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Brief article

Separating hierarchical relations and word order in language production: is proximity concord syntactic or linear?

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Abstract

In this paper we address the question whether hierarchical relations and word order can be separated in sentence production. In two experiments, we assess whether subject-verb agreement errors (such as 'The time for fun and games are over') require linear proximity of a so-called 'local' noun ('games' in the example) to the verb. In the first experiment, we found a proximity effect when participants were asked to complete sentential beginnings of the kind: 'The helicopter for the flights'. In the second experiment, we asked participants to produce a question such as 'Is the helicopter for the flights safe?'. The syntactic relation between the subject noun and the local noun is the same in the two experiments, but the linear position of the local noun is different. The distribution of agreement errors was similar in the two experiments. We argue that these data provide evidence for a stage in language production in which a syntactic structure is built prior to a stage in which words are assigned to their linear position. Agreement is computed during the first stage. © 1998 Elsevier Science B.V. All rights reserved

Keywords: Agreement errors; Grammatical encoding; Language production

1. Introduction

Producing a sentence requires going from an intention to be expressed to a sequence of sounds composing words that express that intention. In going from one to the other, as Merrill Garrett put it, the 'language production system has to get the details of form right' (Garrett, 1980 p. 216). These include details of syntax

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and word order. In the present paper, we will focus on a particular type of 'syntactic detail', agreement between the subject and the verb of a sentence, and we will use agreement errors to assess some of the psychological processes responsible for getting the syntactic details of the form right.

The rule for grammatical subject-verb agreement in English is very simple: if the subject of the sentence is singular, then the verb has to be singular; if the subject of the sentence is plural, then the verb has to be plural. Despite the simplicity of the rule, errors occur in both speaking, as exemplified in (1), and writing, as in (2).

(1) The time for fun and games *are* over. (from Bock and Miller, 1991)
(2) It is then this world of dreams created in the idle brain which *take* out the realm of reality into the sphere of self-deception. (from Strang, 1966)

Errors such as those reported in (1) and (2) have been labeled *attraction errors* (Zandvoort, 1961) or proximity concord (Quirk et al., 1972). In these errors, instead of agreeing with the *head noun*, the subject of the sentence (*time*, in the example in 1) the verb agrees with a *local noun* adjacent to the verb (*games* in 1).

In most theories of language production (Bock, 1982; Garrett, 1976, 1993; Levelt, 1989), agreement (being a long distance dependency relation) would be computed during a stage referred to here as *Grammatical Encoding*. During this stage, based on the message the speaker wants to convey, words are retrieved from the mental lexicon and arranged in a way that reflects not only the speaker's intentions but also the syntactic conventions of the language. This stage is followed by a *Phonological Encoding* stage in which the phonological form of the sentence is spelled out. Grammatical encoding comprises three main functions: assigning grammatical functions to lexical elements (e.g. to map the agent of an action to the subject of the sentence); building hierarchical constituent structures that reflect the assigned grammatical functions (e.g. the subject of the sentence is expressed by a noun phrase (NP)); and arranging these constituents in a serial order. Assigning grammatical functions is a different process from serially ordering words (as suggested by slips of the tongue, e.g. Garrett, 1980 see general discussion). However, the matter is less clear with respect to distinguishing the building of hierarchical constituent structures and the serial ordering of words. Building hierarchical frames for a sentence (i.e. a constituent frame) and linearizing words are highly related, but not necessarily the same process. For example, in English a declarative sentence, such as (3a) and the corresponding question (3b) have the same hierarchical structure (i.e. they have the same major phrases, and the same relation between the noun phrase and the predicate), though the word orders differ[1].

(3a) The helicopter for the flights is safe.
(3b) Is the helicopter for the flights safe?

In this study we assess whether the construction of a hierarchical structure on the basis of the grammatical functions assigned to the lexical elements is separable from

[1]For example, the treatment of questions in 'Government and Binding' (Chomsky, 1981) consists of the application of a movement rule (move-α) that would apply to the corresponding declarative form.

the linearization of these constituent phrases. We do so by looking at the effect of a local noun (proximity concord) on agreement errors.

How can agreement errors reflecting the influence of a local noun (proximity concord) allow us to address this question? Assuming that agreement is computed during the construction of the hierarchical structure (as most linguistic and psycholinguistic theories assume; see Chomsky, 1981; Pollard and Sag, 1994; Kempen and Hoenkamp, 1987; Levelt, 1989), if the building of syntactic frames is separable from the serial ordering of words, the occurrence of agreement errors should be affected by the syntactic relation between the local noun and the head noun and not necessarily by the linear proximity of the local noun and the verb.

