

## When Sex and Syntax Go Hand in Hand: Gender Agreement in Language Production

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In four experiments (two in French and two in Italian), we investigated whether the language production system uses conceptual information regarding biological gender in the encoding of gender agreement between a subject and a predicate. Both French and Italian have a nominal gender system that includes a distinction between nouns reflecting the sex of the referent (conceptual gender) and nouns for which the gender does not reflect the sex of the referent (grammatical gender). The experiments used a constrained sentence completion task (Vigliocco, Butterworth, & Semenza, 1995). In Experiments 1 (Italian) and 2 (French) we found that errors in the agreement of gender between the subject and the predicate were more common when the subject head noun did not have any conceptual correlates. Experiments 3 and 4 established that the advantage for conceptual gender in the first two studies cannot be explained by the difference in animacy between nouns with conceptual gender (referring to humans and animals) and nouns with grammatical gender (referring to objects). © 1999 Academic Press

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Gender distinctions are crucial for every living being. Therefore, it is not surprising that languages have developed linguistic gender distinctions that parallel biological distinctions (Corbett, 1991). For example, most languages have different words for “mother” and “father” and “man” and “woman” and different pronouns for male and female referents (e.g., “he” and “she” in English; “il” and “elle” in French).

Languages differ in whether they include

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gender distinctions for words referring to entities without biological sex. Corbett (1991) distinguishes between languages with a *semantic gender system* and languages with a *formal gender system*. In the first category are languages such as English and Chinese where gender is encoded in linguistic elements only for referents having biological sex. In the second category are, for example, Romance languages. In these languages, all nouns are marked for gender, either masculine or feminine. For nouns referring to animate entities, there is often a transparent relation between the gender of the noun and the sex of the referent (which we refer to as conceptual gender). However, for many animal names, and for a number of nouns referring to humans, the genders of the nouns do not bear any relation to the sex of the referent. The nouns in this latter class are gender marked, but the gender seems to be strictly a property of the

lexical elements, as is the case for nouns referring to objects and abstract entities (referred to here as having grammatical gender).

Regardless of the gender system a language possesses, gender marking is generally used to compute long-distance relations among elements in a sentence, that is, to compute agreement. For example, English subject nouns and pronouns agree in gender, as shown in example (1).

- (1) Mary Smith, the juror, left the court and then *she* went back to *her* room.

In richly inflected languages, such as Italian and French, gender agreement is mandatory between nouns and determiners, nouns and adjective modifiers, subject nouns and predicative adjectives, nouns and pronouns, and so on. Gender agreement is usually computed correctly during fluent language production. However, errors in gender agreement surface from time to time. Two examples from Italian are reported below.

- (2) \*Sono scese quattro persone, dei quali tre sono andati  
Are got-F down four persons-F, of which-M three are gone-M  
(Four persons got off; of the four, three went)  
(3) \*Stanze che sono anni e anni che sono chiusi  
Rooms-F that are years-M and years-M that are closed-M  
(Rooms that have been closed for years and years)

In (2), the word “*persone*” is feminine. Therefore, the relative pronoun (“*dei quali*”) and the past participle (“*andati*”) should be feminine as well (“*delle quali*” and “*andate*,” respectively), regardless of the gender of these four people. Interestingly, (2) is an example of an error occurring for a noun referring to humans but with grammatical gender (that is, “*persone*” is feminine, regardless of the sex of the referent). In (3) an error occurs for a noun referring to an object. Rooms, being objects, only have the formal property of feminine nouns, without any biological correlates. In this example, the presence of a masculine noun in the preverbal environment seems to have triggered the error.

Similar errors are observed in French. Two examples are provided in (4) and (5).

- (4) \*Le pays dans laquelle la recherche se développe le plus. . .  
The-M country-M in which-F research-F is most developed. . .  
(5) \*Il pense que la deuxième est faux.  
He thinks that the-F second-F is wrong-M

In (4) the relative pronoun (“*laquelle*,” F) should agree with the subject head noun (“*le pays*,” M), but instead it agrees with the noun following the pronoun (“*la recherche*,” F). In (5), the predicative adjective (“*faux*,” M) should agree with the subject of the relative clause (“*la deuxième*,” F), but instead it agrees with the subject of the matrix clause (“*Il*,” M).

In this study, we looked at gender agreement errors in Italian and French to assess whether the system responsible for agreement in language production is sensitive to the distinction between grammatical and conceptual gender. Before reporting the experiments, we describe how language production models deal with agreement computation and present two contrasting hypotheses regarding the role of conceptual information during agreement processing. The literature on psycholinguistic investigations of number agreement is also reviewed. We then describe in more detail the gender systems of our two test languages.

## AGREEMENT IN MODELS OF SENTENCE PRODUCTION

Language production entails four main components: a conceptualizer, a grammatical encoder, a phonological encoder, and an articulator. The conceptualizer captures features of the speaker’s intended meaning and communicative perspective and provides the input for *grammatical encoding*. During this stage, abstract lexical representations for words are selected. These representations, also referred to as *lemmas*, specify semantic and syntactic information about the word. According to a number of authors (e.g., Garrett, 1992; Levelt, 1989), the lemma includes the grammatical category of the word (i.e., noun, verb, adjective, etc.), the gram-

matical function it can take (i.e., subject, object, etc.), the kinds of syntactic structures it can be part of (i.e., noun phrase, verb phrase, etc.), and language-specific syntactic features (e.g., grammatical gender). Furthermore, according to some authors (Bresnan, 1982; Kempen & Hoenkamp, 1987; Levelt, 1989; Vigliocco, Butterworth, & Garrett, 1996a), the syntactic information specified in the lemmas guides the grammatical encoding of the sentence. A subsequent *phonological encoding* stage determines the sound structure and the pronunciation codes for the sentence. Lexemes, the phonological representations of words, are retrieved during this second step. Finally, the phonological representation is sent on for articulation.

In this general framework, agreement is computed during grammatical encoding, when a hierarchical structure representing the to-be-uttered sentence is constructed (Bock & Levelt, 1994; Kempen & Hoenkamp, 1987; Levelt, 1989; Vigliocco, Butterworth, & Garrett, 1996a). During the process of grammatical encoding, lemmas are first retrieved on the basis of the speaker's intentions. The selected lemmas are then assigned grammatical functions (e.g., subject, object, etc.) and the construction of the hierarchical frame for the sentence begins. Agreement is computed during the construction of a hierarchical frame, after grammatical functions are assigned to the different constituents but before words are placed in a linear order (Vigliocco & Nicol, 1998). According to a number of authors, frames are constructed as a sharing of agreement features between the different sentential constituents (Kempen & Vosse, 1989; Vigliocco, Butterworth, & Garrett, 1996a), thereby rendering the study of agreement phenomena central to the study of grammatical encoding.

Agreement features are retrieved from conceptual representations and assigned to the lemmas when there is a conceptual motivation for them. For example, number features for nouns are usually assigned to the retrieved lemmas according to the number of entities the speaker wishes to discuss. For gender, since there is a clear distinction between conceptual and gram-

matical gender, we will postulate two different procedures. If the noun refers to an entity with biological sex, then the gender feature of the noun will depend on whether the speaker wants to talk about a male or female entity in a manner analogous to number features. However, for nouns referring to objects, for which gender is not a semantic property, the gender of the noun is not assigned on the basis of the speaker's intention but stored in the lexicon as an inherent property of the lemma (Vigliocco, Antonini, & Garrett, 1997).

The question we address here is whether the encoder treats agreement features with a conceptual connotation (such as conceptual gender or number) differently from features with no conceptual connotation (such as grammatical gender). An answer to this question will provide us with important constraints regarding the type of *input* that the encoder receives from conceptual structures. In turn, the kind of input the encoder receives has consequences for how agreement computation is realized; that is, how agreement features are shared between the agreeing elements.

A first hypothesis concerning the interface between the conceptualizer and the grammatical encoder derives from theories of language production that emphasize the separation between these two levels of processing. In these theories, the impact of conceptual attributes on syntactic processes is strictly limited (Bock, 1987; Bock & Levelt, 1994; Garrett, 1976; Kempen & Hoenkamp, 1987; Levelt, 1989). According to this view, agreement is a purely syntactic operation that takes syntactic features such as the number and gender of an agreement controller (e.g., the subject of a sentence, if we consider subject-verb and subject-predicative adjective agreement) and copies them onto an agreement target (the verb or the predicative adjective). Conceptual connotations (e.g., male or female) are used to establish the syntactic features (e.g., masculine or feminine) of the agreement controller (the noun). After these syntactic features have been established, no other information is retrieved from conceptual structures. We will refer to this hypothesis as the *minimal input*

*hypothesis.* This hypothesis is compatible with most formal linguistic accounts of agreement in which agreement features are copied (Chomsky, 1965, 1981; Akmajian & Heny, 1975) or inherited (Gazdar, Klein, Pullum, & Sag, 1985) from a controller to a target. There are some general arguments in favor of this view of agreement processing. First, syntactic agreement is preferred cross-linguistically over conceptual agreement, at least for certain agreement relations (Corbett, 1983). In British English (and in some cases also in United States English), for example, collective nouns may take a plural verb as in example (6), denoting conceptual agreement. However, noun–specifier agreement has to be syntactic, and therefore (7) is ungrammatical.

