Gender and number processing in spoken French and Spanish

Christel Faussart, Celia Jakubowicz & Marianne Costes

Two experiments were conducted in auditory modality to test the effect of gender and number agreement on lexical decisions in French and Spanish. Each target word was preceded by a determiner that either agreed both in gender and number, or disagreed in number, or disagreed in gender. In both experiments, targets testing gender were animate referring nouns of variable gender. Given that the regular plural form is not audible in French nouns, different items were used to test number and gender in this language, while the same items were used to test both features in Spanish. Results showed that reaction times in the incongruent conditions were always longer than those in the congruent conditions. The difference between number and gender items in French induced a violation type main effect which was not observed in Spanish. Beside this difference due to the French materials, results in both languages were very similar. In particular, both experiments revealed an interaction between grammatical relation (congruent, incongruent) and violation type (number, gender). Namely, gender violations were more disruptive than number violations. This pattern, which was never observed in the visual modality, is discussed with regard to current linguistic proposals concerning the representation of number and gender, and an explanation of the interaction in psycholinguistic terms is suggested. *

0. Introduction

Current literature on the structure of the Determiner Phrase (DP), adopts the idea that Number is realized as the head of an independent functional projection – Number Phrase (NumP) –, situated between the Determiner (D°) and the Noun (N°) (Bernstein 1991, 1993, Carstens 1991, Ritter 1991, Szabolcsi 1987, Valois 1991 among others). In contrast with respect to Gender, two opposing proposals have been recently advanced: (i) Gender is a lexical feature of the noun stem and thus appears on the noun at all levels of syntactic representation (Harris 1991), and (ii) Gender projects onto a syntactic functional category, – Gender Phrase (GenP) –, situated between NumP and Noun Phrase (NP) (Picallo 1991). There are proponents of a third approach that aims to reconcile these two opposing views. According to Di Domenico (1995), two kinds of gender must be distinguished: a gender that has independent semantic content and is

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variable (i.e., *chat/chatte*, 'cat-masc./fem.'), and a gender that may have independent semantic content (i.e., *garçon/fille*, 'boy/girl') or not (*cable/table* 'cable-masc./table-fem.'), but cannot be varied. For this author, variable gender is projected in the syntax together with number under NumP, whereas invariable or fixed gender is assigned lexically and is thereby projected syntactically under N°. Ritter (1993) claims that gender is a feature realized on one of the existing syntactic heads of the noun phrase, and that the choice of the syntactic head that bears gender specification is subject to cross-linguistic variation. Specifically, this author proposes that in Hebrew, gender is attached to the noun stem in the lexicon and thus appears on the noun at all levels of syntactic representation. In contrast in Romance, gender is base-generated as a feature on NumP and is attached to N° as a consequence of syntactic head movement.

Taking into account these different proposals, in this article we ask whether evidence from processing is compatible with a unified or a nonunified view with respect to the representation of number and gender within the DP. The paper is organized as follows: In section 1 we review previous work related to number and gender processing, focussing on studies on the congruency effect, in which subjects make lexical decisions to nouns and pseudonouns following a prime that agrees or not with the target. In section 2 we present our experiments on the congruency effect on lexical decisions in two languages: French and Spanish. In section 3 the results of these experiments are discussed in relation to (i) the linguistic hypotheses summarized above and (ii) previous results obtained by means of the grammatical congruency paradigm.

1. Previous studies

It is well established that the lexical decision time for a target word that follows a single-word prime or incomplete-sentence prime takes longer if the word is unrelated to the linguistic context of the prime than if it is related. Historically, psycholinguistic research has studied semantic/associative relations between a prime word and a target word. For example, Meyer & Schvaneveldt (1971) have shown that the recognition of a target word (e.g., *nurse*) is facilitated if it is preceded by a highly associated priming word (e.g., *doctor*), rather than an unrelated word (e.g., *chair*).

Further work has investigated the role of syntactic congruency in word recognition. Goodman et al. (1981) found that a lexical decision to a visually presented target word is faster when subcategorisation restrictions between the prime and the target are respected (e.g., *whose planet*), than when these restrictions are violated (e.g., *it planet*). Seidenberg *et al.* (1984) replicated this finding and provided evidence in support of the hypothesis that the *locus* of the syntactic effect is post-lexical. That is, unlike the spreading activation among particular lexical items that is proposed to account for associative priming, the grammatical congruency effect is conceived as the result of checking the grammatical coherency of the given context-target pair. This interpretation of the syntactic context effect as a post-access effect assumes that the inhibitory effects on performance are dependent on the syntactic module. If a potential syntactic relation exists between the prime and the target word, this relation is automatically computed, even when a syntactic analysis is irrelevant to the subject's task. Then, when a syntactic incongruency is detected, the computation interferes with the lexical decision concerning the target. That is to say, the lexical decision mechanism must overcome the negative bias of the syntactic processor, resulting in slower decision times.

The hypothesis that the locus of the grammatical congruency effect is post-lexical has been confirmed by a number of experiments in the visual modality, conducted in Serbo-Croatian. As observed by Carello *et al.* (1988), Serbo-Croatian, being a richly inflected language, allows for syntactic violations on agreement features, without affecting the plausibility of the message to obtain. [1] For example, possessive adjectives and nouns must agree in number (singular or plural), gender (masculine, feminine or neuter), and case (nominative, dative, accusative). When a prime and a target word agree on these dimensions, the lexical decision is about 50 ms. faster than when they disagree, for instance, on gender (Gurjanov *et al.* 1985; Carello *et al.* 1988). Grammatical congruency effects have also been observed between pronouns and inflected verbs (Lukatela *et al.* 1982), and between case-marked prepositions and nouns (Lukatela *et al.* 1983). Results from Lukatela *et al.* (1987), are particulary relevant for the question addressed in this paper. These authors observed that the grammatical congruency effect is influenced neither by the type (number, gender or case) nor by the number of violations involved in a two-words sequence (1 or 2 violations). In this study by Lukatela *et al.*, subjects were presented with feminine singular dative targets preceded by first or second person possessive pronouns. Five grammatical conditions were created by varying the form of the pronoun: One congruent condition illustrated in (1) and four incongruent con-

ditions, examplified in (2) through (5). [2] As can be seen, in the congruent condition the possessive pronoun was feminine-singular-dative, in the number incongruent condition it was feminine-plural-dative, in the gender incongruent condition it was masculine-singular-dative, and in the case incongruent condition it was feminine-singular-accusative.

