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Does Gender Information Influence Early Phases of Spoken Word Recognition?

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Abstract

In a cross modal fragment priming study, we tested the hypothesis that gender information is used early to discard gender-incongruent competitors during word comprehension. In three experiments, we compared the lexical decision performances on targets primed by phonological information only (e.g. /kra/-CRAPAUD) or by phonological plus gender information (e.g. un_{mas}/kra/-CRAPAUD). In all experiments, we found a phonological priming effect that was not modulated by the presence of gender information, whether gender was congruent with the target (Exp1 and Exp2) or incongruent with the target (Exp3). Moreover, phonological facilitation was not modulated by the presence of gender information, whether gender allowed exclusion of less frequent competitors (Exp1) or more frequent ones (Exp2). We concluded that gender information extracted from a gender-marked determiner is not used early in the process of spoken word recognition.

Keywords : context effect, word recognition, gender

Introduction

In French, each noun is either feminine or masculine. Determiners obey a gender agreement rule so the gender of a noun following a masculine indefinite article (e.g. "un"/ɛ/) is masculine, and a noun following a feminine indefinite article (e.g. "une"/yn/) is feminine. Since articles always precede nouns in French, the presence of such specific markers in spoken utterances could aid listeners by providing specific cues for decoding what they hear.

Number of studies have indeed shown effects of gender on word recognition. Grosjean, Dommergues, Cornu, Guillelmon, and Besson (1994) compared lexical decision times to nouns preceded by an auditorily non gender-marked adjective or preceded by a gender-marked determiner plus the

same adjective (e.g., "jolie table" vs. "une_{fem} jolie table"). Faster responses were found for the gender marked context condition. Recently, Bölte & Connine (in press) showed faster lexical decision times to targets preceded by valid gender-marked article (either feminine, masculine or neutral in German) compared to targets preceded by a noise masked article. Bates, Devescovi, Hernandez and Pizzamiglio (1996) also showed robust gender priming.

Dahan, Swingle, Tanenhaus and Magnuson (2000) assessed the impact of gender on lexical access in a study where French participants were instructed auditorily to mouse-click on pictures of objects displayed on a computer screen while their eye movements were monitored. When participants heard instruction sentences that did not include gender information – e.g., "cliquez sur les...(boutons)", "click on the...", where "the" is plural but not gender-marked – the probability of fixation was higher for pictures with names that shared initial phonemes with the target ("cohort" effect), compared to pictures that had unrelated names. When a gender-marked article preceded the target noun – e.g., "cliquez sur le bouton", "click on the button", where "the" is marked for masculine gender – the members of the phonological cohort that were not of the marked gender received no more fixations than the unrelated competitors.

Spinelli and Alario (2002) examined whether gender information could constrain the activation of fully ambiguous words: homophones with two different genders (e.g., /sel/ meaning salt masculine or saddle feminine). In a cross-modal semantic priming study, they found that when homophones were presented in isolation, facilitation was found for targets related to both the masculine (e.g., "poivre", pepper) and the feminine (e.g., "cheval", horse) meanings of the homophones. However, when homophones were presented with a gender-marked definite article (e.g., /lasel/, the saddle), facilitation was found only for targets related to the meaning matching the gender information given by the article (e.g., "cheval").

These studies provide evidence for an influence of a gender-marked context on the activation of lexical candidates. However, it is unclear how gender context is used during the recognition of the following word. It could be that activation of lexical candidates is driven by the acoustic input only and gender information is used later in the recognition process. Hence, a cohort of potential candidates would compete for recognition irrespective of their gender, and gender context would act later in the recognition process to select the appropriate candidate. For example, given the acoustic input, « un_{masc} bou... » /ɛbu.../ in French, the competition would take place on all masculine and feminine words beginning with /bu/, the gender information extracted from a determiner—“un”—being used later to select the appropriate candidate. Another account of gender effects would be that a context marked for grammatical-gender influences the early processes of lexical access. Note that the Dahan et al. study suggests that this is the case. Then it could be that gender information extracted from a determiner (e.g., feminine from “la” /la/ -the-or “une” /yn/ -a/one- in French) is used to discard the gender mismatching candidates (e.g. masculine). That is to say, the cohort of phonologically related candidates considered for selection would be restricted to those that have a gender that matches the context.