Proximity concord has been studied in several experiments designed to induce agreement errors (Bock and Cutting, 1992; Bock and Eberhard, 1993; Bock and Miller, 1991; Fayol et al., 1994; Vigliocco et al., 1995, 1996a,b). In most of these experimental investigations, subject-verb agreement errors were induced by presenting participants with preambles consisting of a subject head noun and a local noun embedded in a phrase or clause that modified the subject noun phrase, as shown in (4) and (5). The participants' task was to provide a sentential completion for the preamble.

(4) The king of the colonies
(5) The king of the colony

These studies showed that subject-verb agreement errors occur in a variety of languages. The presence of a local noun mismatching the subject head noun in number, and in the immediate preverbal position, as in (4), increased subject-verb agreement error rates compared to the number control condition, exemplified in (5), where the head and the local noun had the same number specification (Bock and Cutting, 1992; Bock and Eberhard, 1993; Bock and Miller, 1991; Fayol et al., 1994; Vigliocco et al., 1995, 1996a).

In all the published work, the local noun was always in the immediate preverbal position. Therefore the results of these studies can be accounted for in different ways.

One explanation is that due to *linear proximity*. Errors arise because the local noun is the most recent noun produced (in the linear structure) when the verb is to be uttered. As Jespersen (1924) suggested, if the verb comes long after the subject, there is no more mental energy to remember what the number of the subject was, and therefore the system uses the number of the closest most recent, noun (the local noun). Fayol et al. (1994) provided some evidence compatible with the notion that agreement errors are a function of working memory load and linear distance between the head noun and the verb. In their experiment, errors increased when participants were required to memorize a series of three to four unrelated digits while producing the sentence. Based on the results of this study, they suggest that agreement would be computed automatically through spreading of activation from the subject to the verb. When there is a local noun, activation will spread from this too. The local noun, being closer to the verb, can influence agreement computation. In order to guarantee correct agreement with the head noun, a non-automatic

resource consuming checking mechanism is assumed. A concurrent memory task reduces the resources available to the checking, and therefore increases the probability of producing agreement with a local noun (the most recently activated noun). Note that crucially on this view errors would arise in a linearly organized frame.

If *syntactic proximity* is more important, errors depend on the closeness of the local noun to the subject of the sentence in a hierarchical structure. That is, error incidence depends upon the syntactic relation between the subject head noun and the local noun and not on the linear adjacency of the local noun to the verb. According to this view, errors should be found when the local noun is not in immediate preverbal position, if it is syntactically close to the head noun. Some evidence in favor of the role of *syntactic proximity* has been presented by Bock and Cutting (1992) who showed that errors are sensitive to the syntactic properties of the local modifier. In fact, they found errors to be more common when the local noun was embedded in a prepositional phrase modifier, as in (6), than when it was embedded in a relative clause modifier, as in (7).

(6) The editor of the history books
(7) The editor who rejected the books

Crucially, in both (6) and (7) the local noun is in immediate preverbal position, but in (6) it is syntactically closer to the head noun than in (7), as shown in Fig. 1.

This study is important since it provides some evidence for syntactic proximity. However, since the local noun was always in preverbal position, it does not test whether linear proximity is also necessary for errors to occur. In fact, if hierarchical relations and linear order are achieved by the same process, then we would expect that both factors influence error occurrence. However, if instead we assume that hierarchical relations and linear order are achieved in two separate steps, then we may find that only syntactic proximity is necessary for errors to occur.

In the present study, we report two experiments. In the first experiment participants were presented with adjectives and preambles. Their task was to complete the preambles using the adjectives to produce a declarative sentence, as in example (8). In the second experiment, participants were presented with exactly the same materials, but this time they were required to produce a question (with subject-auxiliary inversion), as exemplified in (9).

(8) The helicopter for the flights is safe.
(9) Is the helicopter for the flights safe?

The crucial difference between the two experiments is that while in Experiment 1, the local noun is in the immediate preverbal environment, in Experiment 2 the local noun is further from the verb than the subject of the sentence. Therefore if interference depends only on *linear* proximity, we should find errors in Experiment 1 but not in Experiment 2. If, instead, the effect depends on *syntactic* proximity, we should find errors both in Experiments 1 and 2. If this is the case, then the data at hand speak to the issue of separability between building syntactic frames (i.e. establishing dominance relations) and arraying words in their left-to-right order (i.e. computing precedence relations).