- (6) The committee are voting themselves a raise  
 (7) \*These committee voted for a raise

A second argument comes from the observation that children master agreement production well before they understand the significance of agreement features as expressed by nominal, and especially verbal, morphology of number (Keenay & Wolfe, 1972; Vigliocco & Fava, 1993). Additional support for the minimal input hypothesis comes from experimental investigations of subject–verb agreement in English reviewed below.

Alternatively, conceptual structures may exert a stronger control on the workings of the grammatical encoder. In this view, agreement processing is responsive to features of the conceptual representation beyond using them to assign syntactic features. We will refer to this possibility as the *maximal input hypothesis*. This position has been advocated in linguistic accounts of agreement (Barlow, 1993; Pollard & Sag, 1994) and is compatible with computational psycholinguistic models that use “feature-merging” (unification) as a mechanism for syntactic structure building (Kempen & Vosse, 1989; Kempen, 1997; McDonald, Pearlmuter, & Seidenberg, 1994; Shieber, 1986; Stevenson, 1994; Vigliocco, Butterworth, & Garrett, 1996a).

Compatible with the maximal input hypothesis is the observation that across languages there are agreement relations for which conceptual agreement is strongly preferred over syntactic agreement (along the lines of the agreement hierarchy proposed by Comrie, 1975, and Corbett, 1983). In French, for example, the polite plural pronoun (*vous*, second person plural used to politely refer to second person singular) requires syntactic agreement (plural) with the verb while it requires conceptual agreement (singular) with the past participle (8a) or with the predicate (8b) (Comrie, 1975).

- (8a) Vous êtes venu  
 You-P are-P come-S  
 (8b) Vous êtes loyal  
 You-P are-P loyal-S

Additional evidence for the maximal input hypothesis comes from the phenomenon referred to as *notional concord* (Quirk, Greenbaum, Leach, & Svartvik, 1972) found both in oral and written spontaneous production. Notional concord refers to agreement with the “notion of number” expressed by a singular noun, instead of the (correct) agreement with the grammatical number. Errors like (9) and (10) are taken from spontaneous speech.

- (9) \*Siamo una squadra che giochiamo  
 We are a team-S that play-P  
 (10) \*C'est ce genre de texte qui sont très subtils  
 It's this-S kind-S of text-S that are-P very subtle

A number of experiments have investigated agreement phenomena in language production by looking at errors in the agreement of number between the sentential subject and the verb, as in examples (9) and (10) (Bock & Miller, 1991; Bock & Cutting, 1992; Bock & Eberhard, 1993; Fayol, Largy, & Lemaire, 1994; Eberhard, 1997; Vigliocco, Butterworth, & Semenza, 1995; Vigliocco, Butterworth, & Garrett, 1996a; Vigliocco, Hartsuiker, Jarema, & Kolk, 1996b). Errors were induced by presenting speakers with sentential fragments such as “The king of the colonies. . .” and asking them to create a sentence from each fragment. In all of the pub-

lished studies, the subject noun (also referred to as the *head noun*) and the verb were always separated by another noun (also referred to as the *local noun*) which either mismatched or matched in number with the head noun.

In experimental investigations concerning the role of conceptual factors in subject–verb agreement, the number of tokens in the conceptual scene denoted by a singular head noun was manipulated. This created contrasting cases in which a singular head noun either denoted a single entity, as in (11), where the preferred reading of the preamble requires just one baby, or referred to a multiplicity of entities, as in (12), where the preferred reading entails a number of bottles, each of which has its own label.

- (11) The baby on the blankets  
 (12) The label on the bottles

Errors in agreement of number were found to be more common in Dutch, French, Italian, and Spanish when the subject head noun was conceptually plural (as in 12) than when it was conceptually singular (as in 11), indicating that agreement can be influenced by conceptual numerosity in these languages (Vigliocco et al., 1995; Vigliocco, Butterworth, & Garrett, 1996a; Vigliocco, Hartsuiker, Jarema & Kolk, 1996b). However, this effect has not been reported in English (Bock & Miller, 1991; Vigliocco, Butterworth, & Garrett, 1996a). Therefore, while the results obtained in English are compatible with the minimal input hypothesis, the results obtained in all the other languages are compatible with the maximal input hypothesis.

Two other general findings emerged in this series of studies. First, agreement errors were more common when the subject was separated from the verb by a local noun mismatching in number (as in “The king of the colonies. . .”) than when the local noun had the same number as the subject (as in “The king of the colony. . .”) (e.g., Bock & Miller, 1991; Vigliocco et al., 1995). These results indicate that features of the local noun can interfere with agreement computation. We will refer to this result as the *effect of a local noun*. Also, errors were more

common when the head noun was singular than when it was plural (Bock & Cutting, 1992; Eberhard, 1997). This latter result has been accounted for in terms of *markedness*: a marked (plural) local noun interferes more than an unmarked (singular) local noun in agreement computation.

To sum up, we described two ways in which information from conceptual structures could be retrieved during grammatical encoding. The minimal input hypothesis implies that the grammatical encoder only takes the “needed” information from conceptual structures. According to the maximal input hypothesis the encoder gets “all that it can” from conceptual structures. These two hypotheses, minimal input and maximal input, lead to different predictions about conceptual effects on agreement. Previous experimental studies focused on agreement in number between the sentential subject and the verb, and an effect of conceptual number was shown, at least in some languages. These results provide limited support for the maximal input hypothesis.

The present study tests the two hypotheses introduced above using a different mapping between linguistic and conceptual features. We tested whether conceptual correlates can affect gender agreement in Italian and French. The case of gender agreement between the subject and a predicative adjective is interestingly different from subject–verb agreement in number. If conceptual information is taken into account in gender agreement, then for cases in which gender is conceptually specified there would be a match between the syntactic (masculine, feminine) and conceptual (male, female) features, while for grammatical gender, a lexical property of nouns’ lemmas (Levelt, 1989; Vigliocco et al., 1997), features would be specified only at the syntactic level. Thus, we predict that errors in the agreement of gender would be less common when the syntactic gender has a conceptual connotation than when it does not. That is, conceptual information should help correct agreement since it provides redundant compatible information. The experiments described be-

low also allowed us to investigate other factors, such as the effect of a gender mismatching modifier in prepredicate position and whether there is an asymmetry between masculine and feminine head nouns, parallel to that reported for number agreement.

### GENDER SYSTEMS IN ITALIAN AND FRENCH

In Italian, nouns are always marked for gender (either masculine or feminine). Usually, the gender can be readily inferred from the word ending: masculine words end in *-o*, while feminine words end in *-a*. For most nouns referring to humans, the gender marking is strictly determined by the sex of the referent. The reference to male or female entities is achieved by changing the word ending; for example, *ragazzo* [boy] and *ragazza* [girl]. Nouns of this type are referred to as having conceptual gender. For nouns referring to objects and abstract entities, being masculine or feminine does not bear any conceptual force and the assignment of these words to one or the other gender class is largely arbitrary (so that, for example, *pietra* [rock] is feminine while *sasso* [stone] is masculine.) Nouns in this category are referred to as having grammatical gender. For a large number of animal names, a single form (either feminine or masculine) is used to refer to both sexes (e.g., *scimmia* [monkey-F]; *gufo* [owl-M]). A few nouns referring to humans also belong to this latter class (e.g., *vittima* [victim-F]). It is important to note that at a morphophonological level, words with conceptual gender and those with grammatical gender can have identical gender features (e.g., *ragazza* and *pietra* both end in *-a*; *ragazzo* and *sasso* both end in *-o*). Both *ragazza* and *pietra* take the same form of the determiner (*la ragazza*, *la pietra*) and this is also the case for *ragazzo* and *sasso* (*il ragazzo*, *il sasso*).

Agreement with a predicate containing an adjective follows the same rule for nouns with conceptual and grammatical gender: if the noun is masculine, then the adjective must be masculine; if the noun is feminine, then the adjective

must be feminine (Vincent, 1990). The sentences below illustrate this fact.