(1) mojoj fruli
my-F.SG.DAT flute-F.SG.DAT

(2) *mojim fruli
my-F.PL.DAT flute-F.SG.DAT

(3) *moj fruli
my-M.SG.DAT flute-F.SG.DAT

(4) *moju fruli
my-F.SG.ACC flute-F.SG.ACC

Finally, in the condition with 2 violations, the pronoun was masculine-singular-accusative.

(5) *mom fruli
my-M.SG.DAT flute-F.SG.DAT

Results showed that with respect to lexical decisions in the congruent condition (656 ms), gender violations increased reaction times (675 ms) as much as did number violations (671 ms), case violations (671 ms.) or double (gender+case) violations (675 ms). According to Lukatela *et al.* (1987), this result suggests that the syntactic processor behaves in a binary way: it only needs to detect the fact that there is or not a grammatical incongruency. It should however be noted that the experimental design used by these authors does not allow to test an interaction between a congruency factor and a violation type factor.

A congruency effect with respect to agreement features (number and gender) was also observed in four experiments conducted in French by Colé & Segui (1994). Although the main interest of these authors was to determine whether the congruency effect varies as a function of vocabulary type (closed-class vs. open-class words), they tested this effect using pairs of words that either agreed or disagreed in number or gender. In their experiments, targets were always masculine singular nouns presented in six experimental conditions:

Two congruent conditions where the target is preceded by a masculine singular closed-class word (6a) or an open-class word [3] (6b), and four incongruent conditions, two involving a number violation (7a,b) and two involving a gender violation (8a,b).

(6) a. le chat
the-M.SG cat-M.SG
b. joli chat
pretty-M.SG cat-M.SG

(7) a. *les chat
the-PL cat-M.SG
b. *jolis chat
pretty-M.PL cat-M.SG.

(8) a. *la chat
the-F.SG cat-M.SG.
b. *jolie chat
pretty-F.SG cat-M.SG

Colé & Segui (1994) reported that the congruency effect varies as a function of vocabulary type: closed-class context words induced a stronger congruency effect than did open-class words.

Note that this result is not compatible with the binary hypothesis of Lukatela *et al.* (1987). However, as in Serbo Croatian, these authors observed that the congruency effect was unaffected by the nature (number or gender) of the violation. Although particularly for closed-class context words, the magnitude of the congruency effect was lower for number than for gender (39 ms. vs 61 ms. in Experiment 1; 54 ms. vs. 67 ms. in experiment 2, and 40 ms. vs. 58 ms. in Experiment 3), [4] the interaction between grammatical relation and violation type was not significant.

In contrast to the above results suggesting that number and gender features are processed alike, agrammatic patients showed a dissociation between number and gender in an off-line task conducted in spoken French by one of us (Jakubowicz & Goldblum 1995). Subjects were ten monolingual native-French agrammatic right-handed patients, whose symptoms were attributable to a CVA resulting in an unifocal left cortical lesion, and a group of matched controls without neurological history. They were presented with sentences like (9) and (10) testing number and gender comprehension respectively.

(9) a. Les singes/le singe mangent/mange une banane
'The monkeys/monkey eat/eats a banana.'
b. Des singes/un singe mangent/mange une banane
'Monkeys/monkey eat/eats a banana.'

(10) a. La/le journaliste prend la lettre
'The-fem./masc. journalist takes the letter.'
b. Une/un journaliste prend la lettre.
'A-fem./masc. journalist takes the letter'

Comprehension of the sentences was tested by means of a forced picture choice task. For each test-sentence subjects were presented with a choice of three pictures arrayed at the angles of a fictitious triangle. For sentences belonging to the gender set, the two upper pictures represented feminine and masculine versions of the target. For the sentences belonging to the number set, they represented a singular (one) and a plural version (two or three) of the target. For both sets, the lower picture represented the theme of the sentence. Each set contained 24 test-items.

A post-hoc analysis of the results concerning number and gender comprehension within the DP,[5] showed that the frequency of correct responses was for the agrammatics significantly higher for the number set (95.8% correct) than for the gender set (87.1% correct) (χ_2 = 11,8, p = 0.0006). Given the simplicity of the task, controls performed at near ceiling levels (100% vs. 99.6% correct for number and gender respectively), and differed significantly with respect to the agrammatics for number (χ_2 = 20,28, p = 0.0001) as well as for gender (χ_2 = 57,16, p = 0.0001).

This brief review leaves us with two opposing results: those obtained in the visual modality with normal subjects showing no dissociation beween number and gender processing of congruent and incongruent pairs of words, and those obtained in spoken language with agrammatic patients showing a dissociation between number and gender in a forced picture choice task. For methodological reasons it is however difficult to draw any conclusion on the basis of these results. On the one hand, processing of number and gender was only indirectly investigated in these previous studies. On the other hand, even if this fact is neglected, it is a fact that beyond differences with regard to the modality of presentation and the experimental task, the three studies differed also with respect to the linguistic materials that were taken into account. Thus, in the study by Lukatela *et al.* (1987), with the exception of three target items that

were animate feminine nouns of invariable gender (*snaji* 'daughter-in-law'; *kravi* 'cow', and *sestri* 'sister'), the remaining 45 test-items were inanimate feminine invariable nouns (see (1)). In the study by Colé & Segui (1994), the targets were animate masculine variable nouns (see (6)). Finally, in the study by Jakubowicz & Goldblum (1995), minimal sentences pairs were constructed to the effect that one target feature (number vs gender) should be phonetically realized in only one of a variety of syntactic positions: the determiner position for the data reported above. As the examples in (10) show, the noun following the determiner was an animate human noun that can be either masculine or feminine depending on the gender of the determiner. Furthermore, in contrast with the other two studies, in this study the lexical items testing number and gender were different.

The two experiments presented below focus on number and gender processing within the DP in two Romance languages: French and Spanish. Although both languages distinguish number and gender, as it will become clear through the overview preceding the methodology section of each experiment, their exponence is quite different. This makes the comparison of French and Spanish interesting and necessary. The two experiments are conducted in the auditory modality. As in the studies by Lukatela *et al.* (1987), and Colé & Segui (1994), subjects are asked to make a lexical decision on a target word preceded by a congruent or an incongruent determiner. In both experiments, items testing gender processing are animate variable gender nouns. Items testing number are in Spanish the same than those testing gender, while in French, they are different because in spoken language plural is not overtly realized on nouns (see below). If, as it was the case in the visual modality, the magnitude of the congruency effect is not affected by the nature of the violation (number or gender), a unified view of the representation of number and gender (Picallo 1991) will be favoured. On the contrary, an interaction between grammatical relation and violation type will be compatible with non-unified views of the representation of gender (Harris 1991, Di Domenico 1995, Ritter 1993).