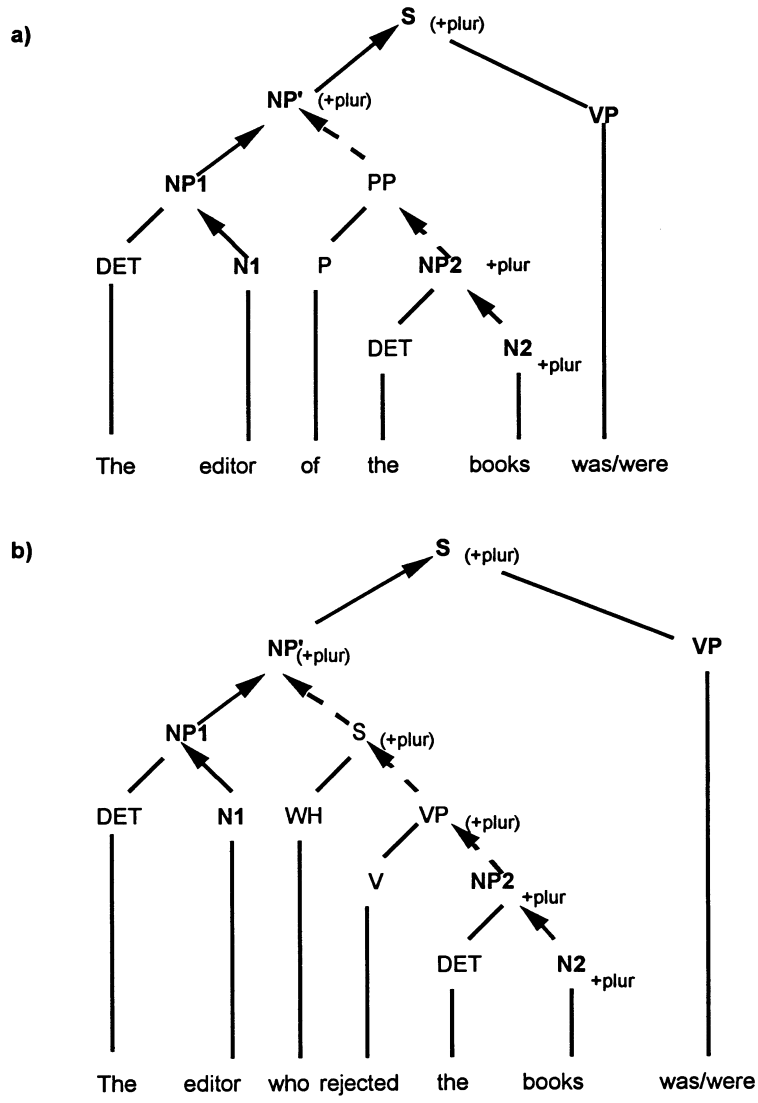

Fig. 1. (a) Syntactic representation of the sentence fragment 'The editor of the books'. (b) Syntactic representation of the sentence fragment 'The editor who rejected the books'. As can be seen in the figure, in both fragments the local noun is *linearly* next to the verb, however, it is *hierarchically* closer to the subject head noun in (a) than in (b). A sketch of how agreement errors could come about is also provided. Features for the mismatching local noun would be mistakenly passed to the highest NP projection from which they could interfere with agreement computation.

2. Experiment 1

Experiment 1 replicates previous work showing a proximity effect for senten-

tial subjects composed of a head noun followed by a local noun embedded in a prepositional phrase, as shown in examples (4) and (5) (Bock and Miller, 1991; Bock and Cutting, 1992; Vigliocco et al., 1995; Vigliocco et al., 1996a,b), using a methodology which imposes greater constraints on speakers' productions. That is, instead of freely completing sentential preambles, participants were required to complete the preambles using adjectives that were presented to them immediately preceding the presentation of the preambles. The purpose of the present experiment is to assess whether a proximity effect can be found using this methodology and therefore to set the stage for the second experiment in which the same materials are used with a different task (i.e. one in which participants are asked to formulate questions).

2.1. Method

2.1.1. Subjects

Thirty-six undergraduate students of the University of Wisconsin–Madison participated in the present experiment to fulfill a course requirement. All were native English speakers.

2.1.2. Materials

The materials for this experiment were sentential preambles matched with semantically plausible adjectives to be used in the completions. 32 experimental sentence beginnings were created. All had a NP-PP structure. Four 64-item lists were created in which there were eight items with a singular head and singular local noun, eight items with a singular head noun and a plural local noun, eight items with a plural head and a plural local noun and eight items with a plural head and a singular local noun. In addition, there were 32 fillers in each list. Fillers were simple NPs (16 were singular and 16 plural) composed of: article + adjective + noun. Items were arranged in a pseudo-random order in the lists; each participant received a different order. The complete list of the experimental items used in the experiment is reported in Appendix A in the singular-singular condition.