- (13) a. *La ragazza e' rossa*  
 The-FS girl-FS is red-FS (meaning: has red hair)  
 b. *La pietra e' rossa*  
 The-FS rock-FS is red-FS
- (14) a. *Il ragazzo e' rosso*  
 The-MS boy-MS is red-MS  
 b. *Il sasso e' rosso*  
 The-MS stone-MS is red-MS

The existence of such contrasts allows us to test whether errors in the agreement of gender are similarly distributed for subject noun phrases (NPs) in which the head noun has conceptual gender and for NPs in which the head noun has grammatical gender. Errors would result in sentences such as "*La pietra e' rosso*" or "*La ragazza e' rosso*."

In French, although the same general distinction between nouns with conceptual and grammatical gender applies, the situation is more complex. There is no general rule of morphophonological marking of gender for nouns with grammatical gender, although certain suffixes are associated with masculine forms (e.g., *-age*, *-isme*, *-ment*) while others are associated with feminine forms (e.g., *-tion*). In oral French, the feminine form of nouns with conceptual gender is determined on the basis of about 15 regular vocalic and/or consonantic variations from the masculine form (e.g., *-eur*, *M/-euse* or *-ice*, *F*, *-ien*, *M/-enne*, *F*, *-on*, *M/-onne*, *F*). In the written form, most feminine nouns tend to end in *-e*, whereas there is no general rule for masculine nouns.

The rule for predicative adjective agreement in French is the same for nouns with conceptual and grammatical gender. In the written modality, the feminine of the adjective is usually formed by adding "*-e*" to the masculine form (Harris, 1990), with the orthographic adaptations this change requires (e.g., doubling of the final consonant). However, depending on the phonological properties of the adjective, gender marking does not always appear in the spoken modality (as illustrated in 15). For other adjectives, the same form is used for masculine and

feminine in both the written and spoken modality (as illustrated in 16). Examples (15) and (16) also illustrate that subject–predicative adjective agreement is the same for nouns with conceptual (15) and grammatical (16) gender. In these examples, the marked words (^) are pronounced the same.

- (15) a. Le serveur est gentil/ Le serveur est gros  
The-MS waiter-MS is kind-MS/ The-MS waiter-MS is fat-MS  
b. La serveuse est gentille/ La serveuse est grosse  
The-FS waitress-FS is kind-FS/ The-FS waitress-FS is fat-FS
- (16) a. Le camion est rapide/Le camion est gros  
The-MS truck-MS is fast-MS/The-MS truck-MS is big-MS  
b. La voiture est rapide/La voiture est grosse  
The-FS car-FS is fast-FS/The-FS car-FS is big-FS

As mentioned above, there are interesting differences between the two test languages. A first difference concerns the morphophonological regularity of gender marking. Italian marking follows a few simple rules transparent both in the oral and written formats, whereas French marking is rather complex. Second, for Italian adjectives, the bound morpheme marking gender (and number) is part of the word (e.g., “malat-o” and “malat-a” [sick-M, sick-F]) for both feminine and masculine forms, while in French, the feminine form is derived from the masculine form through phonemic variations (e.g., “gros,” “grosse” [big-M, big-F]). Using Italian and French as test languages may show whether these fine-grained differences have a role in grammatical encoding.

#### THE PLAN OF THE STUDY

We report four experiments eliciting gender agreement errors between the subject and a predicative adjective in Italian and French. In all of the experiments, participants were presented first with an adjective and then with a sentential fragment. Their task was to repeat the fragment and complete it with the adjective. All the sentential fragments included two nouns, the subject head noun and a local noun, embedded in a prepositional phrase that modified the subject head.

Experiments 1 (Italian) and 2 (French) as-

sessed whether head nouns with conceptual or grammatical gender induce different numbers of agreement errors. Head nouns with grammatical gender are marked at the syntactic level and not at the conceptual level, while head nouns with conceptual gender are congruently marked at both levels. If conceptual information is taken into account by the encoder, agreement errors should be less common for head nouns with conceptual gender than for head nouns with grammatical gender. Experiment 2 (French) also assessed the role of a local noun which did not match the head noun for gender. Experiments 3 (Italian) and 4 (French) assessed whether differences in animacy could account for any difference between nouns with conceptual and grammatical gender in the previous experiments. Because nouns referring to animate entities have conceptual gender while nouns referring to inanimate entities have grammatical gender, animacy was confounded with gender type in Experiments 1 and 2.

In terms of the general model of production presented above, we assume that nouns with grammatical gender have the gender feature set at the lexical (lemma) level. Nouns with conceptual gender receive specification for the gender feature from conceptual structures (e.g., in Italian, there is one lemma for “child” that could receive specification for male “bambino” or female “bambina”).

#### EXPERIMENT 1: ITALIAN

The materials consisted of sentential fragments (composed of a head noun and a local noun) and adjectives that could be used as plausible predicates for the fragments. We manipulated the gender type (conceptual vs. grammatical) of the subject head noun. The minimal input hypothesis predicts no difference between the number of agreement errors in these two conditions, since under this view only syntactic features are relevant for agreement computation. However, under the maximal input hypothesis, errors should be less common for subject head nouns with conceptual gender, since the syntactic and the conceptual features match and therefore can reinforce each other. The syn-

tactic gender (masculine or feminine) of the head noun was also manipulated, while local nouns always mismatched the head noun gender. The rationale for including only mismatching local nouns was to attempt to induce the greatest number of errors possible. Some indication that the use of a gender mismatching local noun induces more errors than a matching local noun comes from observations of spontaneously occurring gender agreement errors (as in examples (2) and (3) above) and the well-documented effect of a local noun on errors in the agreement of number (e.g., Bock, 1995).

### Method

*Participants.* Forty undergraduate students from the Department of Psychology, University of Trieste, volunteered for the study. They were all native speakers of Italian.

*Materials.* Materials consisted of sentence beginnings (preambles), composed of a subject head noun and a local noun, embedded in a prepositional noun phrase that modified the subject noun phrase and adjectives that could plausibly be used to complete the preambles. The variables experimentally manipulated were (1) the gender type of the subject head noun (conceptual gender vs. grammatical gender) and (2) the gender of the subject head noun (masculine vs. feminine). For nouns with conceptual gender, a pretest was conducted in order to ensure that for each experimental form, there was no strong bias toward either the masculine or feminine form in the language. That is, nouns that can take both the masculine and feminine form are often biased toward one gender (e.g., “operaio” [worker-M] is more common than the corresponding feminine form “operaia”). In order to exclude words of this kind, a list of 46 words with conceptual gender was presented to 20 students from the same population as in the main study. Their task was to judge how often they thought those words were used to refer to a man or to a woman in the following fashion. For each word, the two forms (masculine and feminine) were presented as end points of a continuum (e.g., mago [wizard-M] 4-3-2-1-0-1-2-3-4 maga [wizard-F]). Participants were instructed to rate the relative frequency of usage of both forms. A judg-

TABLE 1  
Examples of Experimental Sentence Preambles  
for Experiment 1 (Italian)

Masculine head noun, feminine local noun	Feminine head noun, masculine local noun
Heads nouns with conceptual gender	
Lo sposo in chiesa	La zingara nel parcheggio
The-M groom-M in church-F	The-F gypsy-F in the-M parking lot-M
L'inquilino della casa	La bidella nell'atrio
The tenant-M of the-F house-F	The-F janitor-F in the-M hall-M
Head nouns with grammatical gender	
Il cero in chiesa	La macchina nel parcheggio
The-M candle-M in church-F	The-F car-F in the-M parking lot-M
Lo sgabuzzino della casa	La lampada nell'atrio
The-M closet-M of the-F house-F	The-F lamp-F in the-M hall-M

ment of “0” meant that speakers perceived both forms as equally common. Only those words that received a mean judgment of no greater than 1.5 in either direction were included among the experimental items.

In the experimental items, the local noun always mismatched the head noun gender, leading to two combinations—Masculine head noun, feminine local noun and Feminine head noun, Masculine local noun. All nouns used in the experimental materials were singular. All the local nouns had grammatical gender. Pairs of experimental items were created in the following way. In each pair the same local noun was used with both a head noun with conceptual gender and a head noun with grammatical gender. In each pair, the head nouns were matched for number of syllables. The gender of the head nouns in a pair was also always the same, since only gender mismatching items were used. Examples of experimental preambles are provided in Table 1. Adjectives for each pair of preambles were also matched for number of syllables.

For each preamble, the two forms of the adjective (masculine and feminine) were presented, one

above the other. The position of each form (above or below) of the adjective was counterbalanced in two lists. All the nouns used in the experimental materials were transparently marked for gender. That is, the word ending was “-a” for feminine nouns and “-o” for masculine nouns.