2. The experiments

2.1. French

2.1.1. Number and gender morphology of nouns and determiners: overview[6]

French nouns, determiners and adjectives distinguish number

(singular/plural) and gender (masculine/feminine). No other inflectional category is registered on these classes. Determiners and adjectives participate obligatorily in number and gender concord.

Consider first number. For the majority of French nouns, plurality is manifested consistently with the suffix /-s/, which is attached to the maximal stem of a word, as the following examples illustrate:

(11) a. caiss+ier+s
cashier-M.PL
b. caiss+ière+s
cashier-F.PL

However, in spoken language the singular/plural opposition is not phonetically realized, so that the two forms are homophonous: for example, *caissier* and *caissiers* are both pronounced [kɛsje] while *caissière* and *caissières* are pronounced [kesɛj:r]. [7]

An exception to this pattern is represented by a relatively small subset of nouns ending in /-al/ [al] or /-ail/ [aj] that take /-aux/ [o] in the plural.

(12)				
a.	cheval/chevaux	bocal/bocaux	journal/journaux
	[ʃəval/ʃəvo]	[bɔkal/bɔko]	[ʒuRnal/ʒuRno]
	'horse/horses'	'jar/jars'	'journal/journals'
b.	corail/coraux	vitrail/vitraux	travail/travaux
	[kɔRa:j/kɔRo]	[vitRa:j/vitRo]	[tRava:j/tRavo]
	'coral/corals'	'stained-glass sing/pl'	'work/works'

It should however be noted that for a few but currently used nouns ending in /-al/, plurality is manifested with the suffix /-s/: *bal/bals* ('ball/balls), *carnaval/carnavals* ('carnival/carnivals'), *chacal/chacals* ('jackal/jackals'), *festival/festivals* ('festival/festivals'), *récital/récitals* ('recital/recitals') and *régal/régals* ('feast/feasts'). According to Grevisse (1980), only eleven nouns ending in /-ail/ take [o] in the plural, the few remaining nouns of this form manifest plurality with the suffix /-s/: *détail/détails* (detail/details'), *chandail/chandails* ('sweater/sweaters'). Furthermore, for certain of these nouns, the use of /-s/ or /-aux/ is associated with different meanings (i.e., *émails* ('enamels'), *émaux* ('enameling materials')), whereas for others /-s/ or /-aux/ are used indistinctly without any change in meaning (i.e., *piédestals/piédestaux* ('pedestals')) (Grevisse 1980, Mok 1968).

Finally, a few words like *ciel* [sjɛl] ('sky'), *aïeul* [ajœl] ('grandfather'), and *œil* [œj] ('eye'), although taking /-x/ in the plural, show a

phonetic singular/plural opposition in spoken language: [sjø], [ajø], and [jø].

On determiners, plurality is manifested consistently with the suffix /-s/. In contrast to nouns, the singular/plural opposition is always phonetically realized on determiners, as the following examples illustrate: [8]

(13)						
a.	le	la	les	un	une	des
	[l(ə)]	[la]	[le]	[œ̃]	[yn]	[de]
	the-M	the-F	the-PL	a-M	a-F	some
b.	mon	ma	mes	ton	ta	tes
	[mɔ̃]	[ma]	[me]	[tɔ̃]	[ta]	[te]
	my-M	my-F	my-PL	your-M	your-F	your-PL

Let us now consider gender. As in other Romance languages, inanimate nouns have an arbitrary fixed gender, that is, the gender of these nouns does not express a semantic property of its referent and cannot be varied. As illustrated by the minimal pairs below, it seems that for inanimate nouns, masculine and feminine genders do not correlate with different morphophonological patterns: [9]

(14)	*Masc*	*Fem.*	*Masc.*	*Fem.*
	câble	table	espoir	armoire
	[kabl(ə)]	[tabl(ə)]	[ɛspwaR]	[aRmwaR]
	'cable'	'table'	'hope'	'wardrobe'
	camion	opinion	trapèze	chaise
	[kamjɔ̃]	[ɔpinjɔ̃]	[tRapɛz]	[ʃɛz]
	'truck'	'opinion'	'trapeze'	'chair'

In most animate nouns, particularly in human nouns, grammatical gender matches biological sex and both a masculine and a feminine form exist for most human nouns. Three different subclasses of animate nouns can be distinguished. First, nouns for which different stems correspond to masculine (male referring) and feminine (female referring) gender: As shown below this gender has semantic content but cannot be varied:

(15)	*Masc.*	*Fem.*	*Masc.*	*Fem.*
	oncle	tante	garçon	fille
	[ɔ̃klə]	[tãt]	[gaRsɔ̃]	[fij]
	'uncle'	'aunt'	'boy'	'girl'
	cheval	jument	coq	poule
	[ʃəval]	[ʒymã]	[kɔk]	[pul]
	'horse'	'mare'	'cock'	'hen'

A second group consists of nouns with variable gender: in that case a short form – male referring – and a long form – female referring – have the same stem. According to Grevisse (1980), some of these forms are related by derivational suffixation (see (16)). For other nouns of this subclass, the feminine forms differ from the masculine ones by the presence of /-e/, or in addition to /-e/, by the reduplication of the final consonant of the masculine form in written language. As shown by the phonetic transcriptions in (17), this triggers the pronunciation of the last (latent) consonnant in spoken French.

(16)

Masc.	*Fem.*	*Masc.*	*Fem.*
vol-eur	vol-euse	dans-eur	dans-euse
[vɔlœR]	[vɔløz]	[dãsœR]	[dãsœz]
thief-M	thief-F	dancer-M	dancer-F
direc-teur	direc-trice	insitu-teur	institutrice
[diRɛktœR]	[diRɛktRis]	[ɛ̃stitytœR]	[ɛ̃stitytRis]
director-M	director-F	teacher-M	teacher-F
caiss-ier	caiss-ière	épic-ier	épic-ière
[kesje]	[kesjɛR]	[episje]	[episjɛR]
cashier-M	cashier-F	grocer-M	grocer-F

(17)

Masc.	*Fem.*	*Masc.*	*Fem.*
berger	bergère	avocat	avocate
[bɛRʒe]	[bɛRʒɛR]	[avɔka]	[avɔkat]
shepherd	shepherdess	lawyer-M	lawyer-F
chat	chatte	lion	lionne
[ʃa]	[ʃat]	[ljɔ̃]	[ljɔn]
cat-M	cat-F	lion	lioness

In the third group of animate nouns, each can be either masculine or feminine. This group is relatively small and heterogeneous. A few examples are given below.

