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Normal and pathological development of subject–verb agreement in speech production: a study on French children

Julie Franck[a,*], Stephany Cronel-Ohayon[a,b], Laurence Chillier[a], Ulrich H. Frauenfelder[a], Cornelia Hamann[a], Luigi Rizzi[a,c], Pascal Zesiger[a]

[a]*Laboratoire de Psycholinguistique Expérimentale, Université de Genève, FAPSE, 40, Boulevard du Pont d'Arve, 1205 Genève, Switzerland*
[b]*University Hospital of Lausanne, Lausanne, Switzerland*
[c]*University of Siena, Siena, Italy*

Abstract

We report a study on the spoken production of subject–verb agreement in number by four age groups of normally developing children (between 5 and 8;5) and a group of 8 children with Specific Language Impairment (SLI; between 5;4 and 9;4), all French speaking. The production of verb agreement was experimentally elicited by asking children to complete sentence preambles containing a head noun and a potentially attracting 'local noun'. In contrast to previous studies that focused on attraction with local nouns within the subject constituent (postmodifiers), we also studied attraction with local nouns in structures that are not part of the subject constituent (interpolated adjuncts). In normally developing children, we report that (1) attraction effects appear from early on; (2) singular is produced as the default number until age 7 included; (3) more errors are produced with adjunct structures than with postmodifiers, but only from age 8;5 on. In contrast, even the older SLI children showed no attraction effect, a predominance of the singular as default, no effect of syntactic structure and, more generally, persistent high error rates. The turning point observed between 7 and 8;5 in normal children, characterized by a reduced error rate and a significant effect of syntactic structure, is interpreted as an index of the automatization of agreement. The syntactic structure effect is discussed in terms of the interplay of structural and working memory factors in the computation of long-distance relationships.

Keywords: Language development; Spoken production; Subject–verb agreement; Attraction; Syntactic structure; Automatic processing; Specific Language Impairment

* Corresponding author.
E-mail address: julie.franck@pse.unige.ch (J. Franck).

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1. Introduction

Processes involved in the production of agreement have been the focus of numerous studies in experimental psycholinguistics during the last decade. The interest in this topic is explained by the fact that agreement is a paradigm example of syntactic computation: it specifies relationships between words and phrases in the sentence. The present paper focuses on subject–verb agreement in number. At a computational level, Bock and collaborators estimate that speakers of a language like English, with relatively weak agreement constraints (mostly restricted to number agreement and to the verbal system), have to arbitrate between singular and plural forms about once every five seconds in running speech (Bock, Eberhard, & Cutting, submitted). As a result, the spoken realization of agreement appears as an ideal candidate for a modular, high-speed and automatic component of syntactic production.

In modern linguistic theory, subject–verb agreement is conceived of as a configurational operation of feature checking: the number feature on the verb has no independent semantic content, it just reproduces the number feature on the subject, which is semantically grounded. In the terms of the minimalist program (Chomsky, 1995), the number feature on the verb, being 'uninterpretable', must be checked against the number feature of the subject. Studying verbal number marking therefore provides an interesting window on processes that are assumed to rely on pure syntactic computation, i.e. independently from the semantic and phonetic interfaces that bridge language and other cognitive systems.

Psycholinguistic studies of mature language systems have confirmed the basically syntactic nature of number specification on the verb (e.g. Bock & Cutting, 1992; Bock & Eberhard, 1993; Bock & Miller, 1991; Bock, Nicol, & Cutting, 1999; Vigliocco & Nicol, 1998; Bock et al., 2001; Franck, Vigliocco, & Nicol, 2002). Subject–verb agreement is assumed to be computed at the stage of *grammatical encoding* (Levelt, Roelofs, & Meyer, 1999), after the sentence has been conceptually elaborated, but before word forms are specified. Studying the nature of the constraints (syntactic, semantic, phonological) that influence the realization of agreement at the stage of grammatical encoding has provided important insights into the processes of syntactic production in adult speakers. The main experimental finding is that although some semantic and phonological properties of the words involved in the sentence were found to play a role in agreement realization (e.g. Vigliocco, Butterworth, & Garrett, 1996), their impact appears secondary as compared to the syntactic factors that operate. Syntactic constraints involve: (1) the abstract lexico-syntactic number representation of the subject noun (Bock & Cutting, 1992; Bock & Eberhard, 1993; Bock et al., 2001), and (2) the configurational properties of the sentence, i.e. the syntactic position of the subject head noun and of any potentially interfering noun at the stage of grammatical encoding (Franck, Vigliocco, & Nicol, 2002; Hartsuiker, Anton-Mendez, & Van Zee, 2001; Vigliocco & Nicol, 1998).

In contrast to the relatively well understood agreement processes in adult production, little is known about the development of subject–verb agreement in children. This paper aims at shedding light on the normal and pathological development of subject–verb agreement in complex sentences, and more particularly on the role of syntactic, i.e. configurational constraints at play in these two language systems. Before turning to

the specific questions that guided the present work, we first review the psycholinguistic literature on agreement in adults as well as in the two populations of interest in this paper: normally developing children and children with specific language impairment (SLI).

2. Subject–verb agreement in adults

Despite the apparent simplicity of the rule, subject–verb agreement errors occur in the spontaneous speech of adults, although at a very low rate (less than 1 per 1000 according to Bock (1991)). In all the languages studied, the presence of a noun that follows the head noun, and that mismatches it in number (as illustrated in (1)), has been identified as a major cause of agreement derailment (see Bock and Miller (1991), for a review).

(1) *The proportion of gender agreement errors were much higher (from an anonymous reviewer of JML)

In (1) the verb ('were') agrees with the plural noun ('errors') instead of the singular subject head noun ('proportion'). To describe these agreement errors, some grammarians introduced the principle of 'proximity': a mismatching *local noun* close to the verb tends to dominate, or attract, the agreement relationship, hence the qualification of *proximity concord* or *attraction* errors. The attraction effect can be seen as the performance analogue of grammatical principles of locality according to which certain kinds of interveners block local grammatical relations (in virtue of the principle of Relativized Minimality according to which a trace cannot be separated from its antecedent by another element of the same syntactic nature, see Chomsky (1995) and Rizzi (1990)). In this paper, we will focus on the syntactic factors involved in the attraction phenomenon.

Bock (1991) suggested that a major processing difficulty in language production lies in regulating the interference between elements that are structurally similar and that are part of the same encoding unit. It is commonly assumed that the basic unit of encoding at the syntactic level is the clause, meaning that elements of the same clause are encoded together (Garrett, 1988). In this view, a local noun should interfere more with the agreement process when situated in the same clause as the head noun than when situated in a separate clause. Bock and Cutting (1992) compared the occurrence of attraction errors with local nouns situated in prepositional phrases (e.g. The editor of the history books) to errors with local nouns situated in relative clauses (e.g. The editor who rejected the books). In the first case, the local noun is assumed to be encoded at the same time as the head and the verb since they are all part of the same clause. In contrast, the local noun that is part of a relative clause is separated from the matrix clause, and is therefore assumed to be encoded separately from the head noun and verb. The authors reported that number agreement failed more often when the verb was separated from the head noun by a prepositional phrase postmodifier (*The editor of the history books WERE…) than when the two were separated by a relative clause (*The editor who rejected the books WERE…). In a second experiment comparing prepositional phrase postmodifiers to complement clauses (e.g. The report that they controlled the fires), the authors found again that errors were more frequent after phrasal than after clausal postmodifiers. Nicol (1995) further

confirmed that nouns in a separate clause from the head (e.g. The owner of the house who/which charmed the realtors) hardly interfere with the agreement process in English (less than 1% errors).

In a different study manipulating syntactic structure, Vigliocco and Nicol (1998) reported that the production of subject–verb agreement errors by English speakers was the same in interrogative sentences (e.g. *ARE the label on the bottles green?) as in declarative sentences (e.g. *The label on the bottles ARE green). Such a finding is important since it shows that the closeness of the local noun to the verb in the uttered word string is not at all a necessary condition for attraction to occur.

Franck, Vigliocco, and Nicol (2002) suggested that the phrase, rather than the clause, was to be considered as the unit of agreement encoding. The authors compared the occurrence of subject–verb agreement errors produced by French and English speakers when completing sentence preambles that contained two postmodifying local nouns. Both local nouns were inserted in prepositional phrases and were therefore part of the same clause as the subject head noun. They found a higher rate of attraction with the local noun situated high in the tree structure, but far from the verb in the linear structure (e.g. *programs* in: *The computer with the programs of the experiment ARE broken), than with the local noun situated low in the tree structure, but close to the verb in the linear phrase (e.g. *experiments* in: *The computer with the program of the experiments ARE broken).

This finding further indicates that the linear proximity of the local noun to the verb in the word string is not the critical trigger of agreement failures given that almost no errors were produced with the local noun preceding the verb. Moreover, it shows that although clausal encapsulation does certainly play a role in insulating processes of syntactic production, one needs to adopt a more fine-grained view of syntactic structure in order to provide a full account of attraction. Franck et al. (2002) and Vigliocco and Nicol (1998) suggested that attraction effects are a function of the syntactic distance between the local noun and the S-node in the hierarchical tree structure at the moment of agreement realization[1] (see also Pearlmutter, 2000, for similar findings in language comprehension).

