Access to Phonological and Gender Information during Visual Word Recognition

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Abstract

Alario and Caramazza (2002) have suggested that during noun production, gender and phonological information are both involved in determiner selection, although they act independently. They also suggested that this process occurs later in French than in other languages like German and Dutch. One possible reason is that in French, some determiner forms depend on the initial phoneme of the noun (e.g., the feminine possessive determiner), while others do not (e.g., the indefinite article). The aim of our study was to track the time course of these factors during word comprehension. A lexical decision task and three gender decision experiments (selection of the indefinite article, the possessive determiner or Masculine/Feminine categorization) were conducted. We observed that all gender decision tasks were sensitive to the initial phoneme, whereas a gender effect was only found for categorization possessive articles. The results support the hypothesis that determiners are selected late in comprehension, as in production.

Keywords: Visual Word recognition, phonological access, gender access,

Introduction

Word production and recognition are higly complex tasks, involving the rapid coordination of visual, phonological, semantic and syntactic processes. Many studies were interested, in the last decades, to the temporal integration to phonological and gender cues during language production. They suggested that access to syntactic gender information was likely to be quicker than access to information concerning the phonological and orthographical form of the word (Caramazza & Miozzo, 1997; Levelt & al, 1991, 1999; Schmitt, Rodriguez-Fornells, Kutas & Münte, 2001; Van Turennout, Hagoort & Brown, 1997, 1998). By contrast, very little empirical evidence for the time course of these events was provided in the field of word recognition. Although latest studies argued that both grammatical gender (see Friederici & Jacobsen, 1999 for a review) and phonological information (Coltheart & Rastle, 1994) become activated in the course of this process, there is, however, a debate whether the activated information is selected in any case or only if needed.

The question addresses in the present study concerns the time course of the various processes involved in the treatment of gender, and more precisely, the aim was to determine whether the sequential timing of gender and wordform encoding found in production tasks was reversed in comprehension tasks. To investigate the time course of events involved in gender categorization we used a grammatical property of words stored in the mental lexicon which is their grammatical gender.

French nouns are always marked for gender, either masculine or feminine (Corbett, 1991). Depending on the language, other word classes (i.e. closed-class), such as determiners, could also include gender marks. Selection of these items in the mental lexicon is based on variable information, i.e., according to noun's properties they have to agree with. For instance, in French the forms of possessive articles vary according to grammatical gender of words, but also according to phonological features: nouns with consonant as initial letter are preceded by *mon* if they are masculine (e.g. *mon* fauteuil [my armchair]), and by *ma* (e.g. *ma* table [my table]) if they are feminine. In contrast, when the first phoneme is a vowel, regardless of the gender, determiners are associated with the form *mon* (e.g. *mon* étoile (fem) [my star]; *mon* arbre (masc) [my tree]). However, it is not a general and universal rule. If one considers indefinite articles, then the form used is based only on gender information: Masculine words are

preceded by *un* (e.g. *un* arbre [a tree]; *un* fauteuil [an armchair]) whereas feminine words are following by *une* (e.g. *une* étoile [a star]; *une* table [a table]). In contrast, Dutch crucially differs from French since the variability only depends on grammatical gender: Neutral gender words are associated with the indefinite article form *het*, and common gender words, either masculine or feminine, are following by *de*. Finally, the selection can be based just on phonological cues, as definite articles in English, where words having a consonant for first letter are preceded by *a*, whereas those having a vowel as first phoneme are associated with *an*. This case illustrates that the variability in determiners form does not depend on gender, but that it is assumed to reflect some process of phonological adaptation.