Two experimental lists were generated. Each list was composed of 64 experimental preambles and 64 fillers. Each pair of experimental preambles (i.e., preambles with the same local noun but different head nouns) was presented within the same list. There were eight items per condition in each list. The difference between the two lists was whether the masculine form of the adjective for each item was presented above or below the feminine form. Filler preambles also consisted of a noun phrase and a prepositional phrase. In 48 of the filler preambles, the gender of the head noun and of the local noun matched, while it mismatched in the remaining 16. Thirty-two of the filler preambles had a plural head and a plural local noun, and the remaining 32 had a plural head and a singular local noun. In 32 filler preambles the head noun referred to an animate entity, while it referred to an inanimate entity in the remaining 32 items<sup>1</sup>.

*Procedure.* Trials consisted of the presentation of the adjectives (masculine and feminine form) followed by the preamble. The participants' task was to repeat the preamble and complete it using the adjective. The two forms of the adjective, one above the other, were presented for 600 ms at the center of the computer screen, followed by an interval of 400 ms. The preamble was then presented for 1 s at the center of the computer screen. The presentation of the materials was self-paced; participants were instructed to press the space bar on the computer keyboard in order to proceed from one trial to the next. Instructions emphasized rapid speech. Eight practice trials, performed before the experimental trials, ensured that the participants understood the instructions. The experimental sessions were tape recorded using an analog

recording system (Marantz 201) and then transcribed.

Filler and experimental stimuli were presented in a pseudo-random order, with the constraints that each experimental list started with at least four filler items, and no more than three experimental items were presented in succession.

*Scoring criteria.* Produced utterances were transcribed and scored according to the following criteria. (1) Correct Responses were scored when the participant correctly repeated the preamble and completed the sentence using the correctly inflected form of the adjective. (2) Agreement Errors were scored when the completion met the criteria above but the adjective failed to agree in gender with the subject of the sentence. (3) Miscellaneous Responses were scored when the participant failed to repeat 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.

*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 and the numbers of miscellaneous responses. In each analysis, the following factors were orthogonally combined: (1) Gender type of the head noun (conceptual vs. grammatical) and (2) gender of the head noun (masculine vs. feminine).<sup>2</sup> In this experiment, as in all the following

<sup>2</sup> In this experiment and the following experiments we also considered the position of the adjective (above or below) as a factor in the analyses. This factor was introduced to assess whether participants paid more attention to one or the other position and therefore were affected when the incongruent adjective was in the preferred location. However, we consistently failed to observe any main effect or interaction related to this factor, and so these analyses are not reported.

<sup>1</sup> A full listing of the materials used in Experiments 1–4 can be found at this URL: <http://psych.wisc.edu/faculty/pages/gvigliocco/public98.html>.

TABLE 2  
Number of Responses for Each Scoring Category, Experiment 1

Head noun gender:	Feminine		Masculine	
	Conceptual	Grammatical	Conceptual	Grammatical
Type of response				
Correct responses	569	556	558	570
Agreement errors	8	22	4	17
Miscellaneous	63	62	78	53

experiments, the  $\alpha$  level used for significance testing was 0.05.

### Results

As Table 2 shows, there were 2253 (88%) correct responses, 51 (2%) gender agreement errors, and 256 (10%) miscellaneous responses.

*Distribution of agreement errors.* Agreement errors were more common when the head noun had grammatical gender than when it had conceptual gender. No asymmetry between masculine and feminine nouns was observed. Analyses of variance revealed a main effect of the gender type of the head noun ( $F_1(1,39) = 14.00$ ,  $P = .001$ ;  $F_2(1,124) = 18.42$ ,  $P < .001$ ). There was no difference between masculine and feminine head nouns ( $F_1(1,39) = 1.44$ ,  $P = .238$ ;  $F_2(1,124) = 2.05$ ,  $P = .155$ ) and the interaction between the gender type and the gender of the head noun was not significant ( $F_s < 1$ ).

*Distribution of miscellaneous responses.* None of the factors or interactions were significant: gender type of the head noun ( $F_1(1,39) = 2.00$ ,  $P = .165$ ;  $F_2(1,124) = 2.71$ ,  $P = .102$ ); gender of the head nouns ( $F_s < 1$ ); interaction between the two ( $F_1(1,39) = 2.40$ ,  $P = 1.123$ ;  $F_2(1,124) = 2.31$ ,  $P = .131$ ).

### Discussion

Experiment 1 showed that errors were more common when the head noun had grammatical gender than when it had conceptual gender. No difference was found between masculine and feminine head nouns. The effect of gender type lends support to the maximal input hypothesis. The grammatical encoder does not use only the

syntactic features of the subjects. When available, it also uses the conceptual correlates of these features.

We failed to observe an asymmetric distribution of errors for masculine and feminine head nouns. There are grounds for believing that the masculine form of nouns and adjectives is the unmarked form (this form is used in conjoined noun phrases in which there is a masculine and a feminine noun; it is used as the unmarked form of past participles; and when the reference is to a generic entity). However, this difference did not affect error production. Perhaps a tendency to consider the masculine as the unmarked form for nouns with conceptual gender was neutralized in the present experiment because we excluded all those nouns that presented a marked bias. However, this fact cannot account for the lack of asymmetry, since the large majority of errors occurred with nouns with grammatical gender. For these nouns, there is only one form, either masculine or feminine.

This first experiment did not include a control condition in which the gender of the local noun matched the subject head noun. It is therefore not clear whether the local noun played a role in increasing the number of errors. Moreover, if the local noun indeed affects the computation of agreement (increasing errors only in case of gender mismatch with the subject), it may be that this effect interacts with the effect of the gender type of the head noun. In order to investigate this possible interaction, Experiments 2 (French) and 3 (Italian) used a fully factorial design with all possible combinations of mas-

culine and feminine gender between the head noun and the local noun.

## EXPERIMENT 2: FRENCH

The main purpose of this experiment was to assess whether the effect of gender type found in Italian could also be found in French, using the same procedure as that of Experiment 1. This experiment also provided an additional control: we systematically varied the gender (masculine, feminine) of the local noun in order to explore whether the traditional mismatch effect could also be found in gender agreement. On the basis of previous findings regarding errors in the agreement of number (e.g., Bock & Miller, 1991; Vigliocco et al., 1995) we expected that agreement errors would be more common when the head noun and the local noun mismatch in gender than when they match. Local nouns with conceptual gender and local nouns with grammatical gender were used in the present experiment, balanced between experimental conditions.

### *Method*

*Participants.* Seventy undergraduate students from the Department of Psychology at the Université Catholique de Louvain took part in the experiment. All were native French speakers. They received credit for their participation.

*Materials.* Experimental items consisted of sentence preambles and adjectives. Preambles contained a subject head noun and a local noun embedded in a prepositional phrase modifying the subject noun phrase. The manipulated variables were (1) the gender type of the head noun (conceptual vs. grammatical), (2) the gender of the head noun (feminine vs. masculine), and (3) the gender of the local noun.

Frequency of occurrence of the head nouns was kept constant (between 150 and 250 per 100 million in the Brulex database, Content, Mousty, & Radeau, 1990), and all head nouns were bisyllabic. Adjectives were plausible continuations of the preambles.

There were eight ( $2 \times 2 \times 2$ ) experimental conditions according to the gender of the head and of the local nouns and the gender type of the

head noun (conceptual, grammatical). Half of the experimental items had a local noun with conceptual gender and the other half had a local noun with grammatical gender. A total of 32 items were created, with 4 items in each condition. The lexical content was different for each item. Adjectives were always plausible predicates of the subject head nouns. All items were part of one list given to all participants. Examples of experimental preambles with head nouns with conceptual and grammatical gender, and matching and mismatching local nouns are presented in Table 3.

The masculine and feminine forms of each adjective were presented one above and one below the center of the screen. The positions of the two forms were counterbalanced: for half the items, the masculine form was above; in the other half it was below. All adjectives were marked for gender in the spoken modality.

There were 16 filler items: 8 single head nouns and 8 complex noun phrases consisting of a head noun followed by a relative clause. The list started with 3 filler items and was preceded by eight practice trials.

*Procedure.* Participants were tested individually. The two forms of the adjective were presented visually for 800 ms and replaced by a blank screen for 500 ms. The preamble was then displayed for 900 ms. Participants were asked to silently read the adjectives and the preambles. As soon as the preamble disappeared, they were instructed to repeat the preamble and complete it with the adjective. The instructions emphasized rapid speech.

The experimenter presented the following item as soon as the preamble had been completed by the participant. Experimental sessions were tape recorded using an analog recording system (Marantz 210).

*Scoring criteria.* The same scoring criteria were used as those in Experiment 1.