The studies reported until here all concern attraction with subject postmodifiers, i.e. with nouns situated within the subject constituent. Interference with nouns situated outside the subject constituent has received much less attention, although some observations of attraction with verbal objects have been reported. In a study on Dutch, Hartsuiker, Anton-Mendez, and Van Zee (2001) found that number features on the preverbal object significantly interfere with subject–number agreement. Attraction was reported both for full object NPs (e.g. **Karin zegt dat het meisje de kransen WIN*, *Karin says that the girl the garlands win) and for clitic object pronouns (e.g. **Ed ziet dat de kapitein hen VAL AAN*, *Ed sees that the captain them attack). However, both these attracting features were found to disrupt agreement to a lesser extent than subject postmodifiers (e.g. **Karin zegt dat het meisje met de kransen WIN*, *Karin says that the girl with the garlands win). Similarly, attraction with full nominal objects was reported in stylistic inversion in French (e.g. **C'est les négociations que le ministre SUSPENDENT*, *It's the negociations that

[1] The empirical evidence brought by these authors does not allow to determine whether the crucial syntactic distance to account for attraction effects concerns the distance between the local noun and the head noun or between the local noun and the verb.

the minister stop) as well as with clitic object pronouns (Franck, 1998; Franck, Lassi, & Rizzi, in preparation). Finally, attraction with clitic objects was also found in the written production of agreement in French (Fayol, Largy, & Lemaire, 1994). These studies show that attraction is not limited to number features within the subject phrase, but that the phenomenon extends to other features in the sentence.

Finally, in a study in progress on French, Franck and Nicol (in preparation) contrasted the occurrence of agreement errors in the presence of subject postmodifiers (e.g. **Le cuisinier des délicieux restaurants* FONT…, *The cook of the delicious restaurants DO…) to the occurrence of agreement errors in the presence of clausal adjuncts, i.e. structures that are not part of the subject constituent (e.g. **Le pâtissier, en attendant les clients,* FONT…, *The baker, while waiting for the clients, DO…). The data collected on a group of 50 native French-speaking adults show that not only do adjunct structures yield attraction, they generate more agreement errors than subject postmodifiers.

The finding that number features on the direct object constituent or on extrapolated adjuncts interfere with the agreement process brings new insights into how agreement is computed. In particular, it challenges the hypothesis that agreement is operated within insulated encoding units (whether these are clauses or smaller units), indicating that attraction is not necessarily a local disruption occurring inside of the subject constituent. Rather, it appears as a broader phenomenon guided by the syntactic configuration of the different elements in the sentence. Nevertheless, no integrated framework has been proposed to date to account for the different observations in terms of the configurational properties of the sentence. Such a framework is proposed in this paper, and applied to developmental issues (Section 5).

3. Subject–verb agreement in normally developing children

It is usually assumed that number inflections on nouns are reliably produced in the spontaneous speech of three-year old children (Bassano, 2000; Keeney & Wolfe, 1972; Rondal, 1978). Developmental studies have shown that nouns appear in their singular form before the plural form (Cazden, 1968; Mervis & Johnson, 1991) and that children understand singular items before their plural counterparts (Clark, 1973; Lapointe, 1986).

Children produce nominal number markers before they produce verbal markers (Bassano, 2000; Berko, 1958; Keeney & Wolfe, 1972; Thévenin, Totereau, Fayol & Jarousse, 1999; Totereau, Thévenin, & Fayol, 1997), possibly because number is semantically grounded on nouns only. Nevertheless, the analysis of spontaneous productions by children in languages like German or English indicates that subject–verb agreement is acquired from early on (Clahsen, 1991; Wexler, 1994). Authors like Rasetti (2003) and Rondal (1978) suggested that the syntax of number is acquired by French children by the age of 3, although verbal plurals appear to be absent from French children's speech in a first phase (Bassano, 2000; Clark, 1985; Grinstead, 1994; Hoekstra & Hyams, 1996; Pizzuto & Caselli, 1994). Rasetti (2003) recently analysed the spontaneous productions of three irregular verbs (*être*, to be, *aller*, to go, and *avoir*, to

have) by three young French speaking children (aged between 1;8 and 2;10). Plural verbs were found to appear for the first time between the ages of 2;2 and 2;9, depending on the child. Interestingly, all plural forms (30 in total) found at these ages were used consistently in the sense that they occurred with plural subjects only. However, these children were still using singular forms in the context of plural subjects in one third of the cases.

Number morphology is particularly complex in a language like French. Inflectional morphology of number is far from being marked systematically in the spoken modality, even though it can be considered quite regular in writing (Dubois, 1965). In the nominal domain, less than 1% of the nouns are phonologically marked for number, which is mostly marked on the determiner. In the verbal domain, number is phonologically unmarked on verbs in most tenses, and marked mostly on irregular verbs (like *fait*/*font*, does-S/do-P; Dubois, 1965). Given that in many instances number is neither audible on the noun nor on the verb in the French language, it is difficult to derive statistics as to the correctness of subject–verb number agreement in spontaneous speech. Moreover, experimental studies of elicited speech, in which children are forced to produce verbs that are phonologically marked for number, are very rare, one reason being the difficulty to apply adult experimental methods into the developmental field.

However, some studies have been conducted, mostly on the written production of French, based on a paradigm of sentence dictation in which children were asked to write down sentences (Chanquoy & Negro, 1996; Fayol & Got, 1991; Fayol, Hupet, & Largy, 1999; Negro & Chanquoy, 2000; Thévenin et al., 1999). The observations of Fayol and colleagues can be summarized as follows. First, young children (until around 7) tend to produce singular verbs, i.e. lacking the final plural marker *-nt*, whether the subject is singular or plural. Interestingly, attraction only starts to develop around age 8 or 9. Finally, although agreement errors of children aged 9 show similar profiles as adults, they remain considerably more frequent. These results show that children's performance in writing moves from the systematic default use of singular verbs to attraction errors, which are characteristic of expert writers. On the basis of a series of studies conducted on adults, Fayol and colleagues proposed that agreement consists in a two-step process: (1) an automatic procedure of copying onto the verb the number feature situated closest to it in the linear word string, and (2) a controlled, resource-consuming procedure of checking the correctness of the automatic routine (Fayol & Got, 1991; Fayol, Largy, & Lemaire, 1994). In this framework, attraction occurs in expert language systems as a direct consequence of the automatic component of agreement computation. The authors conclude from their developmental studies that agreement becomes automatic around the age of 8–9, when attraction effects start to appear.

One specificity of these developmental studies on written agreement is that they bear on the production of a plural morpheme (*-nt*) which is unmarked in the oral format, that is, a strictly orthographical number marker. Moreover, these studies do not test children under age 7, i.e. an age at which agreement is already assumed to be mastered as attested by the observations of their spontaneous productions. It is therefore possible that what the agreement errors reported in writing reflect is not the syntactic operation of agreeing

the verb with the subject per se, but rather some properties of the process responsible for dealing with orthographic rules of verbal number marking specific to written production.

4. Subject–verb agreement in children with Specific Language Impairment

Developmental psycholinguistics has recently shown a great interest in the study of children with SLI. These children are characterized by severe problems in the development of their language, in production and comprehension. Research on SLI children in different languages has pinpointed severe difficulties with inflectional morphology (Bishop, 1994; Clahsen, 1989, 1991; Rice, Wexler, & Cleave, 1995; Van der Lely & Stollwerck, 1997). Of particular interest here are the studies, most of them on English and German, that found difficulties of SLI children in the use of finite verb morphemes (Clahsen, 1989; Hamann, Penner, & Lindner, 1998; Leonard, Bortolini, Caselli, McGregor, & Sabbadini, 1992; Rice et al., 1995). Similar findings were reported for young French-speaking SLI children (Hamann et al., 2003; Paradis & Crago, 2000).

In order to account for the difficulties with verbal morphology and the overuse of non-finite forms by SLI children, several explanations have been advanced. Clahsen (1989) proposed the Missing Agreement Hypothesis for German speaking SLI children, whereas Van der Lely (1994, 1996) suggested that SLI children suffer from a more general difficulty with structure-dependent relationships (RDDR, Representational Deficit with Dependent Relationships hypothesis), including not only agreement deficits but also troubles in tense marking (Rice et al., 1995), theta role assignment (Van der Lely, 1994, 1996) and reference assignment to anaphors and pronouns (Van der Lely & Stollwerck, 1997). On the basis of analyses of English-speaking SLI children, Van der Lely and colleagues concluded that it is rare for any structure to be totally absent in their speech, rather, they seem to inconsistently manipulate core aspects of syntax involving complex hierarchical relationships. Interestingly, she reports observations about a child who correctly marked agreement on the verb only when it directly follows the overtly expressed subject. From a computational viewpoint, she suggests that movement can optionally occur in the sense that it is not automatic and compulsory, that is, a steady state has not been achieved in contrast to normal grammar (Van der Lely, 2003).

The deficit SLI children have in dealing with complex syntactic dependent relationships has also been proposed to account for younger normally developing children (Giannelli & Manzini, 1995). In the view according to which SLI children show parallel but delayed syntactic development, it has recently been proposed that SLI children remain in a phase also observed for younger normally developing children, the phase of optional infinitives (Wexler, 1994) or truncation (Rizzi, 1993/1994).

To our knowledge, no systematic experimental investigation of agreement capacities of French SLI children has been carried out to date. Under structural accounts (like the RDDR), pervasive difficulties are expected, especially in complex structures involving movement of constituents.

5. Theoretical framework and predictions of the present research

We present two studies on the normal and pathological development of subject–verb agreement in number in French. Three aspects are examined that concern: (1) the development of attraction and the automatization of agreement, (2) the developmental role of structural factors in agreement, and (3) the use of the singular verb form as default. In the first study, 60 children with normally developing language, divided into four age groups (5, 6, 7 and 8;5-year old), were tested. In the second study, 8 children diagnosed as SLI were examined. All of them showed close-to-normal discursive, semantic, lexical and phonological abilities, but impaired syntactic abilities.