(18)

journaliste	locataire	concierge	camarade	collègue
'journalist'	'tenant'	'door-keeper'	'comrade'	'colleague'

2.1.2. Method

SUBJECTS

Sixty-four students from the René Descartes University received course credit for their participation in the experiment. They were all native speakers of French.

MATERIALS AND DESIGN

As this experiment was conducted in auditory modality, 16 masculine singular nouns ending in /-al,-ail/ and taking /-aux/ in the

plural, were selected to test number (i.e., *metal* ('metal'), *local* ('room')). These nouns were matched for frequency and syllable length to 16 singular masculine human referring nouns of variable gender (i.e., *vendeur* ('seller'), *chanteur* ('singer')). The mean frequency of the words used to test number was 36,34 occurrences per million, the mean frequency of the words used to test gender was 33,25 occurrences per million (*Trésor de la langue française* 1971). Within each type, 11 nouns were two-syllables long, the remaining 5 were three-syllables long. All target nouns begin with a consonant sound to avoid a 'liaison' environment. Each target word was preceded by a determiner in a congruent condition (eg: *le métal* ('the-SG metal'), *le vendeur* ('the-M seller-M')) and in an incongruent condition (eg: *les métal* ('the-PL metal-SG'), *la vendeur* ('the-F seller-M')). The determiners (6716,57 occurrences per million) were definite articles (*le/la* ('the-M/F'), *les* ('the-PL')), demonstratives (*ce/cette* ('this-M/F'), *ces* ('these')) and possessives (*mon/ma* ('my-M/F'), *mes* ('my-PL'), *ton/ta* ('your-M/F'), *tes* ('your-PL')). The grammatical number or gender violation was always overtly conveyed by the determiner.

The two two-level factors "Grammatical Relation" (congruent, incongruent), and "Violation Type" (number, gender) were within subjects factors. However, a particular word was presented only one time to a given subject. As shown in Table 1, the same target word was associated with 2 experimental cases. In order to counterbalance the presentation of the experimental materials, 2 experimental lists were constructed. This led to 2 experimental groups of subjects. Each list was composed of 16 test trials and 28 fillers. Fillers were divided into 16 sequences where determiners were the same as those used in the test trials and targets were non-words, and 12 sequences with other determiners: 6 with word targets and 6 with non word-targets.

Table 1. French. The four experimental conditions as a function of Grammatical Relation and Transgression Type.

Transgression Type	Grammatical Relation	
	Congruent	Incongruent
Number	le métal "the-SG metal-SG"	les métal "the-PL metal-SG"
Gender	le vendeur "the-M seller-M"	la vendeur "the-F seller-M"

The lists were recorded preceded by 16 practice trials. The recording was made by a female native speaker of French on one channel of a Revox recorder. There was a 2.5 sc. interval between two consecutive trials. The speech file of stimuli was digitized using the Kessadir system. A marker pulse, inaudible to the subjects, and timed to coincide with the end of the physical signal of each target was recorded on a second channel. This was used to start the reaction time clock of the computer which stops at the subject's response. Both digitized speech and pulses were recorded onto experimental tape.

PROCEDURE

The experimental tape was played to the subjects from a Revox tape recorder over headphones. On each trial, the subject's task was to decide as rapidly as possible whether the last element of each sequence was a word or not. Subjects were instructed to depress one of the two responses buttons of a telegraph key with the right forefinger (or the left one for left handed persons) for a yes response, with the left forefinger (or the right for left handed persons) for a no response.

2.1.3. Results

Average lexical decision latencies and percent of errors in each condition are presented in Table 2.

Table 2. French. Mean reaction times (in ms), percent errors (in parentheses) and standard errors (italics) for targets in each condition.

Transgression Type	Grammatical Relation	
	Congruent	Incongruent
Number	246.52 (0.39%) *13.05*	286.75 (1.07%) *14.13*
Gender	275.30 (0.09%) *12.94*	387.92 (0.89%) *13.43*

As can be seen, responses to congruent sequences were faster than responses to incongruent sequences (261 ms. vs. 337 ms.), responses to number targets were faster than responses to gender targets (267 ms. vs. 332 ms.). Analyses of variance were performed on

these data using subjects (F1) and items (F2) as random variables. Errors (2.44% of the data) and reaction times exceeding 1500 ms. (0.09 % of the data) were excluded from the analyses.

The main effect of the 'Grammatical Relation' factor was significant globally (F1 (1, 63) = 49.65, $p < .001$; F2 (1, 30) = 43.72, $p < .001$), and specifically for sequences testing number (F1 (1, 63) = 10.23, $p < .005$; F2 (1, 15) = 5.76, $p < .05$) and for those testing gender (F1 (1, 63) = 52.52, $p < .001$; F2 (1, 15) = 49.88, $p < .001$). The 'Violation Type' factor introduced a significant main effect (F1 (1, 63) = 34.96, $p < .001$; F2 (1, 30) = 6.15, $p < .05$). Planned comparisons showed that reaction times for number targets were significantly lower than those for gender targets in the incongruent condition in both analyses (F1 (1, 63) = 52.78, $p < .001$; F2 (1, 30) = 12.19, $p < .001$) and in the congruent condition in the subjects analysis only (F1 (1, 63) = 3.91, $p < .05$). The interaction between grammatical relation and violation type was significant (F1 (1, 63) = 15.92, $p < .001$; F2 (1, 30) = 9.85, $p = .005$). As can be seen in Figure 1, the effect of grammatical congruency was more important for gender than for number targets (113 ms. vs. 40 ms.).