These examples underlie the fact that the selection of items which belong to the closed class requires a combination of several types of features at different levels of the word process: encoding of gender information and phonological cues of the subsequent words. This property was used in a previous study, conducted in production in French, by Alario and Caramazza (2002). In their first experiment, the authors used a picture-word interference naming task. Participants were required to name pictures of inanimate objects with consonant as first phoneme, with the congruent definite article (e.g. "*la* table" [the table]), while ignoring presented distractor words. Three different distractor words were used: (1) words with the same gender but phonologically unrelated; (2) words different in gender and phonologically unrelated; (3) words phonologically related but opposite in gender to the name. Under such conditions, naming latencies were not affected by gender, whereas response times were reduced when target words and distractors were phonologically related. From the presence of a phonological effect, the authors concluded that the selection of an article occurred only when grammatical properties and the phonological contents were entirely specified. In their second and third experiments, subjects had to name pictures with two kinds of NPs: Possessive article NPs ("*mon* étoile" [my star]), and possessive-pre nominal adjective NPs ("*ma* nouvelle étoile" [my new star]. Results reported that each type of information independently activates the form of congruent article. Consonant initial pictures were named more quickly with a valid possessive article when the gender of the noun was feminine than when it was masculine. On the other hand, for vowel initial pictures, the effect obtained was more as expected and showed that masculine words significantly took less time to be named than feminine words. Finally, when subjects had to insert an adjective between the article and the noun reported results were similar to those obtained for vowel onsets. The time necessary to name the targets increased when the corresponding nouns and the adjectives did not both begin by the same phoneme.

Two relevant conclusions were drawn from these results by Alario and Caramazza (2002): First that gender and phonological information are both involved in selection of articles, although they act independently; and second, that the selection of a valid article is not an early process in French. The production effects reflect a property of the language which imposes a reversed order of the usually accepted syntax-phonology sequential processing.

The question address in this study is whether this pattern of results will differ in visual word comprehension area.

In this article, we report the results of one lexical decision task that was designed to act as baseline for three Gender Decision tasks. In these experiments, subjects had to categorize nouns according to their gender with or without determiners. The different articles used were indefinites (either *un* or *une*) and possessives (either *mon* or *ma*). In the last experiment participants had to categorize words on the basis of masculine or feminine. We used this task to evaluate whether grammatical gender and information concerning the phonological and orthographical forms of words affect gender judgment latencies.

Experiment 1

This first experiment was designed to be used as a baseline for categorisation experiments. In order to be able to interpret categorization times, we first wanted to be sure that lexical access for our experimental words were comparable. We thus ran a visual lexical decision task experiment. We presented participants with strings of letters corresponding to words or pseudo-words and they had to decide whether they were real words or not. Two mains factors were manipulated in order to create four conditions: The first one, was the gender of nouns (experimental words were either masculine or feminine), and the second one was the nature of the first phoneme (the first letter was either a vowel or a consonant). If the time necessary to recognize a target as a word varies according to conditions, then further categorization times would need to be weighted by lexical reaction times.

Method

Participants Twenty-five French native speakers took part in this experiment. They were between 18 and 31 years old.

Stimuli The experimental items were 64 inanimate singular French nouns (40 feminine and 40 masculine) selected from LEXIQUE database developed by New, Pallier, Ferrand and Matos (2001). A set of 64 pseudo-word fillers orthographically and phonotactically correct were constructed. Half of the experimental words and pseudowords started with vowel phonemes /a/, /é/, and the other half with consonant phonemes /b/ or /p/. Each phoneme was represented equally in the target sets. All selected experimental items corresponded to bi or trisyllabic words (mean: 2.4), with an average length of 6.8 letters (range: 5-9 letters). The mean frequency of occurrence per million word forms (according to

FRANTEXT) was 15.1 for vowel-onset words and 12.3 for consonant-onset ones. Overall words in each condition were matched for word frequency, number of syllables, and word length.

Procedure Visual targets were displayed in the centre of a PC screen and presented using DMDX software (Forster & Forster; 2003). On each trial, a fixation cross was presented (750ms) immediately replaced by a blank screen (750ms) and then the item appeared. It remained on the screen until response or when a deadline of 2500 was reached without overt response. Participants were asked to decide whether the presented string of letters was a word or not.

Results & Discussion

The data of two subjects were not taken into account in the analyses due to technical problems. Reaction times slower than 1500ms and faster than 300ms were removed and counted as outliers. The final error rate being low (3.4%), it was not analysed.