The experimental technique used was inspired by the paradigm of sentence completion developed by Bock and Miller, (1991): children were asked to complete orally presented sentence preambles illustrated by pictures, and their agreement errors were analysed. The same materials used by Franck and Nicol (in preparation, see section on adults) were presented to the children. Attraction with a local noun situated within the subject constituent (i.e. within a prepositional phrase, as in (2)) was compared to attraction with a local noun that is not part of the subject constituent but of a clausal adjunct situated in between the subject phrase and the verb phrase (as in (3)).[2]

(2) **Le cuisinier des délicieux restaurants FONT des gâteaux*
**The cook of the delicious restaurants MAKE cakes*

(3) **Le pâtissier, en attendant les clients, FONT des gâteaux*
**The baker, while waiting for the clients, MAKE cakes*

On the basis of studies of the development of written French, Fayol and collaborators suggested that attraction constitutes an index of when the child starts to compute agreement automatically (Section 4). Indeed, agreement requires not only establishing the right syntactic relationship between the subject and the verb, it also requires keeping track of the subject head noun's number, retrieve the correct morphology of the verb, and its phonological or orthographic word form, all these processes being computed within a very short time-window. The finding that attraction appears around age 8 in written speech made the authors conclude that only at this age does agreement become fully automatic. Although speaking contrasts with writing in that it is extremely fast, there is a priori no reason to assume that the automatization of the agreement procedure starts earlier in the spoken modality. As a result, attraction is expected to develop only in the older group(s) of normally developing children tested (around 7 or 8). Given the important syntactic deficit shown by children with SLI, it is possible that agreement does not reach such a stage

[2] Our attention was drawn on the possibility that these interpolated adjuncts may actually be interpreted as reduced relatives, and therefore act as relative clauses. Although the two constructions may appear similar, interpolated adjuncts clearly do not act as restrictive modifiers as attested by the fact that they can be placed in different positions (sentence-first or post-verbal positions), they have a separate intonation contour (with a pause or a coma in written speech), and that the referent of the NP is established independently of the adjunct (the semantic connection to the NP and the event is much more vague; it can be temporal, causal, etc.).

of automatic computation (Van der Lely, 2003). As a result, no attraction should be observed in these children.

With regard to the role of syntactic structure in agreement realization, though some studies suggested that attraction is strongest with elements that are part of the subject clause (Bock & Cutting, 1992; Nicol, 1995), the study conducted by Franck and Nicol showed that adult speakers produced more agreement errors with adjuncts, i.e. with features that are situated outside the subject constituent, as in (3), than with prepositional phrase modifiers, i.e. with features that are situated within the subject constituent, as in (2). We believe that to explain these apparently conflicting findings, attraction must be analysed in terms of the fine configurational properties of the sentence. Consider the constituent structure of sentences with subject postmodifiers as illustrated in (4) (whether prepositional phrases or subject relative clauses) and the structure of sentences with adjuncts illustrated in (5).

(4) […head noun… […local noun…]] VERB
(5) […head noun…][…local noun…] VERB

In (4) the verb constituent directly follows the head noun's constituent, while the two are separated by the local noun's constituent in (5). Hierarchically, whereas the local noun is situated within the head noun's constituent in (4), it is situated between the head and the verb in (5). In processing terms, this may mean that whereas the verb is being encoded temporally right after the subject constituent is closing, in (5) its encoding has to wait for that of yet another constituent which contains the local noun. It is therefore possible that attraction originates in two different causes in (4) and (5): whereas attraction in (4) would index interference because of the simultaneous encoding of the head noun and local noun, attraction in (5) would index the pervasive role of having the subject and verb separated by another constituent, which may reduce the availability of the head noun's number feature, necessary to compute subject–verb agreement.

Research in the area of normal language development has already brought pieces of evidence suggesting that from early on, young children do proceed to a syntactic structuring of the sentence (Poeppel & Wexler, 1993). However, the question is open as to whether children show the same sensitivity to the syntactic position of the local noun as adults when performing agreement, and if so, from what age on. In contrast, if children with SLI do not fully elaborate the hierarchical structure for the sentence, or if they suffer of a specific deficit with syntactic movement, they are expected to show no sensitivity to the syntactic position of the attractor noun.

Finally, analyses of spontaneous productions as well as experimental research on written French both demonstrate the use of singular verbs as a default value. If spoken agreement follows the same evolution as its written counterpart, normally developing children are expected to stop using such a strategy around age 7, as was found in studies on written production. In contrast, the syntactic deficit of children with SLI may manifest itself as a persistent use of singular verbs as defaults.

6. Experiment 1. Normally developing children

6.1. Method

6.1.1. Participants

A total of 63 children coming from two different schools in Geneva took part in the experiment. All children were native speakers of French, i.e. French was the language spoken by their mother at home. Some of them were bilinguals. Two of them were rejected from the analysis because they kept producing the infinitive form of the verb. A third child was rejected because he showed more than 30% agreement errors in the baseline condition and seemed to have problems to understand the task. The sixty remaining children were divided into four age groups, corresponding to four different classes in the Swiss educational system:

Group 1: 15 children from *Première enfantine*, mean age 4;11 (age range 4;7–5;7).
Group 2: 15 children from *Deuxième enfantine*, mean age 5;11 (age range 5;6–6;4).
Group 3: 15 children from *Première primaire*, mean age 6;11 (age range 6;3–7;3).
Group 4: 15 children from *Deuxième primaire*, mean age 8;5 (age range 7;7–9;5).

Henceforth, Groups 1–3 will be referred to as 5, 6 and 7-year old.

Before the experimental task, two complementary tests were presented to the children in order to ensure that they did not show any major deficits with regard to syntactic production and working memory. The syntactic production test (Ysadile) is a sentence repetition task that is part of a larger battery of language evaluation (Piérart, Comblain, Grégoire, Mousty & Noël, in preparation). The child is required to repeat a set of 30 sentences with different kinds of syntactic structures (negation, passivization, relativization, interrogation, pronominalization). The working memory test (Taillospan, developed by Maillart and Bragard, in preparation) requires children to memorize animal names and to organize the recall from the smallest animal to the biggest. Two versions of the Taillospan test were used: a version with short names (one syllable) and a version with long names (three syllables). On the basis of the available norms collected by the two teams who developed these tests, all children were found to perform normally both with regard to the syntactic production and to the working memory tasks.

6.1.2. Materials

Experimental materials consisted of a series of 32 sentence preambles associated to drawings illustrating people executing actions. All actions could be described using the verb *faire* (to do/make) and children were strongly encouraged to use this verb, in order to have them produce a verb that is phonologically marked for number. Drawings were presented on paper cards and paired with sentence preambles that were read by the experimenter. Sentence preambles contained a head noun and a local noun. Variables manipulated in the preambles were: (1) the number of the head noun (Singular vs. Plural), (2) the number of the local noun (Singular vs. Plural), and (3) the structure in which the local noun was inserted (Postmodifier vs. Adjunct). The design comprised a total of eight

Table 1
Examples of sentence preambles used in Experiments 1 and 2

	Preamble	Action illustrated
Postmodifier condition		
SS	La gagnante du dernier championnat (The winner of the last championship)	Faire du patin. (To do ice skating)
SP	La gagnante des derniers championnats (The winner of the last championships)	Faire du patin. (To do ice skating)
PS	Les habitants du petit village (The inhabitants of the small village)	Faire le sapin. (To do the Christmas tree)
PP	Les habitants des petits villages (The inhabitants of the small villages)	Faire le sapin. (To do the Christmas tree)
Adjunct condition		
SS	La grand-mère, en parlant à la fille (The grandmother, while talking to the girl)	Faire la pâte. (To make the dough)
SP	La grand-mère, en parlant aux filles (The grandmother, while talking to the girls)	Faire la pâte. (To make the dough)
PS	Les garçons, en suivant le moniteur (The boys, while following the instructor)	Faire du ski. (To do skiing)
PP	Les garçons, en suivant les moniteurs (The boys, while following the instructors)	Faire du ski. (To do skiing)

Note. Some of these translations may seem awkward in English though they sound natural in French.

experimental conditions ($2 \times 2 \times 2$) with four experimental items per condition. Examples of items are given in Table 1 and the complete list is presented in Appendix A.

As given in Table 1, each preamble was presented twice with a variation of the number of the local noun. Head nouns and verbs were on average separated by the same number of syllables in the two syntactic conditions (Postmodifier and Adjunct). Preambles were between 8 and 11 syllables long, but the mean length of the items in the Postmodifier condition was the same as in the Adjunct condition. All nouns included in the preambles were concrete. The animacy of the nouns was also controlled such that all head nouns were animate, but inanimate local nouns were introduced in half of the preambles, equally spread across the experimental conditions. Items were arranged semi-randomly such that two items with the same head noun were always separated by a minimum of five other items. Presentation order was the same for all children.

6.1.3. Procedure

The child was sitting in front of the experimenter in a quiet room of the school. A second experimenter was staying on the side taking notes about the child's responses. Additionally, the whole session was recorded on minidisk.

The experimenter started by naming each of the actions depicted on the drawings using the infinitive form of the verb *faire* (to do/make): "*Ici, c'est l'action de faire un gâteau*" (Here, the action is to make a cake). The child was then asked to complete single head noun preambles consisting of each of the 16 subject head nouns from the experimental set (e.g. the child hears "*Le garçon"* (the boy) and is required to say *"fait un gâteau"* (makes a cake)). This task served as a baseline to determine the children's ability to produce

agreement in simple sentences. Finally, the experimental set of 32 sentence preambles and cards was presented. The child was told that the task was the same as the previous baseline task, except that the sentences to be completed would be a bit longer.

Each session started with a stage of familiarization with the task during which the experimenter gave examples and the child was required to practise until the procedure was perfectly mastered. Sessions lasted between 25 and 35 min.

6.1.4. Design and data analysis

Statistical tests were carried out separately for each of the four age groups, with agreement errors as dependent measure. Agreement errors were scored when the child produced a correct completion for the sentence, except for the number on the verb. Only the first production was analysed, meaning that when the child self-corrected, the agreement error was considered. Given that very few self-corrections occurred (less than 1% of the errors), they were not analysed. Repeated measures ANOVAs were run with participants as random factor. The independent variables involved in the design were: number of the head noun (Singular vs. Plural), number match between the head and local nouns (Match vs. Mismatch) and syntactic structure (Postmodifier vs. Adjunct). They were all part of a within-participant design. Post-hoc comparisons using the paired-sample *t* test were also conducted when theoretically motivated.

