A Syntactic Analysis of Interference in Subject–Verb Agreement[*]

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The research presented uses theoretical constructs of formal syntax as tools to capture performance data in agreement production. The phenomenon examined is interference in subject–verb agreement. A general overview of our experimental findings which highlights the different syntactic factors involved in interference is provided. A fine-grained characterization of the hierarchical structure is presented that involves 1) the structural definition of intervention, 2) the distinction between precedence and c-command, 3) the role of intermediate traces, and 4) the role of subject movement. New data are presented that fit the theoretically motivated gradient of computational complexity proposed (Franck et al. 2006).

1. Introduction

This paper illustrates the relevance of combining the experimental approach of psycholinguistics with the refined analytical tools offered by formal syntax. The latter provides theoretical constructs that appear instrumental in capturing aspects of the linguistic behaviour as they emerge from psycholinguistic experiments. On the other hand, experimental psycholinguistics goes beyond off-line observations (such as grammaticality judgments and cross-linguistic comparisons) and thus provides novel types of evidence potentially bearing on the construction of formal syntactic models.

The empirical domain we have focused on is the occurrence of interference errors in agreement production. Agreement is a prototypical example of what syntax does: it links words together in structured hierarchical configura-

tions related to, but distinct from, the semantic status and lexical properties of individual words, their phonological realization or their position in the linear word string. Agreement, i.e. the copy of features of one word onto another, can be considered as one of the best indexes of the syntax-internal dynamics, hence providing a privileged window on the structural specificities of human language.

Linguistic theory developed in the framework of Principles and Parameters/Minimalism has proposed a detailed account of agreement operations taking place during the syntactic derivation of the sentence (e.g., Chomsky 1981, 1995, 2000; Haegeman 1994). In psycholinguistics, the seminal paper of Bock and Miller (1991) opened the way to the experimental study of agreement, and more particularly of the conditions in which it derails (e.g., Bock and Eberhard 1993; Eberhard, Cutting and Bock 2005; Bock and Cutting 1992; Vigliocco and Nicol 1998). Following the long tradition of speech error research in psycholinguistics, these studies view interference errors as a transparent window on the processes underlying agreement production. Unfortunately, the strong guidance from theoretical constructs in linguistics that characterized the initial developments of experimental psycholinguistics (e.g., Fodor, Bever and Garrett 1974, and many references cited there; Garrett 1976) has decreased considerably over the last 30 years. Early attempts to integrate grammatical theory and processing studies through the Derivational Theory of Complexity failed to obtain strong empirical support and were abandoned in favor of a strict division of labor between competence and performance models. This split is particularly flagrant in research on agreement given the important developments on the issue in both disciplines with virtually no link between them.

Our research aim is to bridge psycholinguistics and linguistics again in the domain of agreement, by assuming a tight connection between the language processor and the grammar. We combine both approaches (experimental and theoretical, in the framework of the Principles and Parameters/Minimalist tradition) to unravel syntactic constraints at play in the process of agreement production. In this paper, we integrate our previous findings (Franck, Lassi, Frauenfelder and Rizzi 2006) and novel experimental results. The first section of the paper briefly describes agreement in formal syntax, and the specific role of some critical theoretical constructs used in the interpretation of our data like c-command, movement, and the distinction between AGREE and Spec-head checking. In the second section, we present experimental evidence of elicited interference errors that illustrates the relevance of these linguistic constructs.

2. Agreement and movement in linguistic theory

The following characterization is based on recent approaches to natural language syntax elaborated within the Principles and Parameters framework and the Minimalist Program (Chomsky 1995, and much related work, and see Franck et al. 2006, for a more detailed description). This framework views the generation of syntactic structures as a succession of formal operations: MERGE, AGREE, MOVE. MERGE strings elements together to form a minimal phrase. Successive applications of MERGE assemble the thematic nucleus of the sentence (the verb and its arguments). Further applications of MERGE introduce the functional structure of the sentence (specifications of tense, aspect, mood, etc.), thus

creating a configurational skeleton which can be further modified by additional applications of MERGE and by MOVE, the option of displacing elements already introduced in the structure.

Several intermediate representations are postulated that are the result of the cyclic derivation of the structure. These intermediate representations have a tree-like format that specifies relationships between nodes. Each node in the tree is always involved both in vertical, hierarchical relationships with the other nodes (dominance), and in horizontal relationships (precedence). A particularly important hierarchical dependency, built on the more elementary dominance relation, is the relation of c-command. This structural relation, originally introduced by Reinhart (1976), is defined in (1) (Chomsky 2000).

(1)   X c-commands Y iff Y is dominated by the sister node of X.