In this serie of analyses, mean reaction times were entered into ANOVA by subjects with the first phoneme (Vowel vs. Consonant) and the target gender (Masculine vs. Feminine) as within factors. Pseudo words reaction times were not included. Results obtained are summarized in Table 1.

Table 1: Mean Lexical decision Latencies (in ms) and standard deviations on words (SD) for Experiment 1.

	vowel	*Consonant*	***Means***
Feminine	613 (98)	633 (107)	**623**
Masculine	611 (79)	621 (98)	**616**
Means	**612**	**627**	**619**

The analysis of variance revealed that the first phoneme affects the lexical access of nouns [F(1,22)=4.9, p=.0375]: Subjects were faster for nouns with vowel as initial letter than for targets with consonant as first phoneme. The main effect of Gender and the interaction between the two variables were not significant [both F's<1].

This first experiment was set up to be used as baseline for further categorization task experiments. Indeed a difference in lexical decision times is observed depending on the first phoneme. For further categorization task results we will correct reaction times by mean lexical decision latencies.

Why do we observe differences in lexical decision times while items were matched on frequency, number of syllables, and word length? Moreover what is surprising is that words starting with a vowel take less time to be recognized than words starting with consonant letters. This effect is reversed compared to the one observed in gender monitoring (Desrochers & Al 1989, 1995; Taft & Meunier, 1998). On the one hand, the advantage for the vowel onset words could not be explain by the distribution of pseudoword first letters since half of them

started with a vowel and the other ones with a consonant. In these conditions, participants could not have used a strategy such as 'if the first letter is a vowel, it is a word' which could constitute a valid explanation of our results. On the other hand, this inconsistency could be due to an abnormal increase of words-initial vowels proportion in our experimental items set combined with the task demand. List-context effect hypothesis had received a lot of support in the literature. For example, Gordon (1983) demonstrated that the manipulation of proportion of high frequency words compared to low frequency experimental items modulated the word frequency effect during lexical decision tasks. More recently, Andrews (1997) had argued that if discrepancies were shown in orthographic neighbourhood size effect studies, then it could be due to the presence of unusual stimuli. A corpus analysis will be necessary to determine whether the distribution of both kinds of onset-words is symmetric or not in the mental lexicon. An atypical proportion of vowel onset words in ours experimental lists compared to the one observed in the vocabulary could have render easier the identification of nouns beginning with a vowel. Whatever the explanation is, we mainly used the lexical decision task results as a baseline for the following three experiments.

Experiment 2

The basic idea behind these experiments was to investigate whether grammatical decision task could be affected by grammatical and/or by information carried by nouns form, in other words whether French articles are selected early or not during visual word recognition processes in French.

Method

Participants Seventy-three participants were recruited from the University of Lyon. None of them had participated in experiment 1. There were 24 students in Experiment 2A, 25 in Experiment 2B, and 24 in Experiment 2C.

Stimuli The 64 experimental items were the same to those used in Experiment 1.

Procedure The same procedure was used as in Experiment 1 in three different gender decision tasks. In Experiment 2A, participants were asked to decide whether targets could be preceded either by the masculine indefinite article (*un*) or by the feminine indefinite article (*une*). In Experiment 2B, for each item, subjects had to indicate whether targets could be preceded either by the masculine form of the possessive (*mon*) or by the feminine form (*ma*). In Experiment 2C, they had to decide whether targets were either masculine or feminine.

Results & Discussion

Because of faulty equipment or because of more than 10% erroneous answers, the data from 3 participants in Experiment 2A, 2 in Experiment 2B and 3 in Experiment 2C were rejected from the analysis. We coded as outliers and excluded those trials in which responses latencies were more than 1500ms or less than 300ms. In these three tasks, average percentages of errors being lower than 4%, they were not analysed. However, these weak percentages indicate that the tasks were easily executed by French speakers.