6.2. Results

6.2.1. Group 1: mean age 5

Baseline test. A total of 36 (15%) agreement errors were produced, 7 (2.9%) with singular heads and 29 (12.1%) with plural heads.

Experimental test. A total of 112 (23.33%) agreement errors were produced. The distribution of errors is illustrated in Table 2.

Significantly more agreement errors occurred with plural than with singular head nouns ($F(1,14) = 153.76, p < 0.001$). The presence of a mismatching local noun did not affect the error rate ($F(1,14) = 1.43, p = 0.25$) and this variable did not interact significantly with the number of the head noun ($F(1,14) = 1.97, p = 0.18$). However, in presence of a singular head noun, a plural local noun generated more errors than a singular local noun, as attested by the significant paired sample *t*-test ($t(14) = 1.8, p = 0.05$). The syntactic position of the local noun had no impact on agreement errors ($F < 1$).

6.2.2. Group 2: mean age 6

Baseline test. A total of 35 (14.6%) agreement errors were produced, 5 (2.1%) with singular heads and 30 (12.5%) with plural heads.

Experimental test. A total of 105 (21.87%) agreement errors were produced (Table 2). Again, more errors were produced when the head noun was plural than when it was singular ($F(1,14) = 240.05; p < 0.001$). There was no effect of the number match ($F(1,14) = 2.76, p = 0.12$). The interaction between this variable and the number of the head was not significant either ($F(1,14) = 1.10, p = 0.31$). Nevertheless, like in Group 1 plural local nouns generated significant attraction, as attested by the significant *t*-test

Table 2
Distribution of the agreement errors produced by the four groups of normally developing children (Experiment 1) and by children with SLI (Experiment 2)

	Postmodifier	Adjunct	Total
Group 1 (age 5)			
SS	3 (0.63)	5 (1.04)	8 (1.67)
SP	10 (2.08)	7 (1.46)	17 (3.54)
PS	23 (4.79)	20 (4.17)	43 (8.96)
PP	21 (4.38)	23 (4.79)	44 (9.17)
Total	57 (11.88)	55 (11.46)	112 (23.33)
Group 2 (age 6)			
SS	2 (0.42)	2 (0.47)	4 (0.83)
SP	8 (1.67)	5 (1.04)	13 (2.71)
PS	21 (4.38)	24 (5)	45 (9.38)
PP	17 (3.54)	26 (5.42)	43 (8.96)
Total	48 (10)	57 (11.88)	105 (21.88)
Group 3 (age 7)			
SS	1 (0.21)	2 (0.42)	3 (0.63)
SP	4 (0.83)	4 (0.83)	8 (1.67)
PS	26 (5.42)	29 (6.04)	55 (11.46)
PP	22 (4.58)	24 (5)	46 (9.58)
Total	53 (11.04)	59 (12.29)	112 (23.33)
Group 4 (age 8;5)			
SS	2 (0.42)	1 (0.21)	3 (0.63)
SP	5 (1.04)	8 (1.67)	13 (2.71)
PS	5 (1.04)	8 (1.67)	13 (2.71)
PP	2 (0.42)	7 (1.46)	9 (1.88)
Total	14 (2.92)	24 (5)	38 (7.92)
SLI			
SS	3 (1.17)	3 (1.17)	6 (2.34)
SP	4 (1.56)	5 (1.95)	9 (3.52)
PS	18 (7.03)	18 (7.03)	36 (14.06)
PP	20 (7.81)	22 (8.59)	42 (16.41)
Total	45 (17.58)	48 (18.75)	93 (36.33)

Note. S corresponds to singular and P to plural. The first letter refers to the number of the head noun, the second letter refers to the number of the local noun. Percents are in parentheses.

($t(14) = 2.8, p < 0.01$). The syntactic position of the local noun did not significantly affect error distribution, although a clear trend was present ($F(1, 14) = 3.86, p = 0.07$).

6.2.3. Group 3: mean age 7

Baseline test. A total of 60 (25%) agreement errors were produced, 12 (5%) with singular heads and 48 (20%) with plural heads.

Experimental test. A total of 112 (23.33%) agreement errors were produced (Table 2). As in the two previous groups, plural head nouns yielded more agreement errors than singular head nouns ($F(1, 14) = 378, p < 0.001$). The presence of a number feature on the local noun mismatching with the head generated attraction errors, as attested by

the marginally significant effect of the number match variable ($F(1, 14) = 4.26, p = 0.06$). This variable did not interact with the number of the head noun ($F < 1$). No effect of the syntactic position of the local noun was found ($F(1, 14) = 1.68; p = 0.216$).

6.2.4. Group 4: mean age 8.5

Baseline test. A total of 13 (5.4%) agreement errors were produced, 3 (1.3%) with singular heads and 10 (4.1%) with plural heads.

Experimental test. A total of 38 (7.92%) agreement errors were produced (Table 2). No main effect of the number of the head was found ($F(1, 14) = 1.70, p = 0.213$), indicating that in contrast to the previous groups, children did not produce more errors with plural than with singular heads. Like in Group 3, a main effect of number match was found ($F(1, 14) = 5.24, p < 0.05$), which did not interact with the number of the head noun ($F < 1$). Importantly, syntactic structure significantly affected the occurrence of agreement derailments: more errors were produced with adjunct structures than with postmodifiers ($F(1, 14) = 4.73, p < 0.05$).

7. Discussion

The first important result of Experiment 1 concerns the attraction effect found from very early on: at age 5 children already show a sensitivity to the presence of a plural local noun in the context of a singular head noun. From age 7 on, children are globally affected both by singular and plural local nouns mismatching in number with the head (Fig. 1).[3]

The finding of an attraction effect in the spoken productions of children as young as 5-year old suggests that, from early on, children compute agreement on the basis of similar principles as adult speakers (see Section 9 for a more detailed argumentation). If attraction is to be considered an index of the automatization of the agreement procedure, as suggested by Fayol and collaborators, two interpretations are possible. The first possibility is that agreement becomes automatic earlier in spoken production than in written production. Such a hypothesis is implausible since syntactic operations can reasonably be assumed to be the same in both modalities. The second possibility is that attraction does not reflect the automatization of agreement. In favour of this second hypothesis are two findings. First, young children until age 7 included still produce an extremely high number of errors (still nearly 25% at age 7). Second, until the age of 7 included, children show a strong tendency to produce singular verbs. Importantly, this finding does not seem to be attributable to the complexity of the experimental materials given that the same effect was

[3] One possible explanation that needs to be ruled out is that attraction errors reflect the incorrect assignment of the subject function to the local noun. If this were the case, errors would not have anything to do with the agreement process; they would only reflect the indirect effect on agreement of an erroneous function assignment process. In the present study, half the items had inanimate local nouns which did not constitute plausible subjects for the verb 'to do' that children were required to use. The error distribution reveals that children produced no more errors on items with animate local nouns (which were plausible subjects) than on items with inanimate local nouns (Fs < 1). It therefore appears reasonable to assume that the attraction phenomenon can not (or at least not entirely) be explained by a misassignment of the subject function to the local noun, but rather emerges at a further stage of the production process.

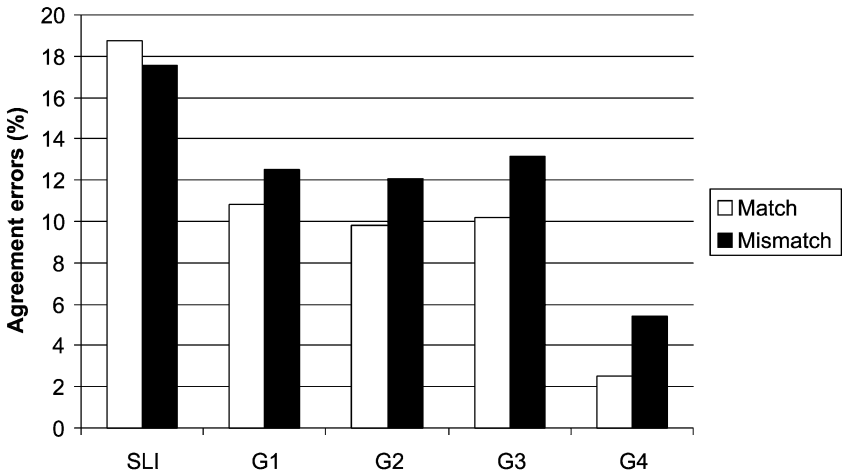

Fig. 1. Attraction in children with SLI and in the four age groups of normally developing children (G1, G2, G3, G4).

reported in the production of the simple sentences of the baseline test (Fig. 2). The asymmetry between singular and plural verbs suddenly disappears in the productions of 8;5-year old children, in parallel to the drastic reduction of the agreement error rate, and to the appearance of a significant sensitivity to syntactic structure. We believe that the functional significance of these major changes in the error patterns between 7 and 8;5 reflects different degrees of automatization of the agreement procedure (see Section 9 for a more detailed account).