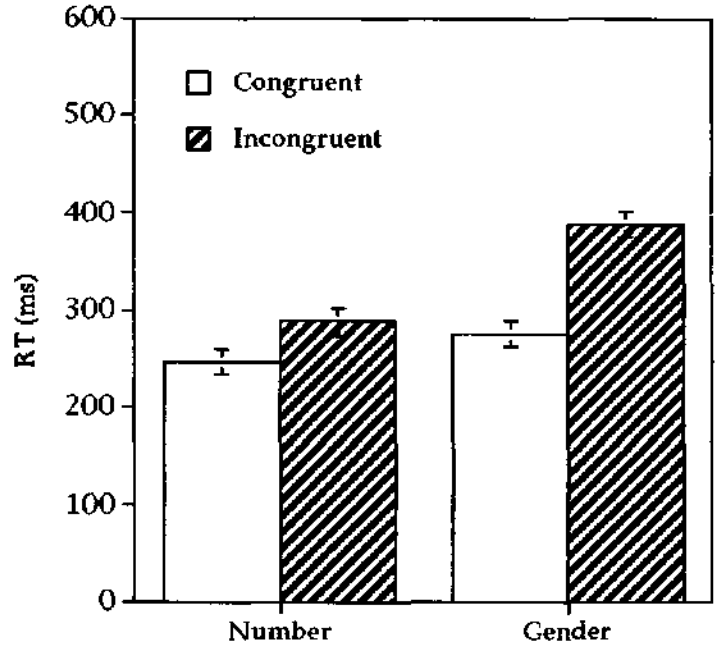

Figure 1. Reaction times as a function of Grammatical Relation and Violation Type in French.

2.1.4. Discussion

This experiment provides evidence of a syntactic congruency effect in natural speech. Recognition latencies for spoken nouns replicate the pattern obtained earlier for visually presented nouns in Serbo-Croatian and French: fast reaction times to targets belonging to a congruent sequence, and slower reaction times for targets that do not agree with the context on a grammatical dimension (number or gender). However our results mainly differ from those observed previously in the visual modality. First, the violation type factor affects the performances in auditory modality. In both grammatical conditions, number targets were judged faster than gender targets. In our view, this effect may be due to the particular items used to test number; indeed results from a follow up study seem to confirm this view. In this follow-up study, a different group of subjects was asked to make lexical decisions on the nouns from the gender and the number set presented without context. The nouns ending in /-al, -ail/, were associated with faster latencies than the nouns used to test gender (323 ms. vs. 442 ms.; F1 (1, 11) = 4.42, p <.0001; F2 (1, 28) = 12, p < .002). Whatever the reason of this difference may be, it cannot however explain our second result, that is the interaction between violation type and grammatical relation. Now, how could we explain the fact that a gender violation increased reaction times about 3 times more than a number violation?

A first type of interpretation is related to the peculiarities of our material testing number. Actually the rule according to which nouns ending in /-al, -ail/ take /-aux/ in the plural is far from uniform in contemporary French. As mentioned above, not all the nouns ending in /-al/ or /-ail/ take /aux/ in the plural. As also reported in section 2.1.1, for certain of these nouns, the use of /-s/ or /-aux/ is associated with different meanings, whereas for others, /-s/ or /aux/ are used indistinctly without any change in meaning. Although no such nouns were included in the materials, it may be that the irregularity of this rule makes it less reliable. Hence it is possible that no number incongruency was detected by some subjects leading the magnitude of the congruency effect to be lower in this condition than in the gender condition. Indeed, the inspection of individual means shows that as for number, about a fourth part of the subjects presented similar latencies in the congruent and in the incongruent conditions. In contrast, in the gender condition, only 4,7% out of the individual means were associated with this pattern.

A second type of interpretation could rely on the difference between the representation of number and that of gender, whether

this difference is conceived in terms of the hypothesis that gender, but not number, is a lexical feature of the stem (Harris 1991), or in terms of the hypothesis that gender is not an independent functional head but is syntactically projected under NumP (Di Domenico 1995, Ritter 1993). From a processing point of view, under the assumption that gender is an inherent property of the stem, it is possible to consider that a gender mismatch between the determiner and the noun may cause some doubt on the identity of the noun itself and hence trigger the repetition of operations involved in the process of lexical retrieval. If repeating these operations takes time, lexical decision times could be larger for gender than for number violations if, as one may assume, the identity of the noun itself remains unquestioned for the latter (see section 3). That a gender mismatch is more disruptive than a number mismatch is predicted also by the the hypothesis that (variable) gender [10] is syntactically parasitic on number, if mismatch detection is conceived as a kind of 'conscious' feature checking (feature checking in the sens of Chomsky 1995). Given that there is no GenderP, mismatch detectors are probably forced to go back to the noun itself where according to Chomsky (1995), features are assigned to words. Since NumP is a maximal projection, number features of the lexical item can be checked in the functional domain. [11]

The experiment in Spanish, presented right below, may allow us to choose among these two different types of interpretation. If the first proposed interpretation is adequate, no interaction between grammatical relation and violation type should be observed in Spanish, where regular plural is phonetically realized, and where the same words can be used to test number and gender. The interaction observed in Experiment 1 could then be considered as an artefact due to the French materials. On the contrary, if an interaction is also found in Spanish, it will confirm that gender and number violations are not processed alike and hence support the idea of a non-unified representation of these features.

2.2. Spanish

2.2.1. Number and gender morphology of nouns and determiners: overview

This overview is based on the morphophonological analysis of Spanish substantives (nouns, adjectives and adverbs) provided by Harris (1991). Spanish nouns and determiners distinguish number (singular and plural) and gender (masculine and feminine). [12] No other inflectional category is registered on these elements.

Determiners (and adjectives) participate obligatorily in number and gender concord. Consider the data presented in (19):

(19)	Stem	-Word marker	-Number	
Class I	a. libr	-o	s	'books-masc.'
	b. man	-o	s	'hands-fem.'
	c. amig	-o	ø	'friend-masc.'
	d. tor	-o	s	'bulls-masc.'
Class II	a. cas	-a	ø	'house-fem.'
	b. map	-a	s	'maps-masc.'
	c. amig	-a	s	'friends-fem.'
	d. vac	-a	s	'cows-fem.'
	e. coleg	-a	ø	'colleague-masc./fem.'
Class III	a. robl	-e	s	'oaks-masc.'
	b. nub	-e	ø	'cloud-fem.'
	c. padr	-e	ø	'father-masc.'
	d. madr	-e	ø	'mother-fem.'
	e. estudiant	-e	ø	'student-masc./fem.'
	f. as	-ø	es	'aces-masc.'
	g. col	-ø	es	'cabbages-fem.'
Class IV	a. torak	-s	ø	'thorax-masc.'
	b. dos	-s	ø	'dose-fem.'
Class V	a. tax	-i	s	'taxi-masc.'
	b. trib	-u	s	'tribe-fem.'
	c. yet	-i	ø	'yeti-masc./fem.'