This dynamic approach to the building up of a sentence has potentially crucial implications for psycholinguistics given that it naturally leads to a view of grammatical encoding as a complex process involving different stages, each stage potentially expressing different structural relationships (in contrast to the assumption of a single hierarchical representation over which all syntactic operations are computed, as in current psycholinguistic models, e.g., Bock and Levelt 1994). Under the assumption of a tight connection between grammar and the language processor, the different derivational steps assumed in linguistics should be traceable in linguistic performance, and for our concerns here, in the way speakers err when producing agreement.

How does formal syntax view agreement realization? A classical assumption is that subject–verb agreement involves a special syntactic node in the functional structure of the clause, AgrS, expressing agreement morphology (Chomsky 1995, and references quoted there).[1] More specifically, the subject is first merged as the specifier of the lexical verb within the VP, the position in which the subject receives its theta role (Sportiche 1988; Koopman and Sportiche 1991). Then, the functional structure, including AgrS, is merged with the thematic structure, and the functional node AgrS enters into an AGREE relation with the subject, still situated in the VP. Basically, the person and number features of the subject are copied onto AgrS. AgrS, the probe of AGREE, looks for a goal with matching features within its local domain of c-command (Chomsky 2000). Once AgrS is specified for these features, the Verb moves to AgrS to receive its morphological specification of number and person (at least in some languages, see Pollock 1989). In English and other languages with Subject–verb order, the subject then moves out of the VP, to the canonical subject position which is the specifier of AgrS.

The movement of the subject into Spec-AgrS creates a local Spec-head relationship between the moved subject and AgrS which we argued may ensure a second checking of agreement, in addition to AGREE (Franck et al. 2006). Evidence in support of this hypothesis comes from the cross-linguistic observa-

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[1] Note that if agreement features, rather than constituting an independent head, are carried by a distinct inflectional head, as in current versions of Minimalism, nothing changes for our purposes.

tion by Guasti and Rizzi (2002) that the morphological manifestation of agreement tends to be more stable when AGREE is associated with the movement of the subject into Spec-AgrS. For example, Standard Arabic manifests agreement in person and number only in SV sentences, not in VS sentences. That is, languages normally admitting VS order often show lack (or optionality) of the realization of agreement in these structures as compared to the corresponding SV configurations. Under our hypothesis, agreement is more stable in SV structures because features are checked twice: (1) through AGREE, following the assumptions of Chomsky (1995), and (2) in the strictly local Spec-head configuration, after movement of the subject.

3. Experimental evidence for the syntactic nature of interference

At the heart of much of the experimental work on agreement is the phenomenon of *attraction* observed in spontaneous speech and illustrated in example (2).

(2)   ***The son** of the <u>neighbors</u> always **come back** late.

In (2), a noun (called *local noun, attractor* or *intervener*) situated in the vicinity of the subject–verb agreement relation imposes its number on the verb: the verb *come* erroneously agrees with the local noun *neighbors* (in the examples hereafter, the subject and the target verb are in bold characters while the potentially interfering noun is <u>underlined</u>). Bock and Miller (1991) first showed that attraction could be elicited experimentally by presenting speakers with complex sentential subjects, and asking them to complete the sentence under time pressure. A number of variants of the sentence completion technique were then used to address different issues specific to the language or to the issues examined. One variant that has been used in all the experiments in French and Italian discussed here consists in preceding the preamble with the target of agreement, the verb, in the infinitival form. Participants have to memorize the verb and the preamble, and then produce a full sentence combining the preamble and verb as soon as the preamble has disappeared from the screen (note that the infinitive form of the verb corresponds neither to the singular nor to the plural verb form in these languages). Most of the experiments on agreement production were designed to test whether the agreement process is influenced by the semantic and (morpho)phonological representation of agreement features. We will not discuss these issues here. Rather, we focus on the experimental reports specifically concerned with the role of structural factors in agreement.

The initial studies were concerned with the possibility that agreement was computed on a hierarchical, rather than linear structure. Bock and Cutting (1992) were the first to report different attraction effects depending on the structural position of the attractor, independently of its linear position. They observed that a local noun interferes more with the agreement process when situated in the same clause as the head noun (e.g., *The editor of the history books were…*) than when situated in a separate clause (*The editor who rejected the books were…*). Nicol (1995) further confirmed that nouns situated in a different clause from the head interfere only weakly with the agreement process, bringing additional support for the hypothesis that attraction is bounded by the clause.

Critical evidence that attraction occurs on a hierarchical structure was then reported by Vigliocco and Nicol (1998) who found that the production of subject–verb agreement errors by English speakers is the same in interrogative sentences (*Are the helicopter for the flights safe?*) as in declarative sentences (*The helicopter for the flights are safe*). This finding suggests that attraction occurs at a stage when words are organized hierarchically and the declarative and interrogative structures are identical. The interrogative sentence is assumed to be formed late, after agreement has been realized (see Pearlmutter 2000, for parallel findings in sentence comprehension).