In the present study, we tested the hypothesis that gender information is used early in the process of lexical access to discard gender incongruent candidates from the competition process. In the series of experiment presented, we used fragment priming in which the initial fragment of a target was presented as prime either with or without gender information. Fragment priming paradigm is known to tap into early phases of word recognition and allows to evidence multiple activation (Zwitserslood, 1989). Hence, if a context marked for gender influences the early processes of lexical access and constrain lexical activation to gender-congruent candidates only, phonological fragment priming should be modulated by the presence of gender. Moreover, the effect of gender should be greater for candidates having more frequent competitors of the opposite gender than for candidates having no more frequent competitors of the opposite gender. Therefore, associated with fragment priming, we manipulated the position in the cohort given the frequency of the masculine and the feminine candidates. For example, if the candidate word “bouteille”_{fem} in French ([butej], bottle) is the most frequent word of the cohort beginning with /bu/, this candidate should weakly benefit from the exclusion of the masculine, less frequent competitors. Contrarily, consider the French word “bouton”_{masc} ([butɔ̃], button), which is less frequent than “bouteille”, but is the most frequent masculine word in the cohort activated by /bu/. The activation of such a candidate (bouton), should be much greater given the input “un_{masc} bou...”, /ɛbu/ than given “bou...”, /bu/ because in the former, gender information allows exclusion of feminine candidate words (thus “bouteille”, more frequent) hence leaving “bouton” the most frequent of its cohort. In summary, if gender information given by a gender-marked context allows exclusion from the competition process of all

related candidates with mismatching gender, (1) phonological priming should be modulated by the presence of gender and (2) gender information should benefit more to candidates that have a more frequent competitor of the opposite gender. We conducted a series of cross modal priming experiments in which the initial fragment of a target was presented as prime (e.g. /kra/-CRAPAUD) either with or without gender information (e.g. un_{masc} /kra/ or /kra/). These conditions were compared to unrelated control ones. In Experiment 1, targets had no more frequent competitor whereas in experiment 2, targets had one more frequent competitor of the opposite gender. Hence in experiment 1, targets were the most frequent words of the cohort (e.g. CRAPAUD_{masc} for the cohort of “/kra/”) whereas in Experiment 2, they were the most frequent words of the other gender cohort (e.g. CRAVATE_{fem}, [tie], for the cohort of “une_{fem} /kra/”).

Pretests

In order to select the targets for the two first experiments, we needed to find the most frequent word of a given phonological cohort. Because frequencies given by French database are obtained from written corpus, we chose to assess frequency by the means of an auditory pre-test. Hence, the term “frequency” refers to subjective frequency. Three pre-tests were carried out on several groups of first year psychology students (approximately fifty students in each group). A first group was presented auditory syllables (e.g. (/kra/ or /bu/...)) and had to write down the first word that came to their mind beginning with this syllable (e.g. “crapaud” –toad- or “bouteille” -bottle). This first pre-test allowed us to establish a list of the most (subjectively) frequent words of the cohort of a given auditory syllable (/kra/or /bu/...). A second group was presented the same auditory syllables preceded by an article marked for masculine gender (e.g. un_{masc} /kra/or un_{masc} /bu/...). The subjects had to write down the first masculine word that came to their mind beginning with this syllable (e.g. “crapaud” –toad- or “bouton” -button). This second pre-test allowed us to establish a list of the most (subjectively) frequent masculine words of the cohort of a given auditory syllable (/kra/ or /bu/...). Conversely, a third group was presented the same auditory syllables preceded by an article marked for feminine gender (e.g. une_{fem} /kra/or une_{fem} /bu/...). The subjects had to write down the first feminine word that came to their mind beginning with this syllable (e.g. “cravate” –tie- or “bouteille” -bottle). This last pre-test allowed us to establish a list of the most (subjectively) frequent feminine words of the cohort of a given auditory syllable (/kra/or /bu/...).