Two important remarks have to be made here. First, when young children did actually produce the plural form of the verb *faire* (to do), which occurred in about 60–75% of

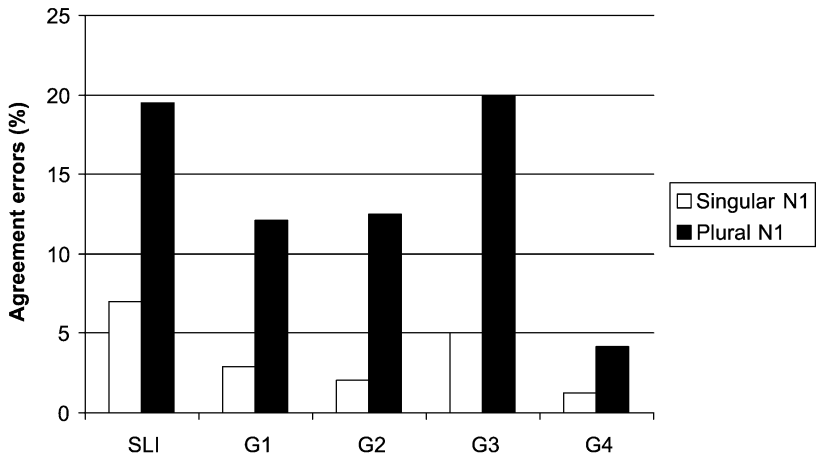

Fig. 2. Percent errors in the baseline condition (single head nouns) in children with SLI and in the four age groups of normally developing children (G1, G2, G3, G4).

the cases (depending on the group), they always produced the correct morphological form (i.e. *font*). That is, children did not produce any other word-form but *fait* and *font* (no overregularization errors, e.g. *faisent*, neither person errors, e.g. *faisons*, or tense changes, e.g. *faisaient*). This rules out the possibility that the children did not master the irregular third person plural morphology of the verb *faire*. Second, children's productions do not reflect a selection at chance level of the verb's number: when they produce a plural verb, they do so mostly in the appropriate context (in more than 90% of the cases), i.e. when the head noun is plural. The fact that the marked form is almost always correctly used clearly suggests that the agreement paradigm is mastered, although it does not appear to be fully automatized as attested by the high proportion of unmarked forms produced.

Although attraction appeared globally significant from age 7, the effect was already present with plural local nouns before that age. Such an asymmetry between singular and plural heads in the attraction effect has been widely reported in adult studies in different languages (Bock & Cutting, 1992; Bock & Eberhard, 1993; Bock & Miller, 1991; Fayol & Got, 1991; Fayol et al., 1994; Vigliocco et al., 1996, Vigliocco, Butterworth, & Semenza, 1995). Some authors interpret this asymmetry as reflecting the markedness of plural nouns: a marked local noun (as in SP) would be more prone to interfere with the agreement process than an unmarked local noun (as in PS) (Eberhard, 1997). Interestingly, no asymmetry was found in children from age 7 on, and we did not find any asymmetrical distribution in the adults tested on the same materials (Franck and Nicol, in preparation). The lack of asymmetry actually parallels a series of reports in the French literature (Franck, 1998; Franck et al., 2002; Hupet et al., 1998; Negro & Chanquoy, 2000). We believe that two potentially conflicting factors are at play in attraction: one that relates to the properties of the local noun (its markedness), the other one that relates to the properties of the verb (its morphological complexity). The interplay of these two factors is addressed in Section 9.

Another important result of Experiment 1 is that whereas children aged 8;5 produced significantly more errors with local nouns in adjuncts (24) than with local nouns in subject postmodifiers (14), a pattern of response that is similar to what we found with adults (Franck and Nicol, in preparation), no significant effect of this structural factor was found in younger children (Fig. 3). Note, however, that children in Group 2 already showed a clear tendency ($p = 0.07$) towards this effect.

Effects of the syntactic position of the local noun have been argued to reflect the hierarchical structure of the sentence during the stage of syntactic encoding, i.e. when agreement is assumed to be computed (Bock & Cutting, 1992; Bock et al., submitted, 2001; Franck et al., 2002). Does the absence of a structural effect in children below 8;5 imply that they do not proceed to a hierarchical structuring of the sentence, i.e. that their sentences are produced on the basis of linear relationships between the words? We believe not, and propose different arguments against this view in Section 9 related to (1) the presence of noise in the highly error-prone systems of children until age 7, and (2) the involvement of attentional/working memory resources.

One final point we need to mention here concerns the observations reported for the third group of children aged 7. This group presents a very high error rate in the experimental task, which appears mostly in the PS condition as compared to the profiles shown by younger children. This may attest of the generalization of attraction to singular local

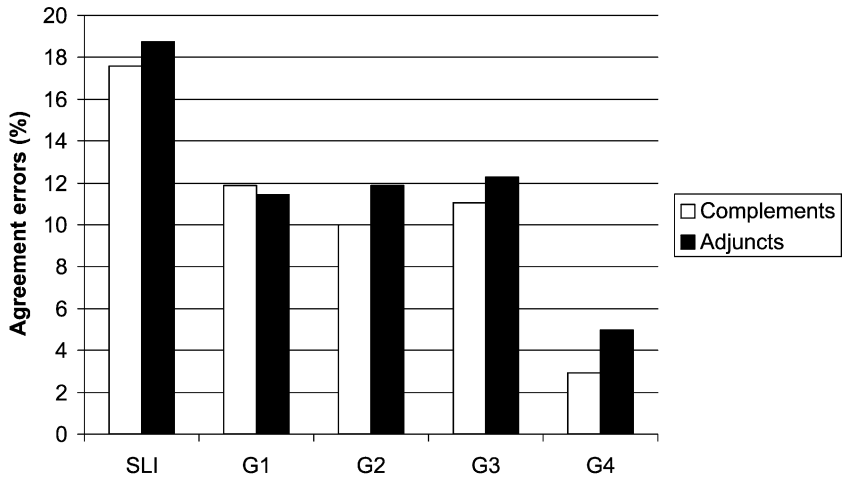

Fig. 3. Structural effect in children with SLI and in the four age groups of normally developing children (G1, G2, G3, G4).

nouns, which indeed remains in older children although with much lower error rates. However, this does not explain why 7-year olds produced so many errors in the baseline test. At this age, children start to learn agreement rules at school; the acquisition of this declarative knowledge might create some conflict with their procedural knowledge and generate meta-linguistic strategies that bring them, for a short period of time, to produce more errors.

8. Experiment 2: children with SLI

8.1. Method

8.1.1. Participants

Eight children between 5;4 and 9;4-year old clinically diagnosed as SLI by a speech therapist, a neuropsychologist and a neuro-paediatrician took part in Experiment 2. A complete language battery assessing lexical, semantic, phonological and syntactic components of language, as well as a battery of cognitive abilities (Wechsler, 1991) were administered to each child. The characteristics of these children complied with the SLI diagnostic criteria (Leonard, 1998) in that they showed normal cognition (QIP $>$ 80) but language acquisition difficulties and delay ($<$1.25SD on more than two language tasks) in the absence of any neurological, organic, hearing, nor psychiatric abnormality. All of them were in speech therapy.

All children were diagnosed primarily as *production* SLI, i.e. having a specific deficit in the production of syntax contrasting with good language comprehension. Note that the absence of comprehension deficits is of considerable importance in experimental testing since it allows us to eliminate any interpretation of the data that would be based on

problems in understanding the instructions. The language of these children was subject to a series of investigations including experimental and clinical studies as well as corpus analyses by our group, with the global aim of refining existing interpretations of the difficulties underlying SLI (Chillier et al., 2001; Cronel-Ohayon et al., 2001; Cronel-Ohayon, in preparation; Hamann et al., 2002, 2001, 2003; Zesiger et al., 2001). For more information as to other aspects of the language of these children, the reader is referred to these studies conducted by the group. In the present study, we do not discuss these children's language in a global theoretical framework, but rather propose to contribute to the understanding of their abilities to produce the specific syntactic operation of subject–verb agreement in number.

8.1.2. Materials, procedure and design

Details are the same as discussed in Section 6.

8.1.2.1. Data analyses. In a first analysis, the eight children were separated into two age groups in order to allow for comparisons between the performances of the SLI to the groups of normally developing children matched on chronological age: SLI1 (mean age 6;1) was matched to Group 2 (mean age 6) while SLI2 (mean age 8;8) was matched to Group 4 (mean age 8;5). Nevertheless, since no statistical differences were found between SLI1 and SLI2, all SLI children were treated as a single group in the further analyses. Student *t*-tests were used to compare means between the experimental conditions.

8.2. Results

Baseline test. A total of 21 (32.8%) agreement errors were produced by the children in SLI1, 4 (6.25%) with singular head nouns and 17 (26.6%) with plural head nouns. Children in the SLI2 group produced a total of 13 (20.3%) agreement errors, 5 (7.8%) with singular head nouns and 8 (12.5%) with plural head nouns. The two groups do not differ statistically ($t(6) = 0.9, p = 0.4$) and were therefore analysed together. The global analysis over all SLI children shows an average of 26.5% errors: 19.5% consisting in producing erroneous singular verbs (i.e. with a plural subject) and 7% consisting in producing erroneous plural verbs (i.e. with a singular subject), a difference that is statistically significant ($t(7) = 1.8, p < 0.05$).

Experimental test. A total of 54 (42.19%) agreement errors were produced by children in SLI1 and 39 (30.47%) by children in SLI2. Again, the two groups did not differ statistically in their error rates ($t(6) = 1.1, p = 0.3$). A correlation test further confirms that the error rate is independent from the chronological age of the children ($r = 0.08$). Given that age does not appear to constitute a relevant criterion to separate the children in two groups, results were analysed over all participants. The distribution of agreement errors in the different experimental conditions is illustrated in Table 2. The SLI children produced significantly more errors with plural subjects (30.5%) than with singular subjects (5.9%) ($t(7) = 2.5, p < 0.05$). The presence of a mismatching local noun did not affect error rate (18.75% errors on average in the match conditions; 17.58% errors on average in the mismatch conditions, $t(7) = 1.2, p = 0.3$). There was no difference between

the postmodifier condition (17.58% errors) and the adjunct condition (18.75% errors) ($t(7) = 0.5, p = 0.6$).