2.1.3. Procedure

Participants were tested individually. They were told they would see on the computer screen an adjective immediately followed by a sentence beginning; and that their task was to make up a sentence using the sentence beginning and the adjective. Participants saw, for example, *safe* and then *The helicopter for the flights* and their task was to say *The helicopter for the flights is/was safe*. Eight practice trials at the beginning of the experimental sessions ensured that participants understood the task.

Items were presented at the center of the computer screen. Each trial consisted of the following: a fixation cross, presented for 400 ms, an adjective presented for 600 ms; a blank interval of 450 ms; and finally, the sentential preamble for 890 ms. The intertrial interval was self-paced; participants were instructed to press the space bar to advance to the next trial.

2.1.4. Scoring

Responses were transcribed and then scored in the following categories: (1) *correct responses* were scored when the participant correctly repeated the preamble and completed the sentence using the adjective and a correctly inflected verb form. (2) *Agreement errors* were scored when the completion met the criteria above but the verb form failed to agree in number with the subject of the sentence. (3) *Errors in the repetition of number* were scored when the participants changed the number marking of either the subject head or the local noun. (4) *Miscellaneous responses* were scored when the participant failed to apprehend the preamble or the adjective (or parts of it), when he/she failed to repeat some words in the preamble, or when he/she produced a completion lacking the main verb. If two different utterances were produced in succession, only the first was scored, including those cases in which an agreement error was produced and immediately corrected.

2.1.5. Design and data analysis

Analyses of variance (with both subjects and items as random factors) were carried out using as the dependent measures the numbers of agreement errors, the numbers of errors in the repetition of number and miscellaneous responses. In each analysis, the following factors were orthogonally combined: number of the head noun (singular vs. plural) and number of the local noun (singular vs. plural).

2.2. Results and discussion

Application of the scoring criteria yielded 850 (73.8%) correct responses; 64 (5.6%) agreement errors; 51 (4.4%) errors in the repetition of number; and 185 (16.1%) miscellaneous responses. Table 1 reports the distribution of responses for the different scoring categories in the experimental conditions.

2.2.1. Distribution of agreement errors

As shown in Table 1, errors were most common when the head noun was singular and the local noun was plural (proximity effect). Such an effect was not found for plural head nouns and singular local nouns, a result that replicates previous investigations.

Analyses of variance showed a significant main effect of the number of the local noun ($F1(1,35) = 22.48$, $P < 0.0001$; $F2(1,31) = 14.59$, $P = 0.001$) and a signifi-

Table 1
Distribution of responses in Experiment 1

	Correct	Agreement errors	Repetition errors	Miscellaneous responses
Sing-Sing	240	1	3	44
Sing-Plur	196	36	12	44
Plur-Plur	197	12	26	53
Plur-Sing	217	15	10	44
Total	850	64	51	185
%	73.78	5.56	4.43	16.06

cant interaction between the number of the head and of the local noun ($F1(1,35) = 16.44$, $P < 0.0001$; $F2(1,31) = 35.98$, $P < 0.0001$). The main effect of the number of the head noun was marginally significant by subjects ($F1(1,35) = 3.1$, $P = 0.07$) but not by items ($F2(1,31) = 2.2$, $P = 0.17$).

2.2.2. Distribution of other errors

Errors in the *repetition of number* were more common when the local noun was plural. The analysis of variance showed a main effect of the number of the local noun ($F1(1,35) = 11.25$, $P = 0.002$; $F2(1,31) = 21.21$, $P < 0.0001$).

There were no significant main effects or interactions in the analysis of *miscellaneous responses*.

This experiment replicates the main finding concerning the proximity effect reported in the literature with our more constrained methodology. The error proportions found in this study are also comparable with previous studies of English that used similar syntactic structures (between 4 and 11%). We also replicated the difference previously reported between singular and plural head nouns, with systematically more errors in the mismatching condition with singular (SP) than with plural (PS) head nouns. This asymmetry has been accounted for, in the literature, in terms of 'markedness' (Bock and Eberhard, 1993; Eberhard, 1997). The singular form, being unmarked, would be more prone to errors than the plural form, which is assumed to be marked.

3. Experiment 2

In this second experiment we presented the same materials to participants who were required to make up questions with subject-auxiliary inversion (as in example 8). Therefore, while the syntactic position of the local noun was kept constant across items and was the same as in the previous experiment, the linear relation between the local noun and the verb was changed. If linear proximity plays a role, we should not find agreement errors in this experiment.