Without denying the role of clausal structure in syntactic encoding, Franck, Vigliocco and Nicol (2002) suggested that the factor responsible for the low attraction rate with clausal subject modifiers is the syntactic depth of the local noun. They found that in the presence of two local nouns, more attraction errors occur with the local noun situated high in the tree structure, though far from the verb in the linear sequence (*The computer with the <u>programs</u> of the experiment are…*) than with the local noun situated low in the tree structure, though linearly close to the verb (*The computer with the program of the <u>experiments</u> are…*). Crucially, the two local nouns are part of the same clause, and the more interfering noun is farther from the verb in the sentence's surface structure. Hence, the critical factor triggering attraction is not the position of the local noun in the final word string, nor its position with respect to the assumed units of encoding, but its position in the syntactic hierarchy.

3.1 Towards a more fine-grained study of the hierarchical structure

The previous experimental reports on attraction clearly illustrate that the hierarchical structure of the sentence is not a purely representational construct, but that it may have a direct impact on performance: syntactic processes, like agreement realization, are sensitive to the structural proximity of the constituents in the sentence's hierarchy. Although the hierarchical nature of syntactic encoding is usually acknowledged in psycholinguistics (but see for example Haskell and MacDonald 2005, for objections), these observations raise a number of unresolved questions. What is the structural condition of intervention in the hierarchy that creates attraction? Is attraction modulated by the type of structural relation in the hierarchy (precedence, c-command)? If sentence derivation involves a succession of movements as assumed in formal syntax, do intermediate traces of movement generate interference in agreement? Are VS constructions more sensitive to interference than SV configurations? All these questions bear on the more general question of whether finer aspects of the hierarchical structure proposed in formal syntax can capture aspects of language performance.

In the following sections 3.2–3.5, we examine each factor in light of the recent experimental evidence collected in our laboratories. In Table 1, we provide an overview of the composition of the experimental work which will be referred to in the remainder of the text. In total, attraction was examined in 8 different syntactic structures manipulated in six different experiments and providing 12 different data points (because some structures were tested more than once). This table characterizes the syntactic structures used in each of the experiments conducted in terms of the crucial factors posited.

Table 1
Sentence structures tested, their word order in the surface representation,
and their structural characterization according to the factors posited
(I = potentially intervening element)

Structure and experiment	*Word order*	Factors		
		Precedence	Precedence + C-command	Precedence + C-command + AGREE only
(a) Declarative Experiment 1	SVI	–	–	–
(b) Compl. Clause Experiment 2	ISV	–	–	–
(c) Free inversion Experiment 3	VSI	–	–	–
(d) PP modifier Experiment 3	SIV	+	–	–
(e) PP modifier Experiment 4	SIV	+	–	–
(f) PP modifier Experiment 5	SIV	+	–	–
(g) Dative clitic Experiment 5	SIV	+	–	–
(h) Accusative clitic Experiment 5	SIV	+	+	–
(i) Accusative clitic Experiment 4	SIV	+	+	–
(j) Object relative Experiment 2	ISV	+	+	–
(k) Object cleft Experiment 6	ISV	+	+	–
(l) Object cleft + inv. Experiment 6	IVS	+	+	+

For clarity of exposition, we will not discuss our results experiment by experiment, but rather as a function of the specific structures tested and their relevance to the theoretical argumentation. For each structure, attraction is examined, either as an effect per se (section 3.2), or as an effect interacting with the type of structure manipulated. Following Bock and Miller (1991) and related work, attraction is measured as the difference between the rate of agreement errors in the condition of number mismatch (i.e., when the attractor has a different number from the subject) and the condition of number match (i.e., when the attractor and the subject have the same number). Such a measure provides us with a pure index of interference in agreement, by factoring out errors unrelated to agreement (reflecting some general complexity). Analyses of variance and

paired comparison tests were conducted on the data, and only statistically significant tests are discussed as effects. Experiments 1–2 and 4–6 were conducted in French, while Experiment 3 was conducted in Italian.

A general picture of all observations is then presented in the Discussion, showing the fit of the new data points in the gradient of complexity previously reported (Franck et al. 2006).

3.2 Structural intervention and interference

Intervention has been the focus of considerable work in syntactic theory, in particular within the theory of locality: a core locality concept is that a local relation between two elements fails when a third element bearing some structural similarity intervenes between them (see, e.g. Relativized Minimality, Rizzi 1990). In the most general case, we can say that an element B intervenes between A and C when configuration (3) holds.