8.3. Discussion

The most striking aspect of the results is the particularly high agreement error rate produced by the SLI children tested. Even the older group of SLI children (mean age 8.8) produced more than 20% errors in the baseline task with simple subjects, and more than 30% errors in the more complex experimental task. These errors show a similar asymmetry between singular and plural verbs (Fig. 2) to what was observed in young normal children until the age of 7, though globally more numerous. Importantly, similarly to normally developing children, SLI children produced rather few errors with singular head nouns, i.e. they rarely used plural verbs in the inappropriate context of a singular subject. This finding suggests that the knowledge of the meaning/form mapping is by and large acquired by SLI children, that is, agreement is being checked. However, the morphological paradigm of number does not seem to be activated systematically, maybe like what was previously reported for other aspects of their grammar (Van der Lely, 2003; Wexler, 1998).

A second important aspect of the results is that SLI children failed to show any sensitivity to attraction (Fig. 1), in contrast to the significant effects reported from early on in normally developing children (i.e. from the age of 5 with singular head nouns). This finding suggests that SLI children rely on different agreement procedures from normally developing children and adults, an argument which is developed in Section 9.

Finally, SLI children did not show any sensitivity to the syntactic position of the local noun. Although this absence of effect is consistent with what was found in Groups 1–3 of normally developing children, the finding that older SLI children did not show any difference between these two structures differs from what was found in their age-matched controls (Group 4) who produced significantly more errors with adjunct structures than with postmodifiers (Fig. 3). This is important since the absence of any syntactic effect, together with the absence of attraction effects, may further attest that SLI children have problems in building the fine details of the structural frame for the sentence and in dealing with non-local relationships. It is interesting to note here that the performance of the children in the experimental task significantly correlates with their results on the syntactic comprehension test ECOSSE (French version of the English TROG test; Lecoq, 1996: $r = 0.79$, $p < 0.05$). In other words, children with a better score in syntactic comprehension showed better agreement performance in the sentence production task. This finding suggests that both tests may reflect functionally related language abilities, which can presumably be considered related to syntactic production.

However, as we argued for normally developing children, the absence of a structural effect can also be interpreted by unrelated factors (e.g. noise, attentional resources). Only a follow-up study of these children would provide the relevant information as to whether their language system matures with age such that they finally show a reduction of the agreement error rate, the appearance of attraction effects, and a sensitivity to the syntactic organization of the lexical items.

9. General discussion

We conducted two parallel studies in French, one on 60 normally developing children (aged between 5 and 8;5) and one on eight children with SLI (aged between 5;4 and 9;4). The objective was to shed light on the normal and pathological development of subject–verb agreement in number in spoken production. Subject–verb agreement errors were experimentally elicited using a paradigm of sentence completion combined with picture presentation. Sentence preambles to be completed contained a head noun and a local noun either as a subject postmodifier or in an interpolated adjunct.

On the basis of corpus analyses it is claimed that the syntax of verb agreement is acquired by the age of 3. However, spontaneous corpuses of spoken French do not provide a large sample of instances of subject–verb agreement given that number is in many cases phonologically unmarked in the verbal system. Moreover, children tend to produce syntactically simple sentences, and it is therefore impossible to arrive at conclusions concerning the correctness of agreement in complex structures. Our results show that normally developing children aged 7 do still produce more than 20% agreement errors when forced to produce complex sentences. The older children tested, aged 8;5, showed a sudden reduction of the error rate to around 8%, a rate which nevertheless remains around twice what is usually reported in adult speakers (around 4%). With regard to the SLI group studied, the eight children were found to have major difficulties with syntax, and therefore represented a group likely to have problems in computing subject–verb agreement. The high error rate reported (more than 30%), together with the absence of attraction and syntactic structure effects, supports the hypothesis that these children have particular difficulties in dealing with complex structural relationships.

Three phenomena were examined more closely: (1) the development of attraction effects, and (2) the production of singular verb forms as default. The three phenomena are discussed in turn in the following sections, (3) the development of a sensitivity to the syntactic structure of the sentence.

9.1. Attraction effects

From early on, children were significantly affected by the presence of an interfering local noun with a number different from the head. The report of early, adult-like attraction effects in normally developing children contrasts with the finding of a lack of sensitivity to the presence of a local noun in SLI children.

In the two younger age groups of normally developing children, attraction is restricted to sentences with singular subjects: SP yielded more errors than SS, but PS did not yield more errors than PP. Such an asymmetry between singular and plural attraction parallels most observations in adults. Bock and colleagues suggested that plural local nouns are better attractors of agreement because they are marked, i.e. specified for number (both at the semantic and morphological levels). The presence of a number feature would render plural local nouns more salient than singular local nouns which carry no number specification and therefore have a zero, default number value (Bock & Eberhard, 1993). Along these lines, Eberhard (1997) obtained experimental evidence in favour of the hypothesis that plural nouns are marked (Section 9.2).

From age 7, the pervasive impact of a local noun was found to be globally significant in that both a plural and a singular local noun attracted verbal agreement, in line with what was found in adults using the same materials (Franck & Nicol, in preparation). A number of independent observations of singular attraction are also reported in the literature on French agreement (Fayol & Got, 1991; Fayol et al., 1994; Franck, 1998; Franck et al., 2002; Hupet et al., 1998; Negro & Chanquoy, 2000). It has been argued that two forces are probably at play in a language like French when selecting the verb form, depending on whether properties of the local noun or of the verb are considered (Franck et al., 2002). The first force acts at the syntactic level and concerns the attraction power of the local noun's number feature: a plural feature, being marked, is a stronger attractor than a singular feature, which drives the system to produce erroneous plural verbs rather than singular ones. The second force acts at the word-form level and consists in a tendency of the system to produce a morphologically simpler verb form, that is the singular in French, which also constitutes the default verb form. It is interesting to note that in English, where the singular-plural asymmetry has been reported most consistently, singular verbs are morphologically more complex than plural verbs. As a result, whereas both forces point towards opposite choices in French, the two converge to select plural rather than singular verbs in English.

With regard to the mechanism underlying attraction, Fayol and collaborators suggested that it arises as a consequence of the automatic component of agreement realization which consists in the copying, on the verb, of the nominal number feature situated closest to the verb in the linear word string (Fayol et al., 1994, 1991; Hupet et al., 1998). In order to ensure correct agreement in sentences in which the subject head noun is separated from the verb by a local noun, the authors assume the existence of a controlled component responsible for checking the appropriateness of the automatic procedure. This control procedure is conceived of as a resource-consuming process involving working memory.

Although a number of studies clearly speak against the hypothesis that the verb automatically receives the number value of the noun situated in its linear proximity in the uttered word string (Bock & Cutting, 1992; Franck et al., 2002; Vigliocco & Nicol, 1998), the hypothesis that agreement computation involves the application of some automatic routine seems necessary to account for the extremely fast and usually correct realization of agreement in spoken speech. Nevertheless, the finding of very early attraction effects in spoken production, at ages where agreement is still highly error-prone and guided by the use of singular verbs as default, questions the possibility that attraction reflects the automatization of the agreement procedure. In Section 9.3 we propose a modified view of how such a routine may be at play, integrating the observations available to date.

9.2. Singular as default

One main characteristic of the agreement errors observed in the three first groups of normally developing children (i.e. until 7 included) is that they nearly all involved producing singular verbs in place of plural verbs: more than 80% of the agreement errors occurred with plural subjects in the complex sentences of the experimental task, and more than 90% in the simple sentences of the baseline task. The same tendency to produce

singular verbs as default was reported in the productions of SLI children (more than 80% of the errors in the complex task and about 75% in the baseline task). However, in contrast to the finding that 8;5-year old stop using the singular as default, older SLI children (aged 9) show a strong persistence of the effect.

The finding of an asymmetry between errors with plural heads and errors with singular heads indicates that both normally developing children and children with SLI do not respond randomly: they show a clear preference for singular verbal forms. This preference cannot be accounted for by the fact that children do not master the morphological paradigm of pluralization of the verb *faire* (to do) which they were required to use: when they produced the plural verb (i.e. *font*), they did produce its correct form. Moreover, the finding that, in spite of using singular verbs as default, younger children correctly produce plural verbs in the context of plural subjects suggests that the child has knowledge of the verbal morphology and of its appropriate use from early on, even though he may frequently opt for the unmarked form rather than searching the morphological paradigm. This finding is in line with the observations made on the basis of corpus analyses in many languages (Clark, 1998; Grinstead, 1994; Pizzuto & Caselli, 1994; Rasetti, 2003; Rondal, 1978).

It is interesting to note that a fine analysis of adult literature shows similar profiles in the match conditions, i.e. more errors in PP than in SS. Though not as strong as the asymmetry reported between the two mismatch conditions (SP being more error-prone than PS, see Section 9.3), and often too weak to appear in statistical analyses, this asymmetry is very systematic and found in all languages (e.g. in French, Fayol et al., 1994; Franck, 1998; Franck et al., 2003; in English, Bock & Cutting, 1992; Bock & Miller, 1991; in Italian, Vigliocco et al., 1995; in Spanish, Vigliocco et al., 1996).

Other experiments have also reported asymmetrical processing of singular and plural forms. For example, in a study of spontaneous errors, Stemberger (1985) reported a strong asymmetry in adult English speakers, with more errors of producing singular verbs than plural verbs. Also, when asked to memorise nouns, participants were found to recall plural nouns as singulars, while no such recall arose with singular nouns (Van der Molen & Morton, 1979). Fayol et al. (1994) reported that verb agreement with plural head nouns was more disrupted by a secondary task than was agreement with singular head nouns (such as when a memory load task was added to a sentence dictation task). It has also been found that elderly people, who show a reduction of working memory resources, are more sensitive to the presence of plurals than young adults (Fayol, Hupet, & Largy, 1999). All these findings point towards the idea that plural forms are in some sense marked, or more complex than singular ones.