3.1. Method

3.1.1. Subjects

Thirty-six undergraduate students of the University of Arizona participated in the present experiment to fulfill a course requirement. All were native English speakers.

3.1.2. Materials

Same as in the previous experiment.

3.1.3. Procedure

The presentation of the materials was the same as in Experiment 1. However, this time participants were asked to make up questions. Participants saw, for example, safe and then *The helicopter for the flights* and their task was to say *Is/Was the*

Table 2
Distribution of responses in Experiment 2

	Correct	Agreement errors	Repetition errors	Miscellaneous responses
Sing-Sing	266	7	5	10
Sing-Plur	215	40	17	16
Plur-Plur	248	14	7	19
Plur-Sing	260	12	7	9
Total	989	73	36	54
%	85.9	6.3	3.1	4.7

helicopter for the flights safe? As in the previous experiment, eight practice trials at the beginning of the experimental sessions ensured that participants understood the task. As in the previous experiment, each trial consisted of the following sequence: a fixation cross (400 ms); an adjective presented for 670 ms; a blank interval of 500 ms, and finally, the sentential preamble for 1 s. Note, however, that the presentation time for both the adjective and the preamble was slightly longer in this experiment than in Experiment 1.

3.1.4. Scoring, design and data analysis

Same as in Experiment 1.

3.2. Results and discussion

Application of the scoring criteria yielded 989 (85.9%) correct responses; 73 (6.3%) agreement errors; 36 (3.1%) errors in the repetition of number; and 54 (4.7%)[2] miscellaneous responses. Table 2 reports the distribution of responses for the different scoring categories in the experimental conditions.

3.2.1. Distribution of agreement errors

In this experiment, despite the fact the local noun in the produced utterance was far from the verb (which in fact, was adjacent to the subject), we found an interference effect of a comparable size as was found for declarative sentences.

Analyses of variance revealed significant main effects of the number of the head ($F1(1,35) = 10.03$, $P = 0.003$; $F2(1,31) = 3.45$, $P = 0.05$) and of the number of the local noun ($F1(1,35) = 26.48$, $P = 0.0001$; $F2(1,31) = 32.4$, $P = 0.0001$). The interaction was also significant ($F1(1,35) = 16.59, P = 0.003; F2(1,31) = 17.9, P = 0.002$).

3.2.2. Distribution of other errors

Errors in the repetition of number were more common when the local noun was

[2]Miscellaneous responses were more common in Experiment 1 than in Experiment 2. Note, however, that a large portion of the miscellaneous responses in the first experiment were cases in which speakers dropped the determiner at the beginning of the preamble (saying, for example: 'Advertisement from the clubs was colorful', instead of 'The advertisement from the clubs was colorful'). Errors of this kind were not present in the question experiment.

plural. The analysis of variance showed a main effect of the number of the local noun ($F1(1,35) = 3.9$, $P = 0.05$; $F2(1,31) = 3.93$, $P = 0.05$).

The were no significant main effects or interactions in the analysis of *miscellaneous responses*.

These results, therefore, show that linear proximity alone cannot explain the error pattern. Agreement errors are similarly distributed and equally common when the local noun is adjacent to the verb and when it is not. However, before discussing more broadly the implications of this study, we need to directly compare the error distributions in the two studies.

4. Comparison of Experiments 1 and 2

In order to assess whether agreement error distributions were different when speakers were producing a declarative sentence and when they were producing a question, an analysis of variance with the number of the head noun (singular vs. plural), and the number of the local noun (singular vs. plural) as within factors and 'Experiment' (1 vs. 2) as the between factor was conducted. This general analysis showed a main effect of the number of the head noun ($F1(1,70) = 10.20$, $P = 0.002$; $F2(1,62) = 8.47$, $P = 0.005$); a main effect of the number of the local noun ($F1(1,70) = 48.64$, $P < 0.0001$; $F2(1,62) = 60.9$, $P < 0.0001$); and an interaction between the number of the head and of the local noun ($F1(1,70 = 32.75$, $P < 0.0001$; $F2(1,62) = 42.65$, $P < 0.0001$). Neither the main effect of the variable Experiment nor any of the interactions involving this factor were significant (all Fs < 1). Fig. 2 compares the percentages of agreement errors in the two experiments in the different experimental conditions.

Therefore, this analysis indicates that the type of sentence (declarative or question) did not affect the number or distribution of the agreement errors.

