preferred reading for *tell* includes an indirect object while the preferred reading for *say* does not:

(20)a. To whom did Mary tell to the manager that he should write?

   b. To whom did Mary say to the manager that he should write?

To my knowledge, there are no available experimental data for French. Nevertheless, I will assume AFS to hold for French as well as for English. Intuition shows on the one hand that (21) is ambiguous with some advantage for interpreting the *wh*-trace with respect to the matrix verb, and on the other hand that (22)a (compatible with an "upstairs"-trace) seems to be slightly easier to process than (22)b (that implies a revision of the first AFS-based trace hypothesis, the indirect object of *donner* being obligatory):

(21) A qui Javotte a-t-elle promis d'expédier les colis?
     To whom J. has-she promised to send the parcels?

(22)a. A qui Javotte a-t-elle promis de brûler son Kama-Sutra?
      To whom J. has-she promised to burn her K-S?

   b. A qui Javotte a-t-elle promis de donner un Kama-Sutra?
      To whom J. has-she promised to give a K-S?

Also, the filled-gap effect seems to be stronger for the matrix clause than for the embedded one, and this regardless of the nature of the extracted element (DP or PP), as the contrast between (23)a and (23)b and (24)a and (24)b respectively indicates:

(23)a. Qui Cunégonde a-t-elle prié Anselme de recevoir pour le week-end?
      Who C. has-she begged A. to receive for the week-end?

   b. Qui Cunégonde a-t-elle prié de recevoir Anselme pour le week-end?
      Who C. has-she begged to receive A. for the week-end?

(24)a. A qui Javotte a-t-elle demandé à Théophile de prêter son Kama-Sutra?
      To whom J. has-she asked T. to lend his K-S?

   b. A qui Javotte a-t-elle demandé de prêter son Kama-Sutra à Théophile ?
      To whom J. has-she asked to lend his K-S to T.?

If the chain formation processes incorporated in the system are based on a gap-hunting strategy and if some version of MCP is implemented (which implies that chains should be constructed and evaluated on-line and that each element in a chain is always tested as a possible foot of the current chain), then there is nothing special that must be done to derive the preferences predicted by AFS and experimentally documented. By default, a *wh*-trace will be deposited and interpreted as an argument of the matrix verb (according to this verb's subcategorization features, naturally). This chain will be replaced by a chain that takes an embedded verb into consideration only it the latter *requires* an argument of the same type as the extracted element. In this case, a message like `Element xyz reanalyzed as an argument of V xyz` could be displayed. In the case of a global ambiguity, the system should present the user with a ranked list of alternatives ("upstairs 1, downstairs 2...n") and leave the task of choosing the correct analysis to the semantico-pragmatic component of the system and/or to the user.

3.4 Ambiguities requiring non-syntactic expertise

3.4.1 PP-attachment

Psycholinguistic data for PP-attachment have shown attachment-to-VP to be systematically preferred over low attachment in early tasks (*e.g.* eye movement studies, see Rayner, Carlson & Frazier 1983, Clifton & Ferreira 1987), but not in later tasks, where semantics seem to play an important role (see a.o. Clifton & Ferreira 1987, Crain & Fodor 1985, Crain & Steedman 1985 for discussion). Moreover, it seems that the VP-preference does not hold for sequences of PPs and is replaced by a low-attachment preference, as shown by the fact that in (25) below, the second PP (*in the box*) is primarily taken as a modifier of *the boy* and not as a predicate to *the candies*:

(25) John gave the candies to the boy in the box.

I suggest that these characteristics of PP-attachment can be dealt with in F/IPS by means of two different strategies — depending on whether the PP to attach is the first one or whether there already is a PP attached on the rightmost edge of the structure tree. If the PP is the first one, attachment-to-VP is preferred over low attachment; otherwise, low attachment receives a higher ranking.

This double strategy makes the correct predictions for attachment preferences in French too. Consider for instance ((26): The preferred interpretation for the second PP (*de mon appartement*) is as a modifier of *gardien* (low attachment), then as a subcategorized complement of *parler* (attachment-to-VP), and then only as a locative adjunct:

(26) J'ai parlé au gardien de mon appartement.
      I have spoken to the keeper of/about/from my flat

According to this twofold strategy, the default value proposed to the user for a given sequence of PPs will be the analysis where preferences are maximally satisfied for all strategies, the less preferred analysis the one where preferences are violated for all strategies, while intermediate combinations will receive some intermediate ranking.