Item selection for Experiment 1 : Targets of experiment 1 had no more frequent competitor. Hence, for a masculine word to be selected for the first experiment, it had to be the most responded item in the first and the second pre-tests. Moreover, it had to reach at least 17 %¹ of the responses in the first one. Similarly, a feminine word was selected for the

¹ The fact that selected targets were the most given item but nevertheless reached only 17% of the total responses reflects the productivity of the syllables that could give rise to many different lexical items.

first experiment if 1) it was the most given in the first and the third pre-test and 2) if it occurred at least in 17% of the responses in the first pre-test. Altogether, these 3 pre-tests allowed us to select 32 bi or trisyllabic words that were the most frequent words of the cohort of a given syllable. They served as targets in Experiment 1.

Item selection for Experiment 2 : Targets of experiment 2 had one more frequent competitor of the opposite gender. Hence for a masculine word to be selected for the second experiment, it had to be the most responded item in the second pre-test but not on the first one. Similarly, a feminine word was selected for the second experiment if it was the most given item in the third pre-test but not in the first one. In other words, targets of Experiment 2 were the most frequent of the cohort of the opposite gender. For example, if “crapaud” (toad_{masc}, selected for Experiment 1) was the most frequent word of the cohort of /kra/ (determined as described above, on the basis that it was the most responded item given both the auditory inputs /kra/ and “un_{masc} / kra/”), “cravate”_{fem} was the most frequent words of the feminine cohort of /kra/ (determined on the basis that it was the most responded item given the auditory input “une_{fem} /kra/). “Cravate” was then selected for Experiment 2.

Experiment 1

Method

Participants. Sixty students of the University of Grenoble, participated in the experiment for course credit. They were native speakers of French, had normal or corrected vision and reported no hearing impairment.

Stimuli and Procedure. *Words* : Thirty-two target words (12 masculine words and 20 feminine words) were selected such as they were the most frequent words of the cohort of a given syllable. They were selected by the means of the pre-tests described above. The average frequency given by the French database “Lexique” (New, Pallier, Ferrand & Matos, 2001) for the targets of Exp1 was 44 occurrences per million. Four primes were chosen for each target. One was a syllable corresponding to the first two or three phonemes of the target (e.g. /kra/-CRAPAUD, beginning-overlap condition); a second one corresponded to the syllable of the beginning-overlap condition preceded by an article marked for the target gender (e.g. /ɛkra/-CRAPAUD, beginning-overlap + gender condition), a third one was a syllable that was not phonologically related to the target (e.g. /pli/-CRAPAUD, unrelated condition), and the fourth one was a syllable that was not phonologically related to the target preceded by a gender marked article (e.g. /ynpli/-CRAPAUD, unrelated + gender condition, see table1). *Pseudowords* : Thirty-two bi or triyllabic pseudoword targets were constructed for the lexical decision task. As for words, four primes were chosen for each target. One corresponded to the first syllable of the target (e.g. /bre/-BREGOT, beginning-overlap condition); a second one corresponded the first syllable of the target preceded by an article (e.g. /ɛbre/-BREGOT, beginning-overlap + gender condition), a third one was a syllable that was not phonologically related to the target (e.g. /pla/-BREGOT, unrelated condition), and the fourth one was a syllable that

was not phonologically related to the target preceded by an article (e.g. /ynpla/-BREGOT, unrelated + gender condition). Examples of material used as primes and targets in all experiments are presented in Table 1. In order to reduce the proportion of related items to 33 %, the experimental lists also included 64 filler prime/target pairs, half the targets being words and the other half being pseudowords. The priming conditions for the filler targets were the unrelated condition and unrelated + gender condition.