5. General discussion

This paper reports two experiments in which agreement errors were induced, in both declarative sentences and questions. In the two experiments we found that a mismatching local noun interfered with correct agreement, both when it was next to the verb (Experiment 1) and when it was far from the verb (Experiment 2). Both the frequency and the distribution of agreement errors in the two tasks are similar, suggesting that indeed the linear proximity of the local noun to the verb does not matter. These experiments also replicate the asymmetrical distribution of errors for singular and plural head nouns reported by a number of investigators for declarative sentences in which the head noun was separated from the verb by a prepositional phrase (e.g. Bock and Miller, 1991; Vigliocco et al., 1995).

Before discussing the implications of these results, we would like to address potential criticisms related to the methodology used in the experiments reported here. First, there is the possibility that errors in both Experiments 1 and 2 arose

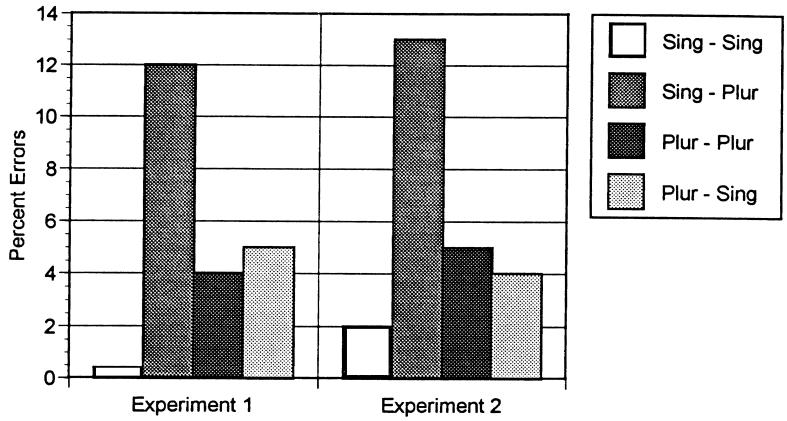

Fig. 2. Percent agreement errors for the different experimental conditions in Experiments 1 and 2 (percentage are computed as the number of agreement errors in a condition divided by the number of items presented in the same condition).

because of linear proximity, in the sense of recency. In Experiment 1 the local noun is the most recently produced noun when the verb is uttered; in Experiment 2, the local noun is the most recently seen (understood) noun when the verb is uttered. Therefore, one may argue that we did not completely rule out an explanation in terms of linear distance. If this is the case, our results do not speak to a separation between building hierarchical structures and linearizing words in production. We addressed this issue by conducting two follow-up experiments using the same materials used in Experiments 1 and 2 and asking participants to produce either a declarative sentence or a question. Crucially the methodology was changed to eliminate the possibility of recency effects from input to output. Specifically, the presentation of the materials was changed in the following manner: speakers first saw the preamble and then after a short interval they saw the head noun. They were instructed to repeat and complete the preambles using a declarative sentence or a question, and to start their productions as soon as the noun disappeared. No adjective was presented, leaving the participants free to complete the sentence as they chose. These two experiments largely replicated the results we observed in the reported studies, providing evidence against an interpretation of the reported data solely in terms of recency (in the production of an NP and verb, in one case, or in the comprehension of an NP to the production of the verb, in the other)[3].

[3]We are thankful to two anonymous referees for raising this important issue. In these follow-up experiments (as can be expected by the fact that the head noun was presented twice), error rates were lower than in the first two experiments reported in this paper. However, crucially, no difference was found between declarative sentences and questions. For declarative sentences, the error rate was 2.7%. Errors were distributed in the following manner in the experimental conditions: singular-singular, 0; singular-plural, 18; plural-plural, 4; plural-singular, 6. For questions, the error rate was 2.3% and errors were distributed in the following manner. Singular-singular, 0; singular-plural, 14; plural-plural, 2; plural-singular, 5. If recency from input to output were an important factor at play, we should have found that errors were less common when a question was produced (since the verb was produced immediately after having seen the head noun) than when a declarative sentence was produced.

A second potential problem concerns the ecological validity of the experimental paradigm. There is evidence that the type of errors induced using the sentence completion paradigm resemble errors from spontaneous speech, as well as errors in spontaneous writing in producing declarative sentences (see Bock and Miller, 1991 for an overview). Converging evidence from spontaneous production for errors occurring in producing questions is scanty. This state of affairs, however, may be due to a variety of reasons, among which the fact that the opportunities for this type of errors are less common than for the corresponding declarative sentence constructions.

Our results, combined with the data reported by Bock and Cutting (1992), showing that the syntactic position of the local noun influences agreement errors, strongly suggest that agreement errors arise as a consequence of *syntactic proximity*. That is, errors would arise, and therefore agreement would be computed, when a hierarchical frame for the to-be-uttered sentence is generated, prior to the serial ordering of the words. Therefore, these results suggest an architecture in which assigning grammatical roles and building hierarchical structures are separate from assigning word order.