*Design and data analysis.* The three experimental variables (gender of the head noun, gender of the local noun, and gender type of the head noun) were part of a repeated measures design by subjects. The design was completely between items, as the lexical content of the items was

TABLE 3  
Examples of Experimental Sentence Preambles for Experiment 2 (French)

Head nouns with conceptual gender	
Feminine head noun, feminine local noun	Feminine head noun, masculine local noun
La soeur de la pharmacienne The-F sister-F of the-F chemist-F	La présidente du jury The-F president-F of the-M jury-M
Masculine head noun, feminine local noun	Masculine head noun, masculine local noun
Le gardien de la prisonnière The-M guardian-M of the-F prisoner-F	Le délégué groupe The-M delegate-M of the-M group-M
Head nouns with grammatical gender	
Feminine head noun, feminine local noun	Feminine head noun, masculine local noun
La couleur de la robe The-F color-F of the-F dress-F	La sortie du tunnel The-F exit-F of the-M tunnel-M
Masculine head noun, feminine local noun	Masculine head noun, masculine local noun
Le travail de la couturière The-M work-M of the-F dressmaker-F	Le visage du voleur The-M face-M of the-M robber-M

different among the conditions. ANOVAs ( $2 \times 2 \times 2$ ) by subjects ( $F_1$ ) and by items ( $F_2$ ) were performed. The gender type of the local noun was not included in the analysis of variance (being introduced to balance the type of local nouns). However, given its potential impact, we conducted a posthoc  $t$  test to assess whether there were differences between local nouns with conceptual and grammatical gender.

### Results

There were 1941 (87%) correct answers, 56 (2%) agreement errors, and 243 (11%) miscellaneous responses. The distribution of responses is presented in Table 4.

*Distribution of agreement errors.* Agreement errors were more common when the head noun had grammatical rather than conceptual gender and when the head noun and the local noun

TABLE 4  
Number of Responses for Each Scoring Category, Experiment 2

Head noun gender:	Feminine		Masculine	
	Feminine	Masculine	Feminine	Masculine
Type of response—Head nouns with conceptual gender				
Correct responses	245	224	233	253
Agreement errors	3	8	5	2
Miscellaneous	32	48	32	25
Type of response—Head nouns with grammatical gender				
Correct responses	254	241	224	267
Agreement errors	9	20	9	0
Miscellaneous	17	19	47	13

mismatched in gender. Furthermore, errors were more common when the head noun was feminine. The gender type of the head noun was significant in both analyses ( $F_1(1,69) = 5.17, P = .026; F_2(1,24) = 4.84, P = .038$ ). There was a main effect of the gender of the head noun, with more errors for feminine than masculine subjects ( $F_1(1,69) = 13.59, P < .001; F_2(1,24) = 6.97, P = .014$ ). No effect of the gender of the local noun was found ( $F_s < 1$ ). The interaction between the gender of the head noun and the gender of the local noun was significant ( $F_1(1,69) = 14.10, P < .001; F_2(1,24) = 9.48, P = .005$ ), with more errors when the two nouns mismatched than when they matched in gender. The analysis by subjects also revealed a significant interaction between the gender of the head noun and the gender type of the head noun ( $F_1(1,69) = 5.01, P = .028$ ), but this was not significant in the analysis by items ( $F_2(1,24) = 3.10, P = .091$ ). The three-way interaction among the gender of the head noun, the gender of the local noun, and the gender type of the head noun was not significant ( $F_1(1,69) = 2.86, P = .091; F_2(1,24) = 1.74, P = .199$ ).

A posthoc *t* test, contrasting local nouns with grammatical gender to local nouns with conceptual gender, was conducted to assess whether the gender type of the local noun had an impact on error induction. Of the 56 agreement errors, 29 occurred on items with a local noun with grammatical gender, while 27 occurred on items with a local noun with conceptual gender. The difference between these two conditions was not significant ( $M = 0.03, SD = 0.82, t(69) = 0.29, P = .77$ ).

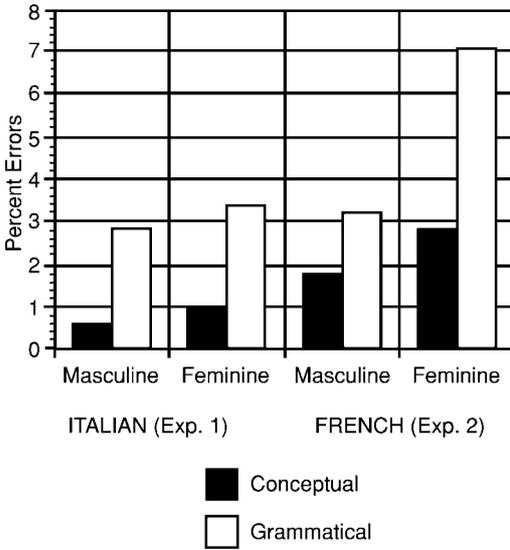
*Distribution of miscellaneous responses.* Miscellaneous responses showed a complex pattern of main effects and interactions that, however, were significant only in the subjects and not in the items analysis. The gender type of the head noun was significant in the subject analysis ( $F_1(1,69) = 7.00, P = .01$ ), with more miscellaneous responses for nouns with conceptual than grammatical gender, but not in the item analysis ( $F_2(1,24) < 1$ ). The gender of the head noun was also significant by sub-

jects ( $F_1(1,69) = 13.36, P < .001$ ), with more miscellaneous responses for nouns with masculine than feminine gender, but not by items ( $F_2(1,24) = 1.89, P = .182$ ). All two-way interactions were significant by subjects but not by items: the interaction between the gender of the head noun and the gender of the local noun ( $F_1(1,69) = 17.98, P < .001, F_2(1,24) = 3.46, P = .075$ ); the interaction between the gender type of the head noun and the gender of the head noun ( $F_1(1,69) = 6.44, P = .013, F_2 < 1$ ), and between the gender type of the head noun and the gender of the local noun ( $F_1(1,69) = 5.80, P = .019, F_2 < 1$ ). The three-way interaction among the gender of the head noun, the gender of the local noun, and the gender type of the head noun was not significant in either analysis ( $F_s < 1$ ).

### Discussion

We found a gender type effect in French, parallel to the results for Italian. Fewer agreement errors were produced when the subject head noun had conceptual gender than when it had grammatical gender. This result favors the maximal input hypothesis, according to which the conceptual correlates of gender are taken into account by the encoder in computing agreement. The fact that both languages showed an effect of the gender type indicates that the principle of maximal input is not a peculiarity of one isolated language but generalizes across different Romance languages. Figure 1 compares the percentages of errors in the gender mismatch condition (where the genders of the head noun and local noun differ) in French and Italian.

The design of this second experiment included a control condition in which both the local noun and the head noun had the same gender. We found a local noun effect: nearly four times more errors were produced in the gender mismatch condition than in the gender match condition. The magnitude of this effect was similar for feminine and masculine head nouns, and this did not interact with the effect of gender type. This result parallels what has been reported in the literature concerning errors in



**FIG. 1.** Percentage of agreement errors in Italian (Experiment 1) and French (Experiment 2). The percentages refer to errors occurring in the gender mismatching condition, to allow a comparison between the two languages, for masculine and feminine head nouns with conceptual and grammatical gender.

the agreement of number between the subject and the verb of a sentence (Bock & Miller, 1991; Bock & Eberhard, 1993; Vigliocco et al., 1995; Vigliocco, Butterworth, & Garrett, 1996a).

In contrast to Italian, it was found that the gender of the head noun was an important factor in inducing agreement errors. Errors were more common when the head noun was feminine than when it was masculine. In other words, speakers more often produced the masculine form of the adjective. As mentioned above, the masculine form of adjectives can plausibly be considered as the unmarked form. A possible explanation for this result is presented in the General Discussion.

We also observed a number of main effects and interactions in the miscellaneous responses. All these effects were only significant by subjects and not by items, raising the possibility that some idiosyncratic features of the items influenced the results of the experiment. However, the main contrast between nouns with

conceptual and grammatical gender was replicated in Experiment 4.

These first two experiments showed an effect of gender type of the subject in both Italian and French. However, animacy covaried systematically with gender type in both experiments. Errors might have been more common for head nouns with conceptual gender than for nouns with grammatical gender because the former refer to animate entities, while the latter refer to inanimate entities. Experiments 3 (Italian) and 4 (French) assessed the role of animacy.

### EXPERIMENT 3: ITALIAN

Animacy clearly has an impact on language production. Animate entities tend to be agents and tend to be mapped into the subject position more often than inanimate entities (Bock & Warren, 1985). Does animacy play a role in inducing agreement errors? Bock and Miller's (1991) study of number agreement showed that the animacy of the head noun did not influence agreement errors when grammatical functions were unambiguous. However, with respect to gender agreement, animacy may be relevant because the type of gender (conceptual, grammatical) strongly correlates with it. Nouns with conceptual gender refer to animate entities and nouns with grammatical gender usually refer to inanimate entities.