For each Experiment, average response latencies were corrected by the baseline, i.e., mean RTs lexical decision

data (Chapman, Chapman, Curran, & Miller, 1994). We have used a relative measure to determine a ratio:

$$\frac{\text{RT in condition X - Mean Baseline RTs in condition X}}{\text{Mean Baseline latencies in condition X}}$$

Weighted values were analyzed in a repeated measure ANOVA by subjects (F). Comparisons implicated Target Gender (feminine vs. masculine), nature of the first Phoneme (vowel vs. consonant), and the kind of Task (Un/Une, Mon/Ma and Masc./Fem.). Results obtained for the Phoneme effect are reported in Table 2, and an overview of the Gender data is provided in Table 3.

Table 2: Summary of corrected mean Reaction Times and Difference Scores across three Gender Decision Tasks for the first Phoneme.

	Experiment 2A (Indefinite Article)		Experiment 2B (Possessive Article)		Experiment 2C (Gender Categorization)	
	Vowel	Consonant	Vowel	Consonant	Vowel	Consonant
Means corrected	.100	.085	.164	.108	.302	.245
Difference Scores	.015*		.056**		.057**	

Note   *p<.05   **p<.001

Experiment 2A In analyses of response latencies when subjects were asked to categorize items by the valid indefinite article, we only found a significant effect of first Phoneme [F (1,20)=4.212, p=.05]. Nouns with consonant in initial position were processed faster than those with vowel as first letter. The main effect of Gender and the interaction of the two factors were not significant [both F's<1].

The results of Experiment 2A demonstrate that participants perform better the gender categorization when nouns have a consonant as first phoneme than when they are initiated by a vowel. Phonological information plays a role during gender classification even if the form of the determiner does not depend on it.

Experiment 2B When participants had to make a decision according to the valid possessive article, analyses of RTs showed a significant effect of Phoneme [F (1,22)=9.467, p=.0055]. Moreover, response latencies were faster to masculine words than to feminine one [F (1,22)=19.950, p=.0002]. The interaction was not significant.

Experiment 2B shows, on the one hand that when feminine nouns are present, responses latencies increase compared to those obtained with masculine targets. On the other hand, a vowel as first phoneme slow noun categorization latencies compared to reaction times to consonant initiated words. These results point out the fact that the selection of the valid possessive form involves the combination of phonological and gender sources of information.

Experiment 2C For categorization according to one of the two possible gender labels (masculine vs. feminine), we only found a significant first Phoneme effect [F (1,20)=15.981, p=.0007]; with faster responses for words initiated by a consonant than by a vowel. The Gender effect did not appear significant, as the interaction between the two variables.

The results of Experiment 2C reveal that consonant initiated nouns were process faster than for nouns initiated by a vowel. Phonological information is used in determining gender during gender monitoring task.

Task effect Mean reaction times were entered into ANOVA by items (F2) with nature of Task (3 levels) as independent variable. The results showed a significant main effect [F2 (2,126)=110.194, p<.0001]. Participants were faster to execute a categorization by the indefinite article (677ms, 53 SD) than by the possessive one (705ms, 57 SD); and on average, these two tasks were also done faster than the masculine-feminine distinction (788ms, 71 SD).

Reaction time latencies vary according to the task. The significant effect observed in this study is similar in direction to the one found by Desrochers, Paivio and Desrochers (1989). They obtained 200ms faster responses in a gender decision with Un/Une than with Masculine/Feminine. RTs needed for the execution of a given task depend on the level of complexity required for the processing.

Table 3: Summary of corrected mean Reaction Times and Difference Scores across three Gender Decision Tasks for Gender of nouns.

	Experiment 2A (Indefinite Article)		Experiment 2B (Possessive Article)		Experiment 2C (Gender Categorization)	
	Feminine	Masculine	Feminine	Masculine	Feminine	Masculine
Means corrected	.09	.096	.174	.098	.273	.274
Difference Scores	.006		.076**		-.001	

Note   *p<.05   **p<.001

General Discussion

The goal of this study was to determine whether phonological cues and gender information could influence mechanisms implicated in categorization tasks. In this line, three main results had to be pointed up: (1) All gender decision tasks showed a strong effect of phonological cues whereas (2) a gender effect was only found during categorization according to possessive articles; and finally (3) variations of mean reaction times were observed depending on task.