(3)   A > B > C

Where ">" is some relevant structural relation. B intervenes between A and C in terms of precedence when A precedes B and B precedes C; A intervenes between A and C in terms of c-command when A c-commands B and B c-commands C.

The first hypothesis that needs to be examined is whether interference observed in performance arises as a consequence of intervention as defined in these structural terms. Under this hypothesis, attraction is expected to occur in configurations like (3) where A and C are the Subject and inflected Verb (in AgrS), and B is the Intervening element (throughout the text, we will refer to I as the potentially interfering element, whether it intervenes or not on the agreement relation). Under this approach to intervention, structures of the type SVI, ISV or VSI in which the local noun does not intervene on the subject–verb relation *at any time in the derivation of the sentence* are expected to be immune to attraction.

Three structures (a, b, c in Table 1) were manipulated to provide support for the hypothesis that configuration (3) is a necessary condition for interference: declarative structures with canonical order, complement clauses with unmoved material and "free inverted" structures (in Italian). Neither the surface order of these structures examined here (SVI, ISV and VSI), nor any intermediate step in their derivation involves the structural intervention, in the sense of (3), of the potentially interfering element I between the subject and the verb. As expected, no significant attraction effect was found in these cases, which were then used as a baseline and compared to cases in which different kinds of structural intervention arise. Let's consider the three baseline cases in more detail. A first experiment was conducted (Experiment 1, Table 1) that examines whether the object situated in its post verbal, canonical position, interferes with agreement (4). In such declarative sentences, the object does not intervene in any structural sense on the subject–verb agreement relation.

(4)   **L'enseignant décrit** les <u>romans</u>.
        'The teacher describes the novels.'

As expected under our hypothesis, the post verbal object did not interfere with agreement: no effect of attraction was found (1% errors). We will see in the following sections that the result is sharply different in constructions in which the object is moved to various kinds of intervening positions.

In a second experiment (Experiment 2, Table 1), attraction with the object of the main verb in a sentence complement clause was examined (5). In this structure, the potentially interfering word *patientes* does not intervene on the subject–verb relation in the complement clause: it is the indirect object of the main verb *dire*.

(5)   Jean dit aux <u>patientes</u> que **le médicament guérit**.
        'Jean tells the patients that the medicine cures.'

No significant effect of attraction was found with the object of the main verb (2.3% errors). Again, this finding was expected since the object of the main verb does not intervene on the subject–verb relation either in terms of precedence or in terms of c-command, at any point of the syntactic derivation. We will see in section 3.4 that things differ considerably in the minimally different relative clause construction.

A third baseline case (Experiment 3, Table 1) comes from a study in which we exploited a typical property of Romance Null Subject languages: the so-called free inversion construction in Italian (6). In Romance free inversion, the subject remains in the VP-internal position (or possibly in a low focal position: Belletti 2001); it is never raised to the position of specifier of the agreement node AgrS. Hence, agreement is established by AGREE but crucially the plural modifier noun *vicini* does not intervene on this relation between AgrS and the subject head noun *amica*.

(6)   **Telefonerà l'amica**   dei   <u>vicini</u>.
        will-phone the friend of-the neighbours
        'The friend of the neighbours will phone.'

We observed no interference with the modifier noun (1.7% errors; see Franck et al. 2006, for a more detailed description of the results).

In sum, it appears that a number featured noun does not interfere with agreement when not situated in a position of intervention as defined by configuration (3). This is not obvious a priori: it could be, for instance, that an object induces attraction errors on subject–verb agreement irrespective of its structural position, by simply being a member of the same argument structure, or minimal clause, or "lexical subarray" in the sense of Phase Theory (Chomsky 2001), like the subject and the verb. But it does not: intervention, as structurally defined by (3), appears to be a necessary condition for attraction. The next question then is whether the interference created by intervention varies depending on whether the element intervenes linearly (precedence) or hierarchically (c-command) in the hierarchical structure.

3.3 Intervention by precedence vs. c-command

C-commanding relations have been shown to play a critical role in syntactic dependencies (as in the binding of anaphors or the determination of quantifier scope). Hence, it is quite plausible that intervention in terms of c-command is more disruptive of agreement than intervention in terms of precedence. However, a preliminary question that needs to be asked is whether linear intervention plays a role at all. The answer is clearly yes; actually, most of the test cases examined in the literature on agreement involve interference from a preverbal subject modifier. In such structures, the prepositional phrase modifier is attached postnominally to the subject NP, and therefore it intervenes in terms of precedence between the subject head noun and the agreeing verb in AgrS.

We tested these structures in the framework of different experiments. Experiment 3 in Italian, testing free inversion and discussed in the previous section, included a comparison of VS and SV structures. In SV structures like (7), the modifier noun *vicini* intervenes in terms of precedence between the head noun and AgrS when agreement is being checked in the Spec-head configuration.