According to Harris, every Spanish nominal consists of a stem, followed by a word marker which is followed by a number suffix. As shown in (19), plurality is manifested consistently with the suffix /-s/, unless the maximally unspecified default vowel /-e/ is inserted for syllabification reasons, as illustrated by the examples (f) and (g) in class III. Harris argues that the classes in (19) are not gender classes. Rather they are form classes whose members share a particular inflectional suffix, or no inflectional suffix, that the author calls "word marker". The choice of word marker is an idiosyncratic property of the stem. The distinguishing distributional property of all word markers is that they appear only at the right edge of a nonplural word.

The majority of Spanish nouns belong to classes I-III. The word markers for classes I and II are /o/ and /a/ respectively. Class III

contains bare stems (examples d and e), and stems followed by /e/. The classes defined by these word markers are unrestricted with respect to gender and with respect to animateness. For example, class I includes inanimate masculine and feminine nouns (examples a and b) as well as animate variable and invariable masculine nouns (example c and d respectively). Class II includes inanimate feminine and masculine nouns (examples a and b respectively), animate variable and invariable feminine nouns (examples c and d respectively), and animate human referring nouns, that can be either masculine or feminine (see example e). Similar observations can be made with respect to the nouns belonging to the other three classes.

According to Harris, neither form class membership nor gender is fully predictable from the other. There is however some partial predictability: within the class of animate human referring nouns, gender is predictable from sex: nouns that refer to biological males are usually masculine gender; those that refer to females are usually feminine. Furthermore, within the class of feminine nouns that take a vocalic word marker, this one is often /a/; within the class of masculine nouns that take a vocalic word marker, the majority take /o/.

As mentioned in the introduction, for Harris gender is a property of the stem. In order to account for the correlation between biological sex and gender, he proposes that some lexical entries are marked as [+ Human]. This specification is the input for his Human Cloning rule which predicts the existence of mated masculine-feminine pairs for every human noun. For example, the stem *amig-* is duplicated into two entries *amig-masc.* and *amig-fem.*, each identical to *amig* except for the addition of the semantic specification "male" and "female" respectively. Further examples of animate variable nouns belonging to classes I and II are given in (20).

(20)	MASC.	FEM.	MASC.	FEM.
	gitano	gitana	dueño	dueña
	'gipsy-M'	'gipsy-F'	'owner-M'	'owner-F'
	gato	gata	hermano	hermana
	'cat-M'	'cat-F'	'brother'	'sister'

As shown in (21), the singular forms of determiners belong to class III in the masculine (they end in /-ø/ and /-e/), and to class II in the feminine (they end in /-a/). [13]

(21)

Masculine		Feminine		
Singular	Plural	Singular	Plural	
el	los	la	las	'the'
un	unos	una	unas	'a, some'
este	estos	esta	estas	'this, these'
ese	esos	esa	esas	'that'

Let us now turn to the experiment conducted in Spanish.

2.2.2. Method

Subjects

Forty-eight native speakers of Spanish from Spain and Latin America (Argentina and Uruguay), participated in the experiment. All of them had lived in their native country at least until they were 15 years old. The distribution of subjects from Spain and Latin America was the same for the four lists.

Materials

Sixteen human referring nouns of variable gender belonging to Classes I and II were selected as targets (eg., *mendigo,* 'beggar-masc.', *portera*, 'door-keeper-F'). Eight of these nouns were presented in the masculine, the other eight were presented in the feminine. Nouns used in the masculine form were matched for frequency with those used in the feminine form (71.74 vs 66.74 occurences per million) (cf. Juilland & Chang-Rodriguez 1964). For both masculine and feminine nouns, two were two-syllables long and six were three-syllables long. Each target was preceded by a determiner and presented in a congruent condition (eg: *un mendigo,* 'a-M beggar-M', *una portera*, 'a-F door-keeper-F'), and in two incongruent conditions: one involving a gender violation (eg: *una mendigo* 'a-F beggar-M', *un portera*, 'a-M door-keeper-F'); the other involving a number violation (eg: *unos mendigo*, 'some-M.PL beggar-M.SG'; *unas portera*, 'some-F.PL door-keeper-F.SG.'). The determiners (9877 occurences per million) were definite articles (*el/la* 'the-sing.M/F', *los/las* 'the-PL-M/F'), indefinite articles (*un/una* 'a-M/F' *unos/unas* 'some-M/F') and demonstratives (*este/esta* 'this-M/F', *estos, estas* 'these-M/F', *ese/esa,* 'that-M/F', *esos/esas* 'those-M/F').

The 'Grammatical Relation' factor was a within subjects factor while the 'Violation Type' factor was a between subjects factor. As gender and number violations were presented separately, the congruent conditions which were the same for both features were repeated twice. However, a particular noun was presented only one time to

a given subject. An example of materials in each condition is given in table 3.

Table 3. Spanish. The four experimental conditions as a function of Grammatical Relation and Transgression Type.

Transgression Type	Grammatical Relation	
	Congruent	Incongruent
Number	el gitano "the-SG gipsy-SG"	los gitano "the-PL gipsy-SG"
Gender	el gitano "the-M gipsy-M"	la gitano "the-F gipsy-M"

In order to counterbalance the presentation of materials, four lists were constructed, leading to four groups of subjects. Each list was composed of 16 test trials and 16 fillers. Fillers were created using the same determiners as in the test trials but with non-word targets. Non-words were obtained by changing the first or the last syllable of real words. As for word targets, three quarters of non-word targets were three-syllables long and a quarter was two-syllables long.

Lists were recorded by a female native speaker of Spanish on one channel of a Revox recorder. Other recording details and the procedure were the same as in the first experiment.

2.2.3. Results

Average lexical decision latencies and percent of errors in each condition are presented in Table 4.

Table 4. Spanish. Mean reaction times (in ms), percent errors (in parentheses) and standard errors (italics) for targets in each condition.

Transgression Type	Grammatical Relation	
	Congruent	Incongruent
Number	388.83 (0.26%) *23.76*	452.69 (0.52%) *26.18*
Gender	360.44 (0.52%) *27.01*	516.77 (0.39%) *25.89*

As can be seen, responses to congruent pairs of words were faster than responses to incongruent pairs (374 ms. vs 483 ms. in average), and responses to number targets were faster than responses to gender targets (421 ms. vs 436 ms. in average). Analyses of variance were performed on these data using subjects (F1) and items (F2) as random variables. Errors (1.69% of the data) and reaction times exceeding 1500 ms (0.13% of the data) were excluded from the analysis.