9.3. Syntactic structure, working memory and automaticity

The observations reported in the present study challenge the view that subject–verb agreement is computed on the basis of 'processing islands' of clause size (Bock & Cutting, 1992), or at least require us to amend it. Indeed, children aged 8;5 showed stronger attraction with local nouns in adjunct structures, i.e. situated outside the 'processing island' of the subject constituent, than with local nouns in postmodifiers, i.e. situated

within the subject constituent. Importantly, this pattern was also observed with adults (Franck and Nicol, in preparation), but diverges from what was found in younger children (between 5 and 7 included) and SLI children (between 5;4 and 9;4) who showed no difference between the two syntactic structures.

The first question is why did children below 8;5 and children with SLI show no sensitivity to the syntactic position of the local noun? A possible explanation, which we favour, has to do with the interpretation of a statistically non-significant effect in highly error-prone systems which show an important internal variability. This was found to be the case in the three first groups of children, who produced around 25% errors, as well as in SLI children, who erred in about 30% of their productions. These language systems may simply be too noisy (as also attested by the baseline results) to allow subtle syntactic effects to show up statistically. Alternatively, it is possible that children below age 8;5 do not structure hierarchically their output; their sentences would be produced on the basis of linear associations between the words. Such a hypothesis is nevertheless difficult to defend in face of the large literature on language acquisition attesting that children start developing hierarchical relationships from early on (see the detailed studies showing early sensitivity to the structure-dependency of rules reviewed in Crain, 1991). Finally, one cannot rule out the possibility that younger children, and maybe SLI children too, have problems in assigning the proper structure to an interpolated adjunct of the 'en V-ant' ('while V-ing') type, and tend to structurally interpret it as part of the subject noun phrase in a kind of relative clause (*The baker, while waiting for the clients*… would be interpreted as *The baker who is waiting for the client*…) or in a present participle structure (*The baker waiting for the clients*…). If such errors in the interpretation of the materials indeed occurred, they may have contributed assimilating adjuncts to some sort of subject postmodifiers, thereby reducing the structural differences between the two experimental conditions.

The second question is why did adjunct structures generate more errors than postmodifiers in our older group? We believe that to understand the structural effects observed in agreement we must more closely consider the fine details of the configurations studied up till now. Previous studies reported in the literature are mostly based on experiments manipulating subject postmodifiers (phrasal or clausal), that is, local nouns that are part of the subject constituent. A few studies showed that attraction also occurs with number features on the direct object (Fayol et al., 1994; Franck, 1998; Hartsuiker, Anton-Méndez, & Van Zee, 2001). These effects suggest that not only subject postmodifiers but also other elements of the sentence can interfere with the agreement process. According to our view, agreement can derail for two different reasons. The first source of error is interference between two nouns that are encoded in the same syntactic unit, and therefore usually in the same time window; this is what has classically been investigated in the literature on phrasal subject postmodifiers, and corresponds to the hypothesis advocated by Bock and colleagues. The second source of error would result from loosing track of the number specification on the head because encoding of the subject is separated from encoding of the verb by a resource-consuming constituent. This factor involves working memory resources which we argue are intimately related to computing the configurational properties of the sentence.

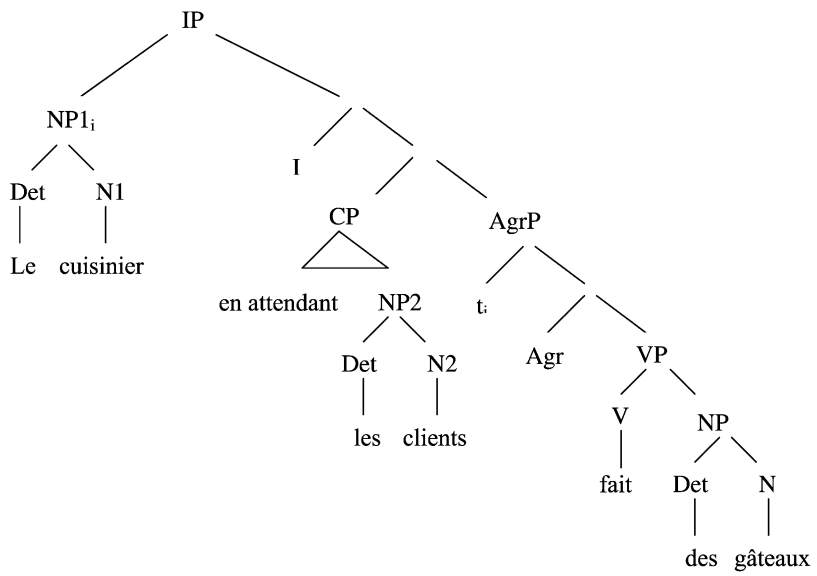

Fig. 4. Syntactic representation of a sentence containing a subject with an adjunct structure. I: inflection, CP: complementizer phrase, AgrP: agreement phrase.

Understanding the relationship between the structural factors at play in agreement and the potential involvement of working memory requires precise assumptions as to the trees that represent syntactic links between the words in the sentences studied. Cardinaletti (2003) points out that at least two distinct syntactic positions must be postulated across interfering adjuncts: a higher position restricted to referential subjects (as in Example 6b) and a lower position, where agreement is checked, accessible to expletive subjects (as in Examples 6a and 7a). In contrast, 7b is excluded because the higher position is not accessible to a non-referential subject.[4]

(6a) Yesterday, John was in Chicago
(6b) John, yesterday, *t* was in Chicago
(7a) Yesterday, there was a snowstorm in Chicago
(7b) *There, yesterday, *t* was a snowstorm in Chicago

If referential subjects preceding interpolated adjuncts are moved to the higher position from the lower position checking agreement, as is the case in our Adjunct condition, we end up with representations like the following, i.e. involving a trace for the subject NP[5] (Fig. 4).

[4] Note that *t* expresses the trace of movements.
[5] We have indicated Cardinaletti's higher subject position as the specifier of an inflectional head I, without discussing its exact nature. See Cardinaletti (2003) for discussion.

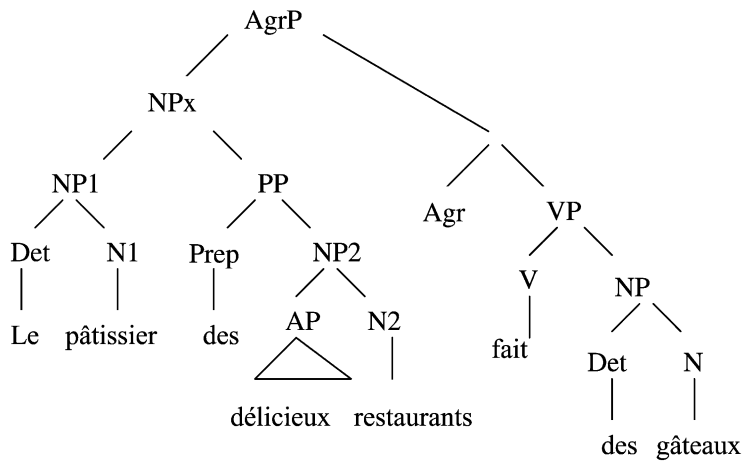

Fig. 5. Syntactic representation of a sentence containing a subject with a postmodifier. I: Inflection, NPx: complex NP, AgrP: agreement phrase.

In the case of subject postmodifiers, this complex structural configuration is not necessarily activated and the subject remains in the specifier of the Agreement Phrase where the agreement relation can be checked locally (at the level of the Agr node), i.e. without the intervention of a trace for the subject NP, as is shown in Fig. 5.

Under this view, the relation between the subject and the agreeing verb is necessarily mediated by an antecedent–trace relation in Fig. 4, but not in Fig. 5. Although the head noun and the verb were on average separated by the same number of words and syllables in the two experimental conditions (that is, the linear distance was the same), the presence of a subject NP trace in the adjunct configuration makes it structurally more complex. It is therefore possible that this higher complexity necessitates the involvement of working memory in order to store the head noun's number while processing the intermediate words, which would make the configuration more error-prone.

Although the role of working memory (or more general concepts like processing capacity) has recently been the focus of a series of studies in aphasiology, sentence comprehension or language development (Gathercole & Baddeley, 1990; Gibson, 1998; Grodzinsky, 2000), its role in agreement realization has received little attention. Some kind of 'mental energy' seems necessary to keep track of the subject's number while computing the structures that sometimes separate it from the verb. This idea found support in studies of the written production of agreement: writers produce considerably more errors (around 30% errors) when they have to perform a working memory task like memorizing a set of numbers or words concurrently to sentence production (Fayol & Got, 1991; Fayol, Largy, & Lemaire, 1994; Hupet, Fayol, & Schelstraete, 1998). In the spoken format, Bock and Cutting (1992) reported that whereas longer phrases increased the occurrence of agreement errors (e.g. The report of the destructive FOREST fires vs. The

report of the destructive fires), longer clauses did not (e.g. The report that they controlled the FOREST fires vs. The report that they controlled the fires). In other words, as the size of a clause increases, the efficiency of grammatical processes that operate within that clause, like subject–verb agreement, decreases. However, according to the authors, this decrease would not be related to working memory since they reported no correlation between attraction errors and the performance of their participants in a working memory test. Along these lines, Almor and colleagues (Almor, MacDonald, Kempler, Andersen, & Tyler, 2001) reported that Alzheimer patients, who suffer from a severe working memory impairment, are able to process subject–verb dependencies just as well as their control group. In contrast, the processing of long-distance discourse dependencies like pronoun–antecedent relationships was found to be significantly affected in Alzheimer patients. In sum, working memory was found to play a role in the written production of subject–verb agreement and in the processing of discourse agreement relationships. In contrast, working memory was not found to significantly influence the spoken realization of subject–verb agreement, nor its comprehension, at least in adults.