Converging evidence showing that agreement is computed prior to the linearization of words comes from a different type of speech errors; exchange errors (i.e. cases in which two elements in a sentence swap position). Relevant here is the contrast between phrasal exchanges and stem exchanges observed in spontaneously occurring speech errors. The exchange of whole phrases (that is, lexical stems along with their determiners and inflectional morphemes), as exemplified in (10), can be seen as the result of a misassignment of grammatical functions. For example in (10), the noun phrase which was intended as a subject is assigned the modifier role, and vice versa. In contrast, stem exchanges can be interpreted as misplacement of a lexical stem within a frame, in this case the lexical stems move, while the inflectional morphemes stay in place, as exemplified in (11), below.

(10) *Most cities* are true of *that*
(intended: That is true of most cities; Stemberger, 1982)
(11) It *waits* to *pay*
(intended: it pays to wait; Garrett, 1976)

In (10), the subject noun phrase and the modifier noun phrase have been exchanged. It is important to note that number agreement is then realized with the *produced* subject (*cities*) and not with the *intended* subject (*that*). Stemberger (1985) reports that this occurred in six out of seven relevant errors in his corpus. This fact suggests that agreement is computed after lexical elements have been assigned to their grammatical functions. In contrast, in the example (11), only the lexical stems are exchanged, stranding their inflectional morphemes (a 3rd person morpheme and a zero morpheme, respectively). In the model of Garrett (1976) such errors may arise after a planning frame that specifies closed class morphology (i.e. determiners, inflections, auxiliaries, etc.) and the linear organization of the elements in the sentence is computed. Lexical stems are inserted in this frame, sometimes in the wrong position.

In sum, errors such as (10) indicate that agreement must be computed after grammatical functions are assigned. Errors such as (11) indicate that agreement with the *intended* subject must have been already specified when lexical stems are inserted into a linearly organized frame.

Additional evidence consistent with a distinction between determining the hierarchical relations among constituents and assigning these constituents to serial positions comes from a recent study by Hartsuiker et al. (1998). The authors, using constructions in Dutch in which a locative phrase is either sentence-final (such as in 12a) or sentence-initial (such as in 12b) showed that word order can be primed when hierarchical relations are kept the same. That is, speakers tend to use more often a frontal locative (12b) in describing a picture if they were previously presented with a different sentence in which a locative was in sentence-initial position than if they were presented with the alternative structure (12a).

(12a) Een boek ligt op de plank
(A book lies on the shelf)
(12b) Op the plank ligt een boek
(On the shelf lies a book)

Why would there be a separation between building hierarchical structures and ordering words in a string? Speakers build sentences on the fly and in a fluent manner. Distinguishing between building hierarchical and linear frames (or between dominance and precedence relations, see Gazdar and Pullum, 1981) solves an important problem that the language production system faces; namely, to be as efficient as possible (in the service of fluency) and at the same time to obey language specific constraints that force the use of only certain word orders. More specifically, fluency commands that the encoding of a sentence is carried out incrementally (Garrett, 1976; Kempen and Hoenkamp, 1987; Levelt, 1989). Incrementality implies that the grammatical encoding of a piece of the sentence (i.e. a syntactic constituent) would start as soon as the message (representing the speaker's communicative intentions in a format ready to be used by the grammatical encoder) has delivered the corresponding information and its lexical head is retrieved, without waiting for the whole sentence (Meyer, 1996; Schriefers, 1992)[4]. However, order of message delivery and lexical retrieval may not always correspond to a word order allowed in the speaker's language. For example, while English imposes a strict subject-verb-object (SVO) ordering of constituents in declarative sentences and uses a strict rule for questions, Italian and Spanish do not impose strict constraints, allowing for dropping the subject, and for SOV as well as OVS orders. In these languages, questions can be constructed with no constituents' inversion or particle insertion. The potential non-isomorphism between order of generation (hierarchical structure) and word order can be solved by separating the construction of hierarchical structures from the serial ordering of the words. In this way, hierarchical structures can be built in an incremental manner as soon as lexical heads are available, and then

[4]Evidence suggests that the accessibility of the lexical elements plays a role in determining the syntactic structure of the sentence (Bock and Warren, 1985; Bock, 1986).

assigned only to permissible positions in the linear array. What positions are permissible depends on the particular language.