Experiment 3 was conducted in order to test the effect of animacy of the subject head noun in Italian. Animate head nouns with grammatical gender (i.e., nouns referring to animals and humans that have a fixed grammatical gender and no conceptual correlates) were compared to inanimate nouns with grammatical gender. That is, animacy was manipulated, while the gender type of the subject was kept constant (purely syntactic with no conceptual features). We also manipulated the gender of the local noun to look for an effect of a mismatching local noun, as documented in Experiment 2.

#### Method

*Participants.* Sixty-four undergraduate students from the Department of Psychology at the University of Trieste, none of whom partici-

TABLE 5

Examples of Experimental Sentence Preambles for Experiment 3 (Italian) and Their Organization in the Experimental Lists (Lists 3 and 4 Used the Same Items with the Counterbalanced Order of the Adjectives)

List 1	List 2
Masculine head noun, Masculine local noun	Masculine head noun, feminine local noun
Animate head noun	
II ghepardo nel villaggio The-M cheetah-M in-the-M village-M	II ghepardo nella foresta The-M cheetah-M in-the-F forest-F
Inanimate head noun	
II capanno nel villaggio The-M hut-M in-the-M village-M	II capanno nella foresta The-M hut-M in-the-F forest-F
Masculine head noun, Feminine local noun	Masculine head noun, Masculine local noun
Animate head noun	
II delfino nella vasca The-M dolphin-M in-the-F tub-F	II delfino nell'acquario The-M dolphin-M in-the aquarium-M
Inanimate head noun	
II ciottolo nella vasca The-M rock-M in-the-F tub-F	II ciottolo nell'acquario The-M rock-M in-the aquarium-M
Feminine head noun, feminine local noun	Feminine head noun, masculine local noun
Animate head noun	
L'aquila sulla cima The-F eagle-F on-the-F peak-F	L'aquila nel cielo The-F eagle-F in-the-M sky-M
Inanimate head noun	
La nuvola sulla cima The-F cloud-F on-the-F peak-F	La nuvola nel cielo The-F cloud-F in-the-M sky-M
Feminine head noun, masculine local noun	Feminine head noun, feminine local noun
Animate head noun	
La talpa nell'orto The-F mole-F in-the garden-M	La talpa nella buca The-F mole-F in-the-F hole-F
Inanimate head noun	
La zappa nell'orto The-F hoe-F in-the garden-M	La zappa nella buca The-F hoe-F in-the-F hole-F

pated in Experiment 1, volunteered for the present experiment. They were all native speakers of Italian.

*Materials.* As in the previous experiments, materials consisted of preambles composed of a subject head noun and a local noun embedded in a

prepositional phrase and adjectives to be used in the completions. The manipulated variables were (1) the animacy of the head noun (animate vs. inanimate); (2) the gender of the head noun (masculine vs. feminine); and (3) the gender of the local noun (masculine vs. feminine). All the nouns

TABLE 6  
Number of Responses for Each Scoring Category in Experiment 3

Head noun gender:  Local noun	Feminine		Masculine	
	Feminine	Masculine	Feminine	Masculine
Type of response—Animate nouns				
Correct responses	468	450	433	458
Agreement errors	1	15	15	2
Miscellaneous	43	47	64	52
Type of response—Inanimate nouns				
Correct responses	461	447	454	459
Agreement errors	1	15	10	1
Miscellaneous	50	50	48	52

in the experimental items had grammatical gender, and the animate head nouns referred to animate entities that have just one gender form in Italian (such as animal names: e.g., “scimmia” [monkey-F], “gufo” [owl-M]). All nouns used in the experimental materials were morphologically transparent with respect to gender, ending in “-o” for masculine nouns and “-a” for feminine nouns. All nouns in the experimental items were singular. As in Experiment 1, pairs of preambles were created in which the same local noun was used for both an animate and an inanimate head noun (as exemplified in Table 5). Furthermore, the same head noun was also used for different (gender matched and gender mismatched) local nouns. Experimental preambles were rated for plausibility by an additional group of eight undergraduate students from the same population. There was no significant difference in plausibility between items with animate and inanimate head nouns (3.8 and 3.6, respectively, on a scale from 0 to 5).

Four lists were created in which each experimental condition was represented by four items. The order (above/below) of the masculine and feminine form of adjectives was counterbalanced. Table 5 reports examples of items in the different conditions for Lists 1 and 2 (the only difference between Lists 1 and 2 and Lists 3 and 4 concerned the position of the masculine and feminine form of the adjective). Filler items were the same as those used in Experiment 1. Each list consisted of 128 items (64 experimental and 64 fillers).

*Procedure.* The same procedure was used as in Experiment 1.

*Scoring.* The scoring was the same as that in Experiments 1 and 2.

*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 and the numbers of miscellaneous responses. In each analysis, the following factors were orthogonally combined: (1) Animacy of the head noun (animate vs. inanimate); (2) gender of the head noun (masculine vs. feminine); and (3) gender of the local noun (masculine vs. feminine). All factors were part of a repeated measures design by subjects. The design by items was treated as a mixed design as factors (1) and (2) were between items, whereas factor (3) was treated as within items.

## Results

There were 3630 (89%) correct responses, 60 (1%) gender agreement errors, and 406 (10%) miscellaneous responses. The distribution of responses is presented in Table 6.

*Distribution of agreement errors.* The interaction between the gender of the head noun and the gender of the local noun was significant ( $F_1(1,63) = 48.31, P < .001$ ;  $F_2(1,188) = 49.66, P < .001$ ). This interaction reflects an effect of the local noun with more errors for preambles in which the gender of the head and

TABLE 7

Examples of Experimental Sentence Preambles for Experiment 4 (French)

Masculine Head Noun, Feminine Local Noun	Feminine Head Noun, Masculine Local Noun
Head noun with conceptual gender	
Le prieur dans l' église The-M prior-M in the-F church-F	La jument du manège The-F mare-F of the-M riding school-M
Head noun with grammatical gender	
Le chaton sur la moquette The-M kitty-M on the-F carpet-F	La méduse sur le sable The-F jellyfish-F on the-M sand-M

local nouns mismatched. None of the other main effect or interactions achieved significance (all  $F_s < 1$ ).

*Distribution of miscellaneous responses.* No difference between masculine and feminine head nouns was found ( $F_1(1,63) = 1.156$ ,  $P = .216$ ;  $F_2 < 1$ ). Similarly, there was no effect of the gender of the local noun ( $F_s < 1$ ). The interaction between animacy and the gender of the head noun was not significant ( $F_1(1,63) = 1.45$ ,  $P = .232$ ;  $F_2 < 1$ ), nor the interaction between animacy and the gender of the local noun or the three-way interaction (all  $F_s < 1$ ).

### Discussion

While no effect of animacy was found, there was a strong effect of the gender match or mismatch between the head and the local noun, replicating the results obtained in Experiment 2 (French). As in Experiment 1 (Italian), but in contrast to Experiment 2 (French), we did not observe an asymmetric distribution of agreement errors between masculine and feminine head nouns. The main conclusion from this study is that the difference reported in Experiment 1 between animate nouns with conceptual gender and inanimate nouns with grammatical gender cannot be attributed to animacy. Experiment 4 aimed to replicate these results in French, controlling for the animacy of the head nouns.

### EXPERIMENT 4: FRENCH

In this last experiment, the gender type of the head noun was manipulated while keeping the

animacy of the head noun constant. This was achieved by using nouns referring to animate entities with grammatical gender and contrasting them to nouns with conceptual gender (so that both types of nouns referred to animate entities). The local nouns always had grammatical gender which mismatched with the gender of the head nouns.

### Method

*Participants.* Thirty students at the Department of Psychology of the Université Catholique de Louvain took part in the experiment. None of them participated in Experiment 2. They were all native French speakers. They received course credit for their participation.

*Materials.* Experimental items consisted of sentence preambles and adjectives. The manipulated variables were (1) the gender of the head noun (masculine vs. feminine) and (2) the gender type of the head noun (conceptual vs. grammatical gender). In all of the experimental items, the local noun mismatched the head noun in gender.

All of the head nouns were animate nouns, while all of the local nouns were inanimate nouns. Frequencies of the head nouns were kept constant (between 150 and 250 per 100 million in the Brulex database, Content et al., 1990), and the head nouns were always bisyllabic. Adjectives were plausible continuations of the preambles.

Preambles were composed of a subject head noun and a local noun, as in the previous ex-

TABLE 8  
Number of Responses for Each Scoring Category, Experiment 4

Head noun gender:	Feminine (LN masculine)		Masculine (LN feminine)	
	Conceptual	Grammatical	Conceptual	Grammatical
Type of response				
Correct responses	197	159	209	187
Agreement errors	6	21	3	12
Miscellaneous	37	60	28	41

periments. There were 32 preambles divided into four experimental conditions according to the gender (feminine or masculine) and the gender type (conceptual or grammatical) of the head noun. The lexical content was different for each item. Both forms of the adjectives were presented on the screen, one above the other. The positions of the two forms were balanced; the masculine form was above in half of the items and below in the other half. Examples of experimental items are presented in Table 7.