(7)   **L'amica** dei   <u>vicini</u>   **telefonerà**.
        the friend of-the neighbours will-phone
        'The friend of the neighbours will phone.'

Attraction was reported with this structure (4.7%), which statistically differs from the corresponding free inverted structure VS (1.7% in (6)).

Hence, experimental evidence clearly indicates that precedence intervention does trigger attraction. But is precedence intervention less disruptive than c-command intervention? Many syntactic processes are sensitive to c-command, and typically a node is active (e.g. as a binder) with respect to another node when c-command holds. So, more attraction errors are naturally expected in structures in which the intervening element c-commands the agreement node than in structures in which it only precedes it.

In a first experiment (Experiment 4, Table 1), interference with a subject modifying noun (8a) was contrasted to interference with a preverbal accusative clitic pronoun (8b) in French. In (8b), the object has moved to the clitic position adjoined to AgrS, a position which structurally intervenes on the Spec-head agreement relation by c-commanding AgrS and being c-commanded by the subject.

(8)   a.   **Le professeur** des   <u>élèves</u>   **lit**.
           the teacher   of-the students reads
           'The teacher of the students reads.'

      b.   **Le professeur** <u>les</u>   **lit**.
           the teacher   them reads
           'The teacher reads them.'

The accusative clitic was found to trigger significantly more attraction than the modifying noun (10.1% vs. 6.3% attraction errors respectively; see Franck et al. 2006, for a more detailed presentation of the data). Although the effect can also

be accounted for by an intervention of the object on the AGREE relation (along the lines developed in the next section for object relatives and clefts), both interpretations involve c-command intervention on agreement (either Spec-head or AGREE), which is the crucial point for the argument here.

In an additional experiment (Experiment 5, Table 1), we manipulated the same structures (9a and 9b) with an additional condition involving a dative clitic pronoun (9c).

(9)   a.   **Le costume** des   <u>danseuses</u> **V**.
              the costume of-the dancers   V
              'The costume of the dancers V.'

       b.   **Le costume** <u>les</u>   **V**.
              the costume them V
              'The costume V them.'

       c.   **Le costume** <u>leur</u>   **V**.
              the costume to-them V
              'The costume V to them.'

Indirect objects differ from direct objects in many languages in that they are introduced by a preposition. We will assume that this difference is preserved in clitic position, in the sense that the dative clitic, contrary to the accusative clitic, is embedded into a PP with a null preposition, as illustrated in (10).[2] Under this analysis, it is expected that the dative clitic will have a lesser effect than the accusative clitic since whereas the former intervenes on Spec-head agreement simply in terms of precedence in (10), the latter intervenes in terms of c-command.

(10)   Le costume [P leur] convient.
       the costume   them suits
       'The costume suits them.'

The results show that the PP subject modifier and the dative clitic pattern alike with respect to attraction (6.3% and 5% attraction errors), and that both structures generate significantly less attraction than the accusative clitic (11.2% attraction errors). Such a finding is captured by the distinction between precedence and c-command intervention: both the dative clitic and the subject modifier, being embedded within a PP node, intervene on agreement in terms of precedence, while the accusative clitic intervenes on agreement in terms of c-command.

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[2] Alternatively, we could assume that dative clitics bear an inherent case, as in Kayne (1983:201), and that inherent case involves an extra structural layer KP, so that we would have [K *leur*]. Either way, the pronoun would not c-command outside the PP or KP.

Hence, these data support the hypothesis that interveners that c-command AgrS disrupt agreement significantly more than interveners that precede it.[3] Up till now, all the structures examined involved an element intervening on the Spec-head checking component of agreement, that is, when the subject has raised into Spec-AgrS. However, the test case manipulated involving c-command, i.e. the accusative clitic, is a construction undergoing movement: the object is displaced from its initial base position in the VP to a preverbal position. Could this movement operation, and the traces it generates, play a role in the attraction rate observed with accusative clitics? This question is discussed in the next section.

3.4 Intermediate traces of movement

Current syntactic analyses of object movement to the left periphery postulate a stepwise movement, with an intermediate position (AgrO) to the immediate left periphery of the VP. In the classical analysis of Kayne (1989, later extended and generalized also to clauses not involving participial forms in Chomsky 1995, 2001), the object moves to the object agreement layer (AgrO), where participial agreement is triggered, and then continues on to the complementizer system. Hence, the AGREE relation between AgrS and the subject in its VP-internal thematic position crosses over this AgrO position and the object in its Spec. As a result, AgrO and the object intervene hierarchically on AGREE by c-commanding the subject still in its VP-internal position and by being c-commanded by AgrS (Figure 1).