The main effect of the 'Grammatical Relation' factor was significant globally ($F1\ (1, 46) = 76.65$, $p < .001$; $F2\ (1, 15) = 32.61$, $p < .001$), and specifically for sequences testing gender in both analyses ($F1\ (1, 23) = 77.26$, $p < .001$; $F2\ (1, 15) = 19.56$, $p < .001$) and for those testing number in the subjects analysis only ($F1\ (1, 23) = 12.90$, $p < .005$).

The 'Violation Type' factor did not introduce any significant effect. The interaction between grammatical relation and violation type was significant in the subjects analysis only ($F1\ (1, 46) = 13.52$, $p < .001$). As can be seen in Figure 2, the effect of grammatical con-

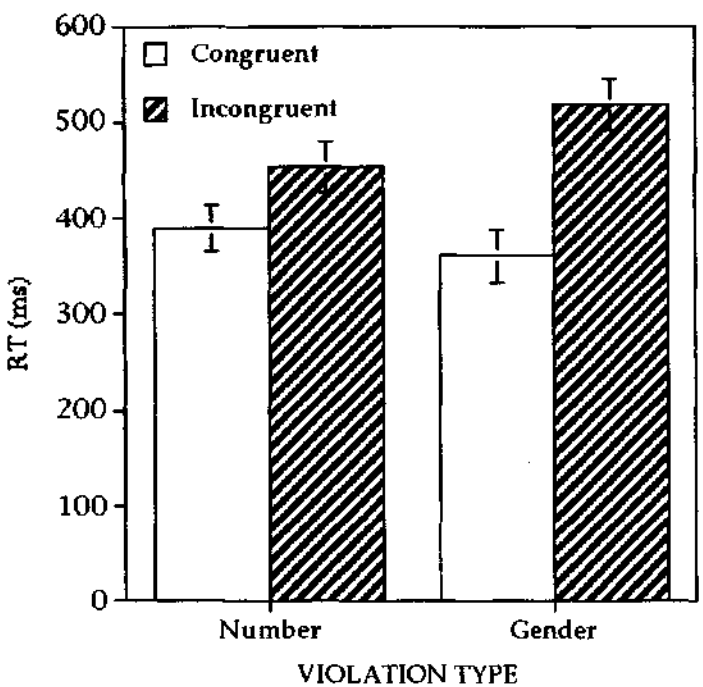

Figure 2. Reaction times as a function of Grammatical Relation and Violation Type in Spanish.

gruency was more important for gender than for number targets (156 ms. vs. 64 ms.).

2.2.4. Discussion

As in the previous experiments, a grammatical congruency effect was observed in Spanish. Reaction times were faster for targets preceded by a congruent determiner than for targets preceded by an incongruent determiner. Interestingly, the results of this experiment are in part similar to those obtained in the visual modality, and in part similar to those obtained in spoken French. On the one hand, as in the studies by Lukatela *et al.* (1987) in Serbo-Croatian, and by Colé & Segui (1994) in the visual modality in French, the violation type factor was not significant in Spanish. In other words, lexical decision times to items testing number did not differ from lexical decisions to items testing gender. On the other hand, contrary to the results in the visual modality studies and similarly to the results in spoken French, violation type interacted with grammatical relation, the magnitude of the congruency effect being larger for gender than for number as in spoken French.

In the light of the Spanish data, it becomes clear that one of the results observed in the experiment in French, namely the violation type effect, was due to the peculiarities of the items used to test number. Nevertheless, the other result observed in spoken French and replicated in Spanish, namely the interaction between grammatical relation and violation type, cannot be explained on the same grounds: in Spanish, as indicated, items testing number and gender were exactly the same. A possible interpretation of the interaction observed in both studies is provided below.

3. General discussion

Two main results obtained in our experiments are to be emphasized. First, number targets were judged faster than gender targets in French but not in Spanish. Second the congruency effect was larger for gender violations than for number violations in both languages.

Consider the first result. The lack of violation type effect in Spanish is consistent with previous results observed in the visual modality both in French (Colé & Segui 1994) and in Serbo Croatian (Lukatela *et al.* 1987). The violation type effect that we observed in French, namely the fact that lexical decision times were longer for

gender than for number targets, may be a consequence of using different lexical items to test the two features, as suggested by the results of the follow-up study reported in section 2.1.4. Excepting this peculiarity of the French results due to the materials, it seems that testing number vs. gender independently of the grammatical relation between the prime and the target, gives the same output (i.e., no effect), in the visual and in the auditory modalities.

Consider our second result. Given that in the visual modality studies no interaction between violation type and grammatical relation was observed, we did not expect to find it in the auditory modality either. Nevertheless an interaction between violation type and grammatical relation was observed in French and in Spanish, and in both languages the magnitude of the effect was larger for gender than for number. The first remark to make about these results is that they provide evidence against the binary hypothesis proposed by Lukatela *et al.* (1987). What causes the grammatical congruency effect cannot be conceived as an all or none process since in the auditory modality it is affected by violation type, and as shown by Colé & Segui (1994), in the visual modality the effect varies as a function of vocabulary type. The second remark to make is that this result is compatible with a nonunified view with respect to the representation of number and gender within the DP.

What processing difference could explain the fact that a gender violation is more disturbing than a number violation? In order to answer this question, a more specific characterization of the congruency effect is needed. First, adopting the proposal by Seidenberg *et al.* (1984), we assume that this effect is post-lexical. Second we propose that in the incongruent condition, the language processor is compelled to repeat one or more operations involved in the lexical decision process depending on the nature (number or gender) of the violation. Repeating more than one operation would take more time than repeating only one, leading in both cases to longer lexical decision times in the incongruent than in the congruent condition.

Following ideas by Bradley & Forster (1987) about lexical retrieval, we propose that a lexical decision to a target that is preceded by a prime, is achieved through a process involving three successive stages: (i) a stage of lexical access, (ii) a stage of readout, and (iii) a stage of evaluation. [14] The first stage covers the process of locating the correct lexical entry and leads to the state labelled lexical identification in Figure 3.