Concerning phonological cues processes, the results of Experiments 2 showed a strong phoneme effect. The observation according to which the words beginning with a vowel are treated more slowly than those starting with a consonant, during gender categorization regardless of the labels, is also in line with the traditional view (Desrochers & Al 1989, 1995; Taft & Meunier, 1998). In conclusion, we could argue that the access to determiners linked to a noun was performed in a such way that it was influenced by phonological cues situated at the beginning of nouns.

Across experiments, the pattern of results also suggests that if gender information is not used to facilitate lexical access, it seems to play a role during categorization processes. More specifically, a gender effect was found when participants had to decide whether a noun could be preceded either by the feminine or by the masculine form of possessive articles; but not in both gender monitoring tasks with indefinites and masculine/feminine as labels. By itself this result implies that article representations can acquire activation from multiple sources, i.e., syntactic and phonological. However, the gender activated information is selected only if needed, whereas the phonological one drives selection of determiners in any cases. Results obtained with possessives articles show that the selection of articles is delayed until gender information is available only when it is necessary, and that the selection of this kind of articles is a relatively late process during visual word recognition.

As it was said previously, in Experiment 2B, during which subjects had to decide by which form of possessive articles nouns could be preceded, we obtained an effect of first phoneme and an effect of gender, but no interaction. At this point, it is interesting to underlie two main assumptions: First that during gender categorization with possessive articles as labels, there are multiple sources of information available, and secondly that the decision making stage requires the prior integration of information coming from earliest processing stages. Thus, concerning the lack of interaction between gender and phonological information, one possible interpretation is that the two signals act independently on categorization processes. Nevertheless, an alternative explanation to the lack of interaction could be proposed. Indeed, our experimental material included an asymmetry between the number of answers requiring *ma* and the answers involving *mon* (75% of the data). This disproportion might have crushed the possible interaction between phonological and gender target effects, i.e. either faster reaction times in the case of words-initial consonants preceded by the feminine possessive form *ma*, or slower latencies for feminine words with a vowel as first phoneme (e.g. *mon* étoile). In order to check this assumption, it would be necessary to reproduce the gender decision task according to possessives, by including a greater proportion of feminine items beginning with a consonant in order to obtain an equivalent number of *mon* and *ma* answers, and verify whether the pattern of results would differ or not. Increasing the ratio of *ma* answers could affect the magnitude of effects by increasing the focus of attention on consonant-onset feminine words.

Another point must be highlighted from the results of Experiment 2. A robust and strong task effect was found between the three gender-monitoring experiments. According to this effect, saying that a word is masculine takes more time when it is preceded by *un* or *mon*, and the time necessary to classify a word with an indefinite article is generally shorter than with a possessive determiner. The RTs difference implies that the level of complexity vary according to the required processing. This suggests that articles will be stored as labels with words in the mental lexicon. On the basis of the assumption that the identification of gender rests on the activation of noun's related data, it is possible to say that the lexical representations likely to be activated after noun recognition are the words which generally covary with their gender. Moreover, it could be argued that the facilitation effect depends on the frequency appearance for the two items co-occurrence in French language. This claim is supported by the result according to which reaction time latencies increased when subjects had to categorize words with Masculine/Feminine labels compared to those obtained with Un/Une. It should also be noted that if the time latencies vary according to the

required task, results do not bring back any interaction with the syntactic and phonological cues. This observation implies that the effect of task (indefinite article, possessives and masculine vs. feminine) is located at the level of the answer production.

Conclusion

In summary, taken together, results of the four comprehension experiments suggest that both phonological and gender information are implicated during gender identification and that noun's wordform is retrieved first. This observation maps results obtained in production, and reflects a property of the language. However an intriguing point is that the initial phoneme effect plays a role across the board, even when the determiner form does not depend on the initial phoneme; whereas a gender effect is only found in the task involving the processing of a determiner form that is sensitive to the initial phoneme: the possessive determiner. More research will be required to determine the exact mechanism underlying these observations and to examine if phonological and gender information act independently in articles selection or not.

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