In order to test whether positions filled by intermediate steps in movement like Spec-AgrO trigger attraction in the same way as positions filled in surface representations do, we manipulated structures involving object movement in which the object does not intervene on agreement when in its final position, i.e., in structures with surface OSV order. If attraction is found in such structures, this would provide evidence that the intermediate position of the object in AgrO interferes with agreement, since neither the base position of the object in the VP nor its final position in the complementizer system intervene on agreement, and we know that intervention is a necessary condition for attraction.[4] Moreover, that would provide evidence that intervention on AGREE causes attraction.

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[3] If Kayne (1994) is right, while there are cases in which precedence holds but c-command does not, there can be no cases in which c-command holds and precedence does not, so that we cannot "doubly dissociate" precedence and c-command in studying their role in interference.

[4] Under trace theory, and in particular the conception of traces as complete but unpronounced copies of the moved element, surface representations recapitulate all the information expressed by the various derivational steps. So, the evidence discussed is compatible with the view that the processor accesses intermediate derivational steps, or the view that it accesses the final derived representations recapitulating derivational steps through traces. For concreteness, we have expressed our analysis in terms of access to intermediate derivational steps. Whatever view is chosen, the substantive fact remains that the processor must access fine and abstract properties of syntactic structures.
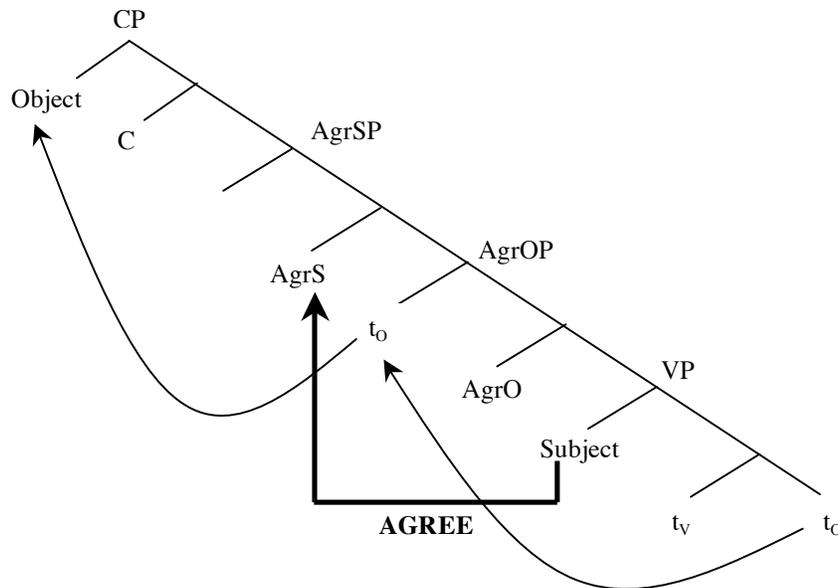
Figure 1
Relevant aspects of the derivation involving object movement
to the left periphery

The sentence complement clauses manipulated in Experiment 2 (repeated in (11a) for clarity, see section 3.2) were systematically contrasted to object relative clauses involving object movement (11b). Note that the experimental contrast is determined by the lexical properties of the main verb (*to tell*, which requires that the clausal constituent following *patients* be a clausal complement vs. *to speak*, which imposes that the clausal constituent following *patients* be a relative clause modifying the object).

(11) a. Jean dit aux <u>patientes</u> que le **médicament** guérit.
          'Jean tells the patients that the medicine cures.'

      b. Jean parle aux <u>patientes</u> que le **médicament guérit** t.
          'Jean speaks to the patients who(m) the medicine cures.'

Whereas, as mentioned in the previous section, *patients* in the complement clause (11a) was not found to generate a consistent rate of attraction (2.3%), we found that the same word in the object relative clause (11b) triggered strong attraction (8.3%).

The possibility that Spec-AgrO intervenes on AGREE between AgrS and the subject in the VP was also examined in object clefts which involve focusing on the object by moving it to the left periphery of the sentence (Experiment 6). These structures undergo a similar operation of object movement to the C-system as in relative clauses, via the intermediate position of AgrO. Sentences like (12) were tested.

(12)   C'est les <u>négociations</u> que **le ministre suspend**.
         'It's the negotiations that the minister stops.'

Again, significant attraction was reported with these structures (15%); in this case, too, the object does not intervene in the surface order (OSV), the only point of intervention in the sentence derivation being when the object transits through the AgrO layer, where it intervenes in terms of c-command in the AGREE relation between AgrS and the subject.