3.4.2 Relative-clause attachment

Regarding relative clauses, a major prediction of Frazier's LC strategy is that a relative clause following a complex DP should be preferably interpreted as a modifier for the most deeply embedded (or the most recent or the just treated) DP. Thus, for (27)a, the preferred analysis should be (27)b and not (27)c:

(27)a. The journalist interviewed the daughter of the colonel who had had the accident.

    b. ... [$_{DP}$ the daughter of [$_{DP}$ [$_{DP}$ the colonel] [$_{CP}$ who had ...]]]

    c. ... [$_{DP}$ [$_{DP}$ the daughter [$_{PP}$ of the colonel]] [$_{CP}$ who had ...]]

However, this preference seems to be inverted in Spanish, which is unexpected under the hypothesis that LC is a universally valid strategy of language processing. Cuetos & Mitchell (1988) report on an experiment on Spanish in which they obtained longer reading times for continuations compatible with a LC-based continuation of the relative clause; this suggests that an Early Closure (EC) strategy is at work to determine preferred attachment sites for relative clauses — at least in Spanish.

To my knowledge, there are no experimental data available for French. Intuitively, though, it seems that neither LC nor EC can completely account for attachment preferences in the case of complex DPs. Apparently, these preferences depends largely on the lexical items. Thus, for the segment given in (28)a, the LC continuation (28)c is more difficult than (28)b, while for the segment (29)a, the EC continuation (29)b is more difficult.

(28)a. Anselme a renversé le chien du fruitier qui se promenait dans le quartier...
    A. has run over the dog of the grocer who was going around in the district

    b. en reniflant les poubelles. (EC)
       sniffing trash cans.

    c. en vendant des oranges. (LC)(difficult)
       selling oranges.

(29)a. Javotte a interviewé le secrétaire de la députée...
    J. has interviewed the secretary$_m$ of the deputy$_f$

    b. qui a eu un accident de voiture avec sa femme. (EC)(difficult)
       who has had an car accident with his wife

    c. qui a eu un accident de voiture avec son mari. (LC)
       who has had an car accident with her husband

It is reasonable to assume that various factors intervene in these preferences, among others the definiteness effect, and maybe also argumental properties of the concurring DPs (Lyn Frazier, p.c., in progress).

Given the lack of clearer indications, I suggest to use low attachment as a default and to let the semantico-pragmatic component of the system and/or the user chose from a ranked list of alternatives. In all cases, agreement could be used whenever possible to associate a low ranking with attachments that are not compatible with the agreement marks, along the lines discussed above (cf. p. 7) for past participle agreement.

4 Future work

Most of the selection strategies discussed in this report are implemented in F/IPS — or at least follow from properties of the parser or of the chain formation mechanisms. What remains to be developed, though, is the interaction component and the ranking device.

As to the interaction component (regardless of the exact mechanisms that allow efficient delayed interaction), it does not yet provide the user with information about preference switches that might occur during parsing when an ambiguity can be solved on-line — even though it does display messages in case a structure violates a grammatical constraint. Also, it does not yet include all the dialogues that are necessary for dealing with the various types of ambiguity discussed in this report. In all cases, these are details that can be fixed relatively easily.

In its current form, the ranking device is limited to a mechanism that associates arbitrary weights with structures violating some grammatical constraint, in a "the heavier the weight, the lower the rank"-way. This mechanism should be extended so that it can handle processing *preferences*, that is cases where the sentence remains acceptable even though later input becomes incompatible with the analysis that had been preferred thus far. Whether preferences must be weighted in the same fashion as grammatical-constraint violations or whether the two classes of phenomena should be dealt with separately is still unclear.[7] Nevertheless, extending the ranking device in such a way that it can deal with the preferences discussed in this report is a necessary preliminary step before verifying that the parser actually exhibits the behavior ascribed to it on the basis of its properties.

Also, in a cross-linguistic perspective, it would be interesting to evaluate the exact predictions of these strategies with respect to the (few) available psycholinguistic data on the processing of head-final languages such as German or Dutch.

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[7]Especially as there might be "hybrid" cases, where maintaining a given preference causes a grammatical constraint to be violated, or complicated cases where a preferred structure, associated with a "fatal" constraint violation (*e.g.* a violation of Binding Principle A), is opposed to an unpreferred one, associated with a "mild" constraint violation (*e.g.* Subjacency in a L-marking environment).

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