Experimental items were part of one list given to all participants. There were 32 filler items: 12 single head nouns, 12 head nouns followed by relative clauses, and 8 head nouns followed by prepositional phrases. Half of the fillers contained adjectives with no spoken gender inflection. The list started with 3 filler items and there were never more than 3 experimental items in a row.

*Procedure.* The procedure was the same as that in Experiment 2.

*Scoring.* Scoring was the same as in the previous experiments.

*Design and data analysis.* The two experimental variables (gender and gender type) were part of a within-subjects experimental design. The design was between items, as the lexical content of the items was different in the different conditions. ANOVAs ( $2 \times 2$ ) by subjects ( $F_1$ ) and by items ( $F_2$ ) were performed on the data.

### Results

There were 752 (78%) correct answers, 42 (5%) agreement errors, and 166 (17%) miscel-

aneous responses. The distribution of responses among the three scoring categories is presented in Table 8.

*Distribution of agreement errors.* More agreement errors were produced when the head noun had grammatical gender than when it had conceptual gender ( $F_1(1,29) = 20.78, P < .001$ ;  $F_2(1,28) = 6.36, P = .018$ ). Although there were nearly two times more errors for feminine head nouns than for masculine ones, this difference was only marginally significant in the analysis by subjects and was not significant in the analysis by items ( $F_1(1,29) = 3.74, P = .063$ ;  $F_2(1,28) = 1.59, P = .218$ ). There was no interaction between the gender of the head noun and its gender type ( $F_s < 1$ ).

*Distribution of miscellaneous responses.* The analysis by subjects showed that significantly more miscellaneous responses were produced when the head noun was feminine ( $F_1(1,29) = 8.07, P = .008$ ). However, this difference was not significant in the item analysis ( $F_2(1,28) = 1.69, P = .204$ ). The effect of gender type, with more miscellaneous responses for nouns with conceptual than grammatical gender was also significant only in the subjects analysis ( $F_1(1,29) = 14.11, P = .001$ ;  $F_2(1,28) = 2.80, P = .105$ ). No significant interaction was observed (all  $F_s < 1$ ).

### Discussion

When animacy was kept constant, we still found an effect of the gender type of the head noun. Furthermore, we found a marginal tendency toward more errors for feminine than masculine nouns, in the same direction as we observed in Experiment 2. Therefore, animacy

cannot account for the different pattern of results with nouns with grammatical and conceptual gender. This result is addressed further in the General Discussion.

In both Experiments 2 and 4, we found more miscellaneous responses for nouns with conceptual than grammatical gender (a result significant by subjects only). This trend, in the opposite direction to that found for agreement errors, can be explained considering that the feminine and masculine forms can be confused for nouns with conceptual gender, creating opportunities for repetition errors such as “*La presidente du jury* · · ·” [the-F president-F of the jury · · ·], given “*Le president du jury* · · ·” [The-M president of the jury · · ·]. This situation does not apply to nouns with grammatical gender, where there is only one form: either feminine or masculine.

## GENERAL DISCUSSION

In this series of four experiments, we found that gender agreement errors between a subject and a predicative adjective were more common when the head noun did not have any conceptual connotation of gender than when it did. This was true for both French and Italian. We also found that this effect cannot be accounted for by the difference in animacy between nouns with conceptual and grammatical gender. These results are inconsistent with the minimal input hypothesis. Another important factor in inducing gender agreement errors was the presence of a gender mismatching local noun (Experiment 2, French, and Experiment 3, Italian). This finding parallels previous cross-linguistic studies of number agreement showing that agreement errors are more common when the subject head noun is separated from the verb by a number mismatching local noun (e.g., Bock & Miller, 1991; Vigliocco et al., 1995). We also observed a tendency for an asymmetrical distribution of errors for masculine and feminine head nouns in French, with more errors for feminine than for masculine nouns (Experiment 2 and a trend in this direction in Experiment 4). However, errors were similarly distributed for masculine and feminine forms in Italian (Experiments 1 and 3).

In the following section, these three aspects of the results are discussed in turn and compared to parallel results emerging from number agreement studies.

### *Comparisons between Number and Gender Agreement*

A first comparison concerns the role of conceptual features. Conceptual effects on subject–verb number agreement have been reported for different languages (see Vigliocco et al. 1995 for Italian; Vigliocco, Butterworth, & Garrett, 1996a, for Spanish, and Vigliocco, Hartsuiker, Jarema & Kolk, 1996b, for French and Dutch). In these studies, syntactically singular head nouns referring to a multiplicity of objects (where there is a mismatch between syntactic and conceptual information) were compared to syntactically singular head nouns referring to single objects (where there is a match between syntactic and conceptual information). In those experiments, more errors occurred when conceptual and syntactic number mismatched than when they matched.

Here, conceptual effects on subject–predicate gender agreement are reported. In the present studies, the contrast lies between cases in which the conceptual information matched the syntactic gender and cases in which there was no conceptual information, but only the lexically specified syntactic feature. When the conceptual features mismatched the syntactic features (as in the case of subject–verb agreement in number) agreement processes were hindered; when the conceptual features matched the syntactic features (as in the case of gender agreement between the subject and the predicate), agreement processes were facilitated by the congruent conceptual information. Both findings support the maximalist view presented here. Together, they show how a syntactic operation such as agreement can be disrupted or helped by conceptual correlates. They also show that the role of conceptual factors is not limited to a specific agreement relation and a specific agreement feature.

One may argue that if the grammatical encoder is sensitive to conceptual factors, then an effect of animacy should also be found. After

all, animacy plays an important role in grammatical function assignment (Bock & Warren, 1985). However, animacy may not be relevant to processes concerned with syntactic features such as gender (and number). Bock and Miller (1991) and Hupet, Fayol, and Schelstraete (1998) have shown that animacy affects the grammatical encoder at the stage in which grammatical functions are assigned (i.e., animate entities tend to be subjects, while inanimate entities tend to be assigned to other functions). This stage, however, appears to precede agreement computation, as evidenced by speech errors (Bock & Levelt, 1994; Vigliocco & Nicol, 1998). In our experiments, there was no ambiguity with respect to grammatical function assignment: the adjectives participants were required to use in their completions were always better predicates of the head noun than of the local noun. Therefore, no animacy effect would be predicted.

The second comparison concerns the effect of a mismatching local noun in prepredicate position. The most common type of number agreement error reported in the literature is the case in which the verb agrees with the noun phrase that immediately precedes it. In order to understand how the local noun effect comes about, a number of different properties of the modifying noun have been manipulated. Bock and Miller (1991) and Bock and Eberhard (1993) investigated whether the presence of subject-like semantic features in the local noun influenced attraction errors in English. They found that neither the animacy nor the conceptual number of the local noun affected the error pattern. Vigliocco and Nicol (1998) showed that the linear proximity between the local noun and the verb was not the relevant factor in inducing errors, but rather that it was the hierarchical relation between the subject and the local noun phrase.

In the present studies, we showed an effect of a local mismatching noun for gender agreement errors in both French and Italian. As in number agreement, this effect may be the result of interference by the gender feature of the local noun on the gender feature of the head noun

during agreement processing. That is, assuming that agreement is computed during the construction of a hierarchical frame for the sentence, the gender feature of the local noun would be erroneously taken as the gender feature of the subject.

Finally, most studies of number agreement have shown an asymmetrical distribution of errors with more errors when the subject head noun is singular than when it is plural (Bock & Miller, 1991; Bock & Eberhard, 1993; Vigliocco et al., 1995; Vigliocco, Butterworth, & Garrett, 1996a). This asymmetry has been accounted for in terms of the markedness of the head and local nouns. In particular, Bock and Cutting (1992) and Eberhard (1997) have proposed that the singular form is unmarked (the default form), while the plural is marked with respect to number (see Tiesma, 1982). A marked feature is more likely to interfere with correct agreement than an unmarked feature.

In our studies we found an apparent cross-linguistic difference. In Italian, errors were equally frequent for masculine and feminine head nouns. In French, errors were generally more common for feminine than for masculine head nouns. Although this result requires replication because of methodological differences between the experiments in the two languages, and because the asymmetrical distribution in French was significant only in Experiment 2, it may relate to differences between the two test languages. Italian and French differ in how gender is morphophonologically realized. In Italian, the feminine form of an adjective (e.g., "delicato" [delicate-M]) is obtained by changing the inflectional morpheme (e.g., "delicata" [delicate-F]). In French, the feminine form of an adjective (e.g., "delicat" [delicate-M]) is obtained by adding a morpheme to the masculine form (e.g., "delicate" [delicate-F]). Therefore, the asymmetry in French and the lack of asymmetry in Italian may reflect the fact that while erroneously producing the masculine or the feminine always implies changing the inflection in Italian, erroneously producing the masculine in French implies

omitting the inflection, while producing the feminine implies adding an inflection. Adding an inflection might be computationally more expensive than omitting it.