The fact that intermediate positions trigger attraction raises a new possibility for interpreting interference with the accusative clitic reported in the previous section: interference could be due to the intervention of the clitic on the Spec-head relation as previously suggested, but it could also be due to the intervention on AGREE of the object moving through Spec-AgrO to the clitic position (see, e.g., Belletti 1999). Along similar lines, the reduced attraction observed with dative clitics (9c) could be attributed to the fact that datives don't trigger past participle agreement, hence don't transit through AgrO. We are currently investigating structures involving direct object movement that does not trigger participle agreement (e.g., *Jean parle aux patientes que le médecin **veut** guérir* 'Jean speaks to the patients that the doctor **wants to** cure'). In these structures, the object of *guérir* cannot pass through the Spec-AgrO position of the superordinate verb *vouloir* for reasons of locality (Kayne 1989; Rizzi 1990). The finding of a weaker attraction in these structures as compared to the structures in which the object transits via Spec-AgrO of the crucial target verb (as in (11b) and (12)) would suggest a specific role of AgrO in interference. We intend to study this issue in future work.

The major result of this section is the report of attraction with the object in structures where neither its base nor its final position intervenes on agreement. Such a finding suggests that it is necessary to appeal to intermediate representations that mediate between the initial thematic structure of the sentence and the surface representation. Thus, such intermediate positions appear to have a visible effect on performance: they affect production in inducing a high rate of agreement errors.

3.5 Subject movement to Spec-AgrS

The previous sections were concerned with the characterization of the structural conditions of intervention on the agreement relation. However, we proposed in Section 2 that agreement is realized in two separate and successive steps: AGREE links the subject in the VP to AgrS, whereas, after subject movement to Spec-AgrS has taken place, a follow-up checking takes place in the local Spec-head configuration (Franck et al. 2006). On the basis of the work by Guasti and Rizzi (2002), we suggested that the additional Spec-head checking acted to reinforce agreement, and therefore that structures lacking subject raising would show more sensitivity to agreement errors than structures in which the Spec-head checking can take place.

If we consider the experiments already reported here, the subject modifier triggers interference as it intervenes on Spec-head when the subject has moved, while the object triggers interference as its intermediate trace in Spec-AgrO intervenes on AGREE and, in the case of clitics, on Spec-head when in its final

position too. What is still missing is an experimental contrast involving two structures with the same configuration of intervention but contrasting moved and unmoved subjects.

Such a contrast was investigated with clefting in French. Clefting is among the constructions which license Stylistic Inversion, i.e. the VS order, by the preposing of a clause-internal constituent (French, unlike Italian, does not allow free inversion but permits this kind of triggered inversion). Here, the movement of the object allows both SV order (repeated in (13a)) and the VS inversion in (13b). Note that the inverted structure (13b) critically differs from the free inversion manipulated in Italian (example (3)) in that here AGREE between AgrS and the VP-internal subject crosses the object in Spec-AgrO (on its way to the peripheral focus position).

(13) a.   C'est les <u>négociations</u> que **le ministre suspend**.
            'It's the negotiations that the minister stops.'

      b.   C'est les <u>négociations</u> que **suspend le   ministre**.
            it's   the negotiations that stops   the minister
            'It's the negotiations that the minister stops.'

Attraction was much larger in OVS than in OSV (29.4% vs. 15% respectively). This result supports our hypothesis that intervention in a VS structure, that is, in a structure in which agreement is ensured by AGREE only, is stronger than in a SV structure which undergoes the additional local Spec-head checking.[5]

4. Discussion and conclusion

In our recent work, we have suggested that at least four theoretical constructs from formal syntax in the tradition of Principles and Parameters/Minimalism are instrumental to capture the performance data on interference in agreement: the definition of structural intervention, the type of intervention (precedence vs. c-command), the successive steps in the derivation of the sentence involving intermediate representations, and the assumption of a two-step agreement checking process (Franck et al. 2006).

The research presented here extends our previous work by providing six new experimental data points: the non-intervening object in its post verbal position (a), the non-intervening main verb's object in the complement clause (b), a

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[5] One could argue that OVS sentences are in some sense more complex than their OSV counterparts, in which case the word order effect reported in agreement errors would be explained by factors unrelated to agreement. The major argument against this possibility is that most agreement errors occurred in the context of a number mismatching local noun; that is, agreement errors arise precisely when the system deals with number specification. Moreover, although word order also affected miscellaneous responses (consisting of substitutions or omissions of NPs, number changes or null productions) which were more frequent in OVS than OSV sentences, this effect was equally distributed over number match and mismatch conditions, suggesting that the critical interaction between number and word order is specific to agreement errors.