To integrate the different results, we argue that working memory (or more generally computational resources) is not systematically required to process agreement relationships. Its involvement would be a function of (1) the syntactic distance that separates the subject from the agreement node Agr (where agreement takes place after the verb has raised from the VP), and (2) the level of expertise of the language system. The scenario for expert language systems is the following. When the subject and the agreeing verb are contiguous to each other in the tree in a local specifier–head configuration, like in Fig. 5, agreement would be computed without the need of particular computational resources (or with very low requirements that are not observable), on the basis of some automatic routine that basically says 'agree the inflected verb with the head noun of its specifier'. The spoken realization of agreement production appears as a good candidate for automaticity given that it meets with the usual characteristics of automatized processes like high speed, low error rate, lack of effort required, and absence of general capacity use. The hypothesis of an automatic computation of agreement in such local Spec-head configurations accounts for the reports that working memory abilities of unimpaired adults do not correlate with their agreement performance in such structures (Bock & Cutting, 1992), and that Alzheimer patients, in spite of their working memory impairment, have no trouble dealing with local agreement checking (Almor et al., 2001).

In contrast, structures as the one shown in Fig. 4, in which the subject and verb are separated by another constituent, are assumed to require additional computational resources in order to keep track of the subject's number feature until the verb is raised into Agr. The accrued computational load related to the presence of a subject trace in this configuration would be responsible for the higher error rate reported both for older children and for adults. It is interesting to note that in favour of this interpretation, speakers tended, even in the match conditions (SS and PP), to produce more agreement errors in the adjunct condition (children: 13.34%, adults: 8%) than in the postmodifier condition (children: 6.67%, adults: 3.5%). If the subject's number feature is lost, the system can either use the available number feature on the local noun (as attested by the attraction effect, still present), or select the number feature by chance (as attested by the high

proportion of errors in the match conditions). The report by Almor et al. (2001) that Alzheimer patients are in difficulty when dealing with non-local dependencies like antecedent–pronoun agreement, in spite of their good performance in local relationships, further indicates that the involvement of working memory resources in agreement depends on configurational properties of the sentence.

Our scenario for non-expert language systems is slightly different. The observations reported in the present paper suggest the existence of a turning point in the agreement process situated between age 7 and age 8;5; we reported (1) a substantive reduction of agreement errors, (2) a disappearance of the singular as default use, and (3) the appearance of a significant difference between postmodifiers and interpolated adjuncts. Importantly, children from early on showed sensitivity to attraction and knowledge of the verbal number morphology, suggesting that an agreement procedure similar to adults' is already at play, in accordance with continuity principles assumed in much recent literature on development. The difference between expert and non-expert systems would therefore rather lie in the degree of automatization of the agreement procedure. Given that attraction is found in still immature systems with extremely high error rates and a default use of singular verbs, it seems difficult to assume that it provides a relevant indicator of the automatization of agreement in spoken speech (as was suggested by Fayol and collaborators). Rather, the sudden reduction of the error rate combined to the loss of the singular as default strategy observed between age 7 and 8;5 may well indicate a switch towards such an automatic computation of agreement. Initially, the system is not fully in place in the sense that it does not rely on a fully automatic agreement routine; as a result, it is resource-consuming and error-prone. Young children know the verbal paradigm and the configuration in which agreement is checked, but given the complexity of the task, they tend to rely on a strategy of default use of the singular verbal form. In this framework, the absence of a significant structural effect in young children is not due to a discontinuity in the nature of the agreement procedure, but rather to the considerable noise resulting from the high error rate until age 7 included, which itself derives from the non automatization and highly resource-consuming agreement checking.

Data collected with children with SLI diverge from what was found in normally developing children in different respects. First, they still show extremely high error rates at the age of 8;5 (more than 30%). Second, they perseverate in their production of singular verbs as default, a strategy that is abandoned by normal children from the age of 8;5 on. However, like normally developing children, the overuse of singular verb forms as default is accompanied by an occasional, but correct use of verbal plurals. It is therefore probable that SLI children do master the verbal paradigm but do not realize it systematically, similarly to other aspects of their grammar like tense marking (Van der Lely, 2003). In this view, SLI children would not use deviant agreement procedures but rather would fail to rely on the routine that ensures fast, and usually correct agreement. Nevertheless, the absence of an attraction effect reported in SLI children, in contrast to its early appearance in young normally developing children, comes to qualify the possibility that agreement is computed following normal feature checking. Rather, together with the extremely high error rate, we believe these observations indicate that these children have difficulties in elaborating the adequate syntactic relationships

between the words in complex sentences, in accord with structural accounts like the RDDR (Van der Lely, 1994, 2003, 1996).

10. Conclusion

In this paper we argue that the two existing theoretical accounts of attraction in agreement that have been contrasted until now in the literature, i.e. in terms of working memory (or linear distance), or in terms of syntactic structure (or syntactic distance, that is, a specifically linguistic factor), actually deal with two aspects of a complex, highly integrated process. The hypothesis of a basic, precompiled routine of agreeing the verb with the subject when the two are configurationally close to each other (in a specifier–head relationship) is argued to account for the extremely fast and efficient computation of agreement in expert language systems. Automatic feature checking allows for a minimal involvement of other components, both inside the language system (e.g. conceptual information) and outside of it (e.g. working memory). In contrast, non-expert language systems of young children below 8 do not seem to make use of such a routine; singular verbs are often produced by default and agreement is highly error-prone. In contrast, the children with SLI examined were found not only to have failed to develop such an automatic computation of feature checking, but they also seem to show a deviance in elaborating structural dependencies.

When the head noun is not in a local, Spec-head relationship to the agreement node, i.e. when the two are separated by another constituent in the hierarchical structure and agreement is mediated by the NP's trace, the routine would call for some additional, resource-consuming support. If, as we advocate, working memory is indeed responsible for the higher error rate found in such structures in expert systems (children aged 8;5 and adults) in such structures, its involvement is argued to be tightly linked to the configurational properties of the sentence: keeping track of the head noun's number depends on the syntactic (and not linear) distance that separates the head from the verb (or, more precisely, the Agreement node). To date, the nature of these language-related working memory processes and their involvement in syntactic production have not received much attention. Further empirical investigations and theoretical modelling of agreement production will need to integrate a fine description of the configurational properties of the sentences examined and a detailed conception of the computational resources involved in language production.

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Appendix A. Materials used in Experiments 1 and 2

	Preamble	Action illustrated
Postmodifier condition		
SS	L'amie de ma meilleure copine (The friend of my best pal)	Faire du cheval. (To horse ride)
SP	L'amie de mes meilleures copines (The friend of my best pals)	Faire du cheval. (To horse ride)
SS	Le fils du très méchant voisin (The son of the very nasty neighbour)	Faire du foot. (To play football)
SP	Le fils des très méchants voisins (The son of the very nasty neighbours)	Faire du foot. (To play football)
SS	Le maçon du superbe bâtiment (The builder of the beautiful building)	Faire un mur. (To make a wall)
SP	Le maçon des superbes bâtiments (The builder of the beautiful buildings)	Faire un mur. (To make a wall)
SS	La gagnante du dernier championnat (The winner of the last championship)	Faire du patin. (To do iceskating)
SP	La gagnante des derniers championnats (The winner of the last championships)	Faire du patin. (To do iceskating)
PS	Les élèves de la gentille maîtresse (The pupils of the nice teacher)	Faire de la gymnastique (To do the gym)
PP	Les élèves des gentilles maîtresses (The pupils of the nice teachers)	Faire de la gymnastique (To do the gym)
PS	Les cousines de mon meilleur ami (The cousins of my best friend)	Faire de la musique. (To play music)
PP	Les cousines de mes meilleurs amis (The cousins of my best friends)	Faire de la musique. (To play music)
PS	Les habitants du petit village (The inhabitants of the little village)	Faire le sapin. (To do the Christmas tree)
PP	Les habitants des petits villages (The inhabitants of the little villages)	Faire le sapin. (To do the Christmas tree)
PS	Les pâtissiers du délicieux restaurant (The bakers of the delicious restaurant)	Faire des gâteaux. (To make cakes)
PP	Les pâtissiers des délicieux restaurants (The bakers of the delicious restaurants)	Faire des gâteaux. (To make cakes)
Adjunct condition		
SS	La grand-mère, en parlant à la fille (The grandmother, while talking to the girl)	Faire la pâte. (To make the dough)

(*continued on next page*)

Appendix A (*continued*)

	Preamble	Action illustrated
SP	La grand-mère, en parlant aux filles (The grandmother, while talking to the girls)	Faire la pâte. (To make the dough)
SS	Le gamin, en jouant avec son frère (The kid, while playing with his brother)	Faire une tour. (To build a tower)
SP	Le gamin, en jouant avec ses frères (The kid, while playing with his brothers)	Faire une tour. (To build a tower)
SS	Le garçon, en sautant sur le pull (The boy, while jumping on the pullover)	Faire sa valise. (To prepare the suitcase)
SP	Le garçon, en sautant sur les pulls (The boy, while jumping on the pullovers)	Faire sa valise. (To prepare the suitcase)
SS	La fille, en dormant sous le drap (The girl, while sleeping under the sheets. (sg))	Faire un rêve. (To make a dream)
SP	La fille, en dormant sous les draps (The girl, while sleeping under the sheets)	Faire un rêve. (To make a dream)
PS	Les garçons, en suivant le moniteur (The boys, while following the monitor)	Faire du ski. (To ski)
PP	Les garçons, en suivant les moniteurs (The boys, while following the monitors)	Faire du ski. (To ski)
PS	Les cuisiniers, en attendant le client (The cooks, while waiting for the client)	Faire le repas. (To make the meal)
PP	Les cuisiniers, en attendant les clients (The cooks, while waiting for the clients)	Faire le repas. (To make the meal)
PS	Les docteurs, en tenant la patte (The doctors, while holding the leg)	Faire une piqûre. (To do an injection)
PP	Les docteurs, en tenant les pattes (The doctors, while holding the legs)	Faire une piqûre. (To do an injection)
PS	Les enfants, en se tenant la main (The children, while holding (each other's) hand)	Faire la ronde. (To make a round)
PP	Les enfants, en se tenant les mains (The children, while holding (each other's) hands)	Faire la ronde. (To make a round)

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