All items were recorded in a soundproof room by a female native speaker of French on a PC MITSUBISHI DIAMOND PTO 900 U at a sampling rate of 16 kHz. Participants were tested individually in a quiet room. The prime was presented auditorily through Technics headphones. At the end of the auditory prime the target was visually displayed in lower case at the center of the computer screen and remained on the screen until the participant’s response. Participants were informed that they would first hear an auditory sequence that could either be a syllable or a syllable preceded by a gender marked article, then they would see either a word or a pseudoword. They were required to perform a lexical decision task on the visual targets. The computer clock was triggered by the presentation of the target on the screen and stopped by the response. Stimuli were counterbalanced across four experimental lists so that each participant received all conditions (beginning-overlap, beginning-overlap + gender, unrelated and unrelated + gender conditions) but saw each target only once. The order of prime/target pairs presentation was randomized. Response latencies and errors were collected.

	Priming conditions			TARGETS
		Without gender	With gender	
EXP1	Related	[kra]	[ɛkra]	CRAPAUD
	Unrelated	[pli]	[ynpli]	[krapo]
EXP2	Related	[kra]	[ynkra]	CRAVATE
	Unrelated	[pli]	[ɛpli]	[kravat]
EXP3	Related	[kra]	[ynkra]	CRAPAUD
	Unrelated	[pli]	[ɛpli]	[krapo]

TABLE 1: Example of material used as primes and targets in experiments 1, 2 and 3.

Results and Discussion

The results are presented in Table 2. Incorrect responses (2.3 % of responses), and RTs longer than 1500 ms and shorter than 200 ms (0.2 %) were removed. The data of one subject that gave rise to 30% of errors were also discarded from the analyses. Two-way analyses of variance with relation (related vs unrelated) and presence of gender (without gender, with gender) were performed on the data. F values are reported by subjects (F1) and by items (F2) and all significance tests have associated p levels of less than .05.

	Related (beginning overlap)	Unrelated	Priming effect
Without gender	531 ms (81) 1.5 %	550 ms (90) 3 %	19 ms
With congruent gender	535 ms (84) 1.5 %	555 ms (99) 3.2 %	20 ms

TABLE 2: Mean Reaction Times in Milliseconds (ms), Standard Deviation for correct responses to the word targets and Error rates in the four priming conditions.

Analyses of RTs revealed a main effect of relation, significant by subjects ($F(1,58) = 10.2$; $p < .005$), and by items ($F(1,31) = 18.9$; $p < .001$), target words being responded faster when they were preceded by phonologically related primes than when preceded by unrelated primes. However, analyses of RTs revealed no main effect of the presence of gender (Both $F_s < 1$) and no interaction between these two factors (Both $F_s < 1$).

Analyses of errors revealed a main effect of relation significant by subjects ($F(1,58) = 5.38$; $p < .05$; $F(1,31) = 2.7$; $p < .1$). This result is in line with the RTs data: there were fewer errors for target words preceded by phonologically related primes than for target words preceded by unrelated primes. Moreover, analyses of errors revealed no main effect of the presence of gender and no interaction between these two factors (All $F_s > 1$).

In this experiment, we found a phonological priming effect suggesting that presenting the beginning of a word (/kRa/ or un_{masc}/kRa/) activates the lexical representation of this word (CRAPAUD). This result is compatible with previous ones on fragment priming (Spinelli, Segui & Radeau, 2001; Zwitserlood, 1989; Marslen-Wilson, 1990). However, no gender effect was found, “CRAPAUD” being as much activated by phonological information only (/kRa/) and by phonological plus gender information (un_{masc}/kRa/). Note however that targets in this experiment were the most frequent candidates of the competition. Therefore, it may be that no gender effect was found because gender information allowed exclusion of less frequent competitors. On the contrary, a stronger gender effect is expected in Experiment 2 in which all targets have one more frequent competitor of the opposite gender. Gender information, in that case, should strongly aid targets processing by excluding the higher frequency competitors.