The distinction between building hierarchical and linear frames is implemented in the model of grammatical encoding developed by Kempen and collaborators (De Smedt, 1990; Kempen and Hoenkamp, 1987; Kempen and Vosse, 1989). In this model, a *Word Order Rule* would be responsible for assigning syntactic constituents (such as NP, V, PP) to slots after their hierarchical relations have been established. In this framework, grammatical encoding is conceived as *lexically guided* as well as *incremental*. Lexical guidance implies that the grammatical encoding of bits and pieces of the sentence starts with the retrieval of the corresponding lexical heads, on the basis of the speaker's intentions. Thus, constituents' order would depend upon the order in which lexical elements are retrieved. However, how much of this 'order-of-retrieval' will appear in the surface form will depend upon the structure of the language. The word order rule in strictly SVO languages, such as English, will ensure SVO order is respected in declarative sentences and that non-canonical orders (e.g. questions or topicalization) are realized only if there are pragmatic constraints (i.e. the intention to ask for information or the intention to stress one participant). When the sentence to-be-uttered is, for example, a question, a *pragmatic marker* will be retrieved from the conceptual representation and this will either force the 'do' insertion or the 'Subj-auxiliary' inversion. Fig. 3 sketches how the two forms (declarative and question) of a sentence can be constructed as

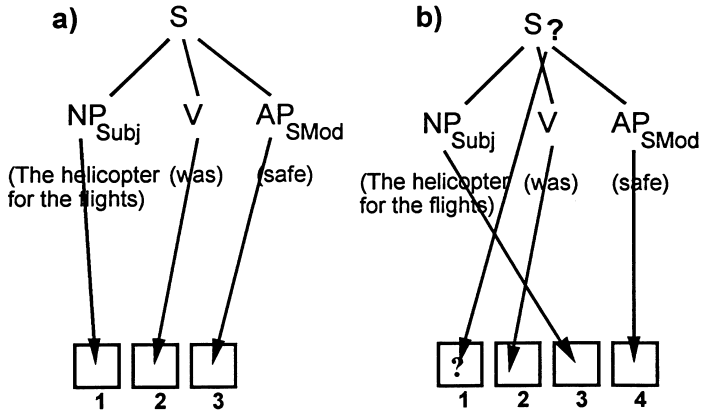

Fig. 3. Assuming a separation between building hierarchical structures and arranging words in a serial order, (a) represents the construction of the declarative sentence 'The helicopter for the flights is safe'. First, the grammatical functions and the hierarchical relations among constituents are determined, then constituents are placed in slots representing word order. Assuming incremental production, constituents would be assigned to positions on the basis of the order of retrieval. The word-order rule would be responsible to block orders not allowed in the language. (b) Represents the construction of the corresponding question 'Is the helicopter for the flights safe?'. It is assumed in this case that the intention to ask for information (depicted in the picture as a '?') forces the fronting of the copula. Following De Smedt (1990) and Kempen and Hoenkamp (1987), when the pragmatic marker ('?') is found, the word-order rule will block the subject NP from occupying the leftmost position and will assign it to the third slot, since the second would be reserved for the copula or the 'do'.

a result of the application of the word-order rule (for a more detailed treatment of this issue, see Vigliocco et al., 1996a).

To conclude, we presented here evidence compatible with a view of the production system in which hierarchical syntactic frames for the to-be-uttered sentence are generated before constituents are placed in their left-to-right order. This separation would solve a fundamental problem that the system faces, namely to respect language specific constraints on the possible word orders and, at the same time, to allow for generation based on order of retrieval from message level representations.

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Appendix A. Experimental sentence preambles for Experiments 1 and 2 (items are listed in the singular, singular condition, adjectives in parentheses)

The advertisement from the club (colorful)
The announcement by the director (important)
The article by the writer (confusing)
The author of the speech (young)
The bill from the accountant (reasonable)
The computer with the program (available)
The contract for the actor (acceptable)
The crowd in the street (restless)
The deck of the yacht (spacious)
The discussion about the topic (boring)
The friend of the editor (blonde)
The gift for the baby (expensive)
The helicopter for the flight (safe)
The lesson about the government (interesting)
The letter from the friend (emotional)
The manual for the machine (comprehensible)
The meal for the guest (delicious)
The museum with the picture (open)
The new design of the engine (successful)

The path around the lake (scenic)
The photo of the girl (blurry)
The prescription from the doctor (ready)
The producer of the movie (famous)
The publisher of the book (wealthy)
The statue in the garden (impressive)
The support for the platform (solid)
The switch for the light (hidden)
The telegram to the soldier (unexpected)
The threat to the president (serious)
The tour of the museum (disappointing)
The train to the city (crowded)
The truck on the bridge (noisy)

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