replication of the subject modifier (f), the dative clitic (g), a replication of the accusative clitic (h), and the object relative clause (j). Figure 2 plots the 12 data points collected to-date. Attraction appears distributed along four graded levels corresponding to the four levels of complexity identified by the theory.
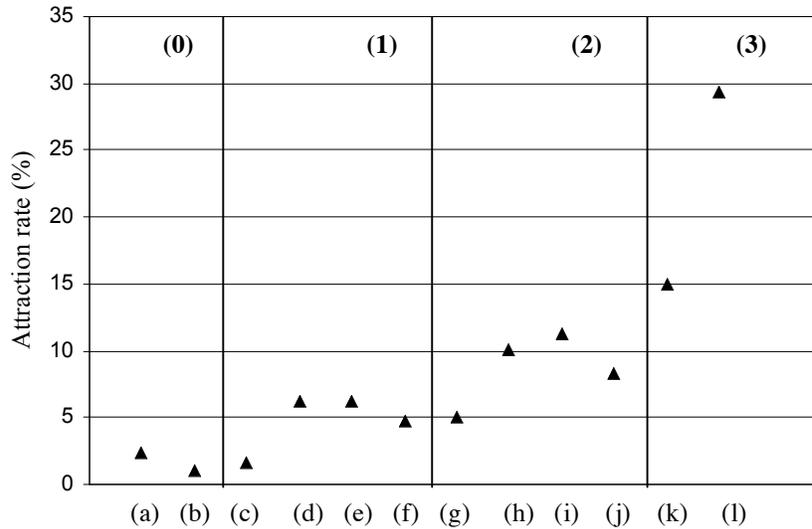

Figure 2
Attraction rate (Errors in number mismatch – Errors in number match)
as a function of the structures manipulated (represented by letters)
and the four levels of the gradient (represented by numbers)

What distinguishes level 0 from the others is that it involves no intervention, either linear or hierarchical: subject–verb agreement is established through AGREE (c) or AGREE and Spec-head (a, b), but the non-subject NP does not intervene on any of these two agreement relations. What distinguishes level 1 from others is that the attractor noun intervenes linearly (in terms of precedence), but not hierarchically (in terms of c-command). The subject modifier (d, e, f) and the dative clitic (g) precede AgrS while intervening on Spec-head. From level 2 on, intervention is not just linear but hierarchical, in terms of c-command. All test cases in this condition involve the direct object of the verb which has been shown to intervene either on Spec-head when in its final clitic position by c-commanding AgrS (h, i) or on AGREE when in its intermediate position in Spec-AgrO (j, k) by c-commanding the subject in the VP and being c-commanded by AgrS. Finally, what distinguishes level 3 from the others is that it involves c-commanding intervention in a structure in which agreement is ensured by AGREE only, without the additional local Spec-head checking. The strongest attraction effect here can thus be understood as a consequence of the inherent fragility of agreement in the VS configuration, along the lines discussed previously.

In addition to the six novel data points fitting the gradient, we provide critical evidence in support of our claim that intermediate traces of displaced

elements play a role in language production. This claim was initially made on the basis of the results obtained in clefting (Franck et al. 2006). However, the test case in Experiment 2 (contrasting object relatives to complement clauses) is even more compelling since it shows that the same word in the same surface position has dramatically different consequences on agreement depending on its syntactic status (whether it is the moved object of the target verb in the relative or the unmoved object of the main verb in the complement clause).

Evidence for the role of traces in language processing has been provided in psycholinguistics by way of different experimental techniques, including cross-modal priming (e.g., Nicol and Swinney 1989; Stowe 1986; Tanenhaus et al. 1989; Zurif et al. 1993). These studies showed that the semantic properties of a moved element were reactivated at the position of its base trace, suggesting that the syntactic parser interprets displaced constituents in their thematic position. Evidence for a specific brain locus of traces has also been provided (e.g., Ben Schachar et al. 2003; Fiebach et al. 2002; Grodzinsky 2000; Kaan et al. 2000). However, all these studies were concerned with traces of the thematic position of the moved element. The data presented here constitutes, to our knowledge, the first piece of evidence for the role of intermediate traces of movement in language production (evidence for their role in language comprehension was recently reported by Gibson and Warren (2004)).

In conclusion, the research presented here illustrates concretely the relevance of having experimental psycholinguists and linguists work together on the same questions. The detailed analyses of formal syntactic structures raise new questions, different from those that typically guide research in psycholinguistics, and offer new potential answers. This is possible thanks to the fine description of the syntactic hierarchy and the operations that underlie sentence derivation. In turn, psycholinguistics can test specific hypotheses with controlled experiments, thus considerably enriching the types of evidence normally used in theoretical syntax. We hope that our work will contribute to consolidate the link between our two disciplines, much in the spirit of the collaborative research which gave rise to modern psycholinguistics in the early years of generative grammar.

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