Experiment 2

Method

Participants. Forty-one students of the University Pierre Mendes France, Grenoble, participated in the experiment for

course credit. All participants were native speakers of French, had normal or corrected vision and reported no hearing impairment. None of them had participated in Experiment 1.

Stimuli and procedure. *Words* : Thirty-two target words (12 feminine and 20 masculine words) were selected such as they were the most frequent words of a gender constrained cohort (of a given syllable) but not the most frequent of the general cohort (not constrained by gender). Hence, they had a more frequent competitor of the opposite gender. They were selected by the means of the pre-tests described earlier. The average frequency given by the French database “Lexique” (New et al. 2001) for the targets of experiment 2 was 25 occurrences per million. As for Experiment 1, four primes were chosen for each target corresponding to the beginning-overlap condition (e.g. /kRa/-CRAVATE), the beginning-overlap + gender condition (e.g. /ynkRa/-CRAVATE), the unrelated condition (e.g. /pli/-CRAVATE) and the unrelated + gender condition (e.g. /ẽpli/-CRAVATE, see table 1).

Pseudoword and *filler pairs* were the same as those of Experiment 1 except that the gender was swapped in order to keep the proportion of masculine/feminine primes constant. The procedure paralleled that of Experiment 1.

Results and Discussion

The results are presented in Table 3. The data of one subject that gave rise to 47% of errors were discarded from the analyses. Three items were discarded from the analyses for the same reason (57,5%, 32,5 % and 40 % of errors). Moreover, incorrect responses, RTs longer than 1500 ms and shorter than 200 ms were removed, excluding 1.67 % of responses. Two-way analyses of variance with relation (related vs unrelated) and presence of gender (without gender, with gender) were performed on the data.

	Related (beginning overlap)	Unrelated	Priming effect
Without gender	535 ms (81) 2.1 %	545 ms (73) 1.8 %	10 ms
With congruent gender	536 ms (76) 1.1 %	553 ms (92) 1.7 %	17 ms

TABLE 3: Mean Reaction Times in Milliseconds (ms), Standard Deviation for correct responses to the word targets and Error rates in the four priming conditions.

Analyses of RTs revealed a main effect of relation, significant by subjects ($F(1,39) = 4.7$; $p < .05$; $F(1,28) = 3.3$, $p < .075$). As in Experiment1, target words were faster responded to when they were preceded by phonologically related primes than when preceded by unrelated primes. Moreover, analyses of RTs revealed no main effect of the presence of gender (Both $F_s > 1$) and no interaction between these two factors (Both $F_s < 1$). Analyses of errors revealed no effect of

relation, no effect of the presence of gender and no interaction between these two factors (All $F_s < 1$).

As in Experiment 1, we found a phonological priming effect suggesting that presenting the beginning of a word (/kRa/ or une_{fem} /kRa/) activates the lexical representation of this word (CRAVATE). However, no gender effect was found, “CRAVATE” being as much activated by phonological information only (/kRa/) and by phonological plus gender information (une_{fem} /kRa/). Because all targets had one more frequent competitor of different gender, gender information was expected to help targets processing by excluding the higher frequency competitors. The absence of gender effect in the last fragment priming experiment could be explained by the fact that contrary to our hypothesis, gender information is not used to discard mismatching candidates early in the competition processing. Alternatively, it could be that targets of Experiment 2 are so frequent that they do not benefit from the exclusion of their competitor. Remember that they are the most frequent words of their gender-based cohort even if they all have one more frequent competitor of the opposite gender. A less elegant (because it involves incongruity) but more direct way to test our hypothesis is to present prime-target pairs that do not share the same gender (e.g. “une”_{fem} /kRa/-CRAPAUD_{masc}). Then, if gender-mismatching candidates are discarded early in the competition process, we should find no phonological facilitation (or even inhibition) when the “wrong” gender information is available on top of phonological information (e.g. “une”_{fem} /kRa/-CRAPAUD_{masc}). In the next experiment, participants were presented to prime-target pairs that did not share the same gender.