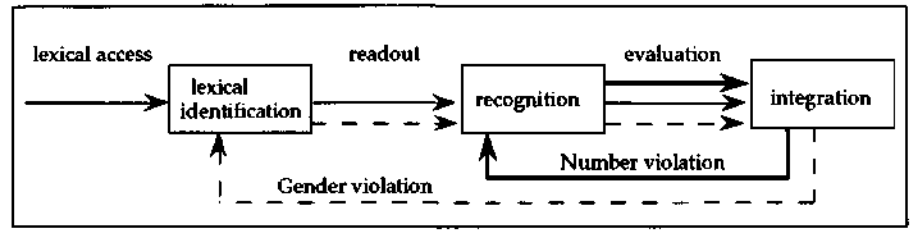

Figure 3. A model of the congruency effect for number and gender.

The second stage, readout in Bradley and Forster's (1987) model, makes available the relevant content of the entry to the relevant processors (categorial properties and concord relevant features such as number, gender and case for the parser; semantic properties for the interpreter). This stage leads to the state of lexical recognition. According to Bradley and Forster (1987), stages (i) and (ii) form lexical retrieval. Under this view, whatever happens after the recognition state is post access. As for the grammatical congruency effect, we must add a third stage which is mentioned but not described by these authors. This stage evaluates the appropriateness of the target to the context and leads to the state of integration.

On this basis let us again consider our second main result. It is natural to assume that this result reflects the fact that for the processor, a gender violation is more disruptive than a number violation. Under the hypothesis that gender is an inherent property of the stem itself (Harris 1991; see also Levelt 1989), it is tempting to suggest that in the case of a gender violation, the processor may be uncertain about whether or not the correct lexical entry has been located through the stage of lexical access. The processor may then be compelled to go back to the lexical identification state, thereafter repeating the stages of readout and evaluation (dotted arrow in Figure 3). In contrast, if number is not an inherent property of the stem, in the case of a number violation, the processor may only need to redo the evaluation stage to confirm that the result of the readout stage was adequate, in spite of the feature mismatch between the determiner and the noun (bold arrow in figure 3). As indicated in section 2.1.4, the same result could be accounted for under the hypothesis that gender is projected under NumP, if it is assumed that a parasitic feature (ie. gender) is not accessible to the checking process compelling therefore the processor to go back to the noun itself. The data presented in this experiment may be compatible with both interpretations. However as

previously indicated, [15] the second interpretation adapts concepts of the checking theory of Chomsky (1995) to account for the congruency effect but does not clarify the relevance of the distinction between maximal and non maximal projections (i.e. number vs. gender) for a processing account. Further research is needed to settle this question.

A last point that needs to be clarified concerns the difference between the results obtained in the visual modality studies and those obtained here. As mentioned in section 1, processing of gender and number was only indirectly investigated in the visual modality studies. However, given that both gender and number were experimental factors in the designs by Lukatela *et al.* (1987) and by Colé & Segui (1994), we cannot ignore the fact that in their studies no interaction between grammatical relation and violation type was observed. Actually, we cannot exclude the hypothesis that the presence of such interaction in our studies vs. its absence in the former studies is related to the modality of accessing the linguistic representation: visual presentation vs. spoken language. Insofar as this question is not clarified, our remarks concerning the compatibility between our results and a nonunified view of the representation of number and gender within the DP, should be considered with caution.

Address of the Author:

Christel Faussart C/o Celia Jakubowicz, Laboratoire de Psychologie Expérimentale, Université R. Descartes, C.N.R.S. UMR 8581 28 rue Serpente, 75006 Paris, France e.mail: faussart@psycho.univ-paris5.fr - fax: 33.01.40517085

NOTES

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1 Carello *et al.* (1988) argue that the inhibitory effects observed by Goodman *et al.* (1981), and Seidenber *et al.* (1984) in English, cannot be unambiguously interpreted as resulting from a syntactic violation only, since subcategorization restriction violations, like *whose swear*, used by these authors, necessarily also induce a semantic violation.

2 To facilitate the reading of the examples, we repeated the same target in each condition; however, Lukatela *et al.* (1987) do not specify if that was the case in their experiment.

3 Colé & Segui (1994: 388) indicate that 'only adjectives were used when the first elements were open-class words (...) the closed-class first words included possessive adjectives, demonstrative adjectives, definite articles and exclamatories'.

4 The data concerning gender and number transgressions are collapsed in the results section of Experiment 4.

5 We report here a subset of the results obtained by Jakubowicz & Goldblum (1995), namely those concerning number and gender on a function word (the determiner) within the DP.

6 This overview is not intended as a comprehensive analysis of gender in French. We focus on points relevant to our experimental study.

7 Nouns ending in /-au/, /-eau/, /-eu/, and seven nouns ending in /-ou/ take /-x/ in written language (i.e., *tuyau/tuyaux* ('pipe/pipes'), *manteau/manteaux* ('coat/coats'), *cheveu/cheveux* ('hair-sing./pl.'), *bijou/bijoux* ('jewel/jewels')). Similarly to the nouns for which plurality is manifested with the suffix /-s/, the singular/plural opposition is not phonetically realized, except in 'liaison environments' where /-s/ and /-x/ are pronounced [z]: *idees étonnantes* [idezetɔnãt], ('surprising ideas'), *bijoux importants* [biʒuzẽpɔRtã].

8 Note that in French gender in determiners gets neutralized in the plural.

9 However, Tucker *et al.* (1977) suggest that in French, noun-ending and gender co-occur in a systematic and predictive fashion. See Carroll (1989) for discussion of this claim.

10 Recall that for Di Domenico (1995), variable gender only is assigned syntactically under NumP.

11 This interpretation has been suggested to us by an anonymous reviewer. It seems to be based on the idea that a syntactic feature that does not project as a maximal projection, is not accessible (or is less accessible) for checking relations. To our understanding, within the minimalist framework, syntactic features on the functional domain must be checked. Thus the reviewer's suggestion must be conceived as an alternative processing account compatible with the hypothesis that (variable) gender is syntactically projected under NumP. We do not know about independent evidence in favour of the reviewer's suggestion.

12 Note that third person nominative pronouns, definite articles and demonstratives manifest a third gender form, traditionally called neuter. We do not consider this form here (see Harris 1991).

13 See Harris (1991) for an analysis of the lexical entries and derivations of the definite articles *el/los*.

14 Although along the lines of Bradley & Forster (1987) we make a distinction between lexical access and recognition, we do not necessarily assume that the process of lexical retrieval involves the five steps suggested by these authors.

15 See footnote 11.

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