If we compare the findings for number agreement errors and the findings reported here for gender agreement errors in Experiment 2 (French), a puzzle arises. As discussed above, the asymmetrical distribution of errors in number agreement reported in a variety of languages has been accounted for by assuming that the unmarked form of the subject noun is the most affected from interference by a local (marked) noun. The same reasoning does not apply for gender. In Italian, both forms seem to produce interference. In French, the marked form of the head noun is the most error prone. We suggest that the apparent asymmetry between masculine and feminine we found in French can be described as a tendency to use the unmarked form of the adjective. It is not related to the properties of nouns, presumably because the majority of errors were observed for nouns with grammatical gender, for which there may not be a marked/unmarked dichotomy.

#### *Relevance of the Present Studies for Theories of Sentence Production*

According to the maximal input hypothesis, the grammatical encoder takes all of the information available from conceptual structures. Regarding the distinction between conceptual and grammatical gender, this hypothesis predicts that if conceptual information is redundant with the syntactic information (conceptual gender), then errors should be less common than when there is no such conceptual information (grammatical gender). Therefore, conceptual information on gender should enhance correct agreement. This is what we found in Experiments 1, 2, and 4. In the investigations of subject-verb agreement in number, on the other hand, conceptual information on number hampered correct agreement, because the conceptual number conflicted with the syntactic number.

What are the general implications of the hypothesis of maximal input for grammatical en-

coding? In the language production system, nonlinguistic representations exert a fine control over grammatical encoding. According to this view, accuracy in production cannot be defended on the basis of insulation from nonsyntactic information, but can be explained in terms of having available information that most often is congruent from different sources (a "maximal input view"). This position is similar in nature to "constraint satisfaction accounts" put forward in the literature concerning sentence comprehension (e.g., Trueswell, Tanenhaus & Gansley, 1994; McDonald et al., 1994). However, the accounts developed in the comprehension domain assume that *all* kinds of information could influence syntactic processing, including morphological and phonological information. For sentence production, while we believe there is evidence for a fine-grained control by conceptual structures on grammatical encoding, the evidence for effects of morphological and phonological factors is scant at present (but see Vigliocco et al., 1995).

Can we be more precise with respect to the mechanisms responsible for computing agreement? The results presented here are compatible with two different mechanisms, both allowing conceptual input. A first view, proposed by Vigliocco et al. (1995) for number agreement, is that the grammatical encoder retrieves agreeing features from conceptual representations for the different agreeing elements. For the case of number agreement between subject and verb, conceptual information about the number of participants would be independently retrieved for both the noun and the verb. This information, being redundant most of the time, contributes to accurate and efficient production. Independent retrieval of agreement features for the different agreeing elements would ensure that in case features are lost from one of the elements, they would still be available to the encoder on the other element, ensuring accuracy. Furthermore, from a processing standpoint, independent retrieval of agreement features may be important in order to allow simultaneous encoding of the different constituents. Simultaneous encoding contributes to efficient production,

since it implies that the encoder does not need to wait for a constituent to be fully encoded before encoding another constituent. Evidence for simultaneous encoding of phrases and clauses comes from speech errors (e.g., Garrett, 1976), showing that during grammatical encoding parallel elements in separate phrases and clauses can interact with each other, resulting, for example, in exchanges such as (17).

- (17) examine *the horse of the eyes* (intended: the eyes of the horse)  
(Garrett, 1976, pp. 136)

For the specific case of gender agreement, this view implies that when gender reflects the sex of the referent, the encoding of the sentence is, in principle, both more accurate (as our studies have shown) and also more efficient. In this case, the sex of the referent provides features for the different agreeing elements: the likelihood of losing the gender features is low (since the same feature is specified on both noun and adjective) and the noun phrase as well as the adjective can be fully encoded simultaneously. When the gender of the noun does not have conceptual connotations, however, there is more chance of losing the gender features (solely represented on the noun), and simultaneous assembly of the noun and adjective phrase would not be possible, since information from the noun phrase is necessary for the specification of the adjective phrase.

Alternatively, agreement could be computed only on the basis of the features of the noun. Nouns with conceptual gender are specified for gender both at the conceptual and at the syntactic level. Nouns with grammatical gender are specified only at the syntactic level. Therefore, nouns with conceptual gender would have a stronger gender marking than nouns with grammatical gender. The stronger the marking, the less likely it is to be lost, causing an error. We believe it is not possible to decide between these two alternatives solely on the basis of the present data. However, there are two observations that are not easily integrated with the “strength” view. First, the strength view pre-

dicts that a noun with “stronger” features should produce more interference as a local noun. If it is assumed, as discussed above, that the effect of a mismatching local noun comes about because the features of the local noun are erroneously taken for agreement computation, then the strength of the local noun’s features should matter. Preambles with local mismatching nouns with conceptual gender (e.g., *Le travail de la couturière*, the work of the dressmaker) should induce more errors than mismatching local nouns with grammatical gender (e.g., *La couleur de la robe*, the color of the dress). The gender type of the local noun was not experimentally manipulated in our experiments, and a posthoc test was possible in only a single experiment. However, no difference was found, suggesting that preambles with local nouns with conceptual gender may not show stronger interference than preambles with local nouns with grammatical gender.

Studies of number agreement errors mentioned earlier (see Vigliocco, Hartsuiker, Jarema, & Kolk, 1996b for a review) are also incompatible with the “strength” idea. In those studies, the conceptual numerosity came about, not as a feature of the head noun, but as a feature of the complex subject noun phrase. That is, conceptual number was manipulated by contrasting sentential preambles with a preferred single token (example 11) or multiple token (example 12) interpretation. For single token items (e.g., “The baby on the blankets”) there is only one baby, sitting on a number of blankets. However, for multiple token items (e.g., “The label on the bottles”) there are multiple labels, each of which is attached to a separate bottle. In these preambles, the conceptual number is strictly a property of the complex noun phrase including the head and the local noun. Finding an effect (at least in French and Italian) of conceptual number first motivated the hypothesis of independent retrieval of features for the different agreeing elements (see Vigliocco, Butterworth, & Garrett, 1996a, for a detailed discussion). The strength hypothesis, focusing on features strictly related to a single

lexical item, is silent with respect to the results concerning number agreement. We do not see any logical reason why conceptual effects should have a different mechanism for number and gender agreement; therefore, we favor an interpretation of the present findings in terms of independent retrieval of gender features for the two agreeing elements in the case of conceptual gender.

Throughout the paper, we have assumed that conceptual and syntactic correlates of gender are separate kinds of information in production. However, some have argued against this distinction. For example, Tawmoski-de Ryck and Verluyten (1982) claim that information about the grammatical gender of nouns is used together with information about the content in the selection of appropriate referring expressions. These authors point out that the gender of the noun that would naturally be used to refer to something determines the form of a pronominal reference when there is no pronominal antecedent (i.e., in deictic pronominal use). For example, in talking about something that could be named “table” (la-F table-F, in French), it is appropriate to say (18).

(18) Tu n'arriveras jamais à la faire entrer dans la voiture

You'll never manage to get it-F into the car  
(Tawmoski-de Ryck & Verluyten, 1982, p. 328)

However, for “a desk” (le-M bureau-M), the masculine pronoun would be used. These observations are taken to indicate that grammatical gender and semantic representations are intimately connected in determining the selection of pronouns (hence, agreement between nouns and pronouns) in language production (see Garnham, Oakhill, Ehrlich, & Carreiras, 1995, for a similar view in comprehension). According to this view, both grammatical and conceptual gender are semantic/conceptual in nature. It would be difficult for such a position to explain why nouns with grammatical and conceptual gender induce different numbers of agreement errors. A distinction between conceptual and grammatical gender is also supported in other

investigations concerning subject–pronoun agreement (see Cacciari, Carreiras, & Barbolini-Cionini, 1997, for comprehension and Meyer & Bock, 1998, for production).

### Conclusions

We have addressed issues concerning the type of input the grammatical encoder receives from conceptual structures. We used errors in the agreement of gender between the subject of a sentence and a predicative adjective to test predictions derived from assuming minimal or maximal input to grammatical encoding. Results from our studies support a maximalist view according to which nonsyntactic information, such as conceptual information concerning the sex of the referent, is used in computing gender agreement between the subject and a predicative adjective. Our findings suggest that syntactic features reflecting conceptual features are retrieved for the different sentential elements. This redundant information ensures accuracy and allows for a more efficient encoding of the sentence.

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