Experiment 3

Method

Participants. Forty-four students of the University Pierre Mendès France, Grenoble, participated in the experiment for course credit. All participants were native speakers of French, had normal or corrected vision and reported no hearing impairment. None had participated in the previous experiments.

Stimuli and procedure In this experiment, the thirty-two target words were the same as those of Experiment 1 (i.e. the most frequent words of the cohort, e.g. CRAPAUD) and the primes were those used for Experiment 2. It means that when gender information was available in the prime on top of phonological information, the gender was not congruent with that of the target (e.g. “une”_{fem} /kRa/-CRAPAUD_{masc}, see table 1).

Results and Discussion

The results are presented in Table 4. Incorrect responses and RTs longer than 1500 ms and shorter than 200 were removed, excluding 2.9% of responses. Two-way analyses of variance

with relation (related vs unrelated) and presence of gender (without gender, with gender) were performed on the data.

	Related (beginning overlap)	Unrelated	Priming effect
Without gender	514 ms (64) 1.7 %	536 ms (78) 4 %	22 ms
With incongruent gender	514 ms (59) 3.4 %	530 ms (54) 2.6 %	16 ms

TABLE 4 : Mean Reaction Times in Milliseconds (ms), Standard Deviation for correct responses to the word targets and Error rates in the four priming conditions.

Analyses of RTs revealed a main effect of relation, significant by subjects ($F(1,43) = 16.2$; $p < .001$), and by items ($F(1,31) = 6$; $p < .05$), target words being responded faster when they were preceded by phonologically related primes than when preceded by unrelated primes. However, analyses of RTs revealed no main effect of the presence of gender and no interaction between these two factors (All $F_s < 1$).

Analyses of errors revealed no effect of relation ($F(1,43) = 1.22$, ns; $F(2, < 1)$), no effect of the presence of gender (Both $F_s < 1$), and no interaction between these two factors ($F(1,43) = 3.06$, $p < .08$; $F(1,31) = 3.52$, $p < .07$).

As in all previous experiments, we found a priming effect suggesting that presenting the beginning of a word activates the lexical representation of this word, whatever gender is given on top of phonological information. Targets were still facilitated when they were preceded by phonologically related primes with incongruent gender.

General discussion

In three experiments, we found a phonological priming effect suggesting that presenting the beginning of a word activates its lexical representation. This result is in line with previous studies showing fragment priming (Spinelli et al, 2001; Zwitserlood, 1989). However, this phonological facilitation was not modulated by the presence of gender information, whether this information was congruent with the target (Exp1 and Exp2) or incongruent with the target (Exp3). Moreover, phonological facilitation was not modulated by the presence of gender information, whether this information allowed exclusion of less frequent competitors (Exp1) or more frequent ones (Exp2 and Exp3).

This study was designed to test the hypothesis of an early influence of gender on lexical activation, with gender information acting as a means of excluding incongruent competitors. Cross modal fragment priming was chosen to tap into early processes of lexical access. With such a design, no influence of gender was found suggesting that gender

information has no early influence on gender incongruent competitors.

The fact that phonological facilitation was not modulated by the presence of gender contradicts the results obtained by Grosjean et al. (1994). They found faster responses for the gender marked context condition (*une jolie fille*) compared to the unmarked condition (*jolie fille*), a result that was interpreted as an indication that gender marking on the article serves as a cue to the recognition of the noun. However, no indication of the timing of this process is given and the discrepancy with our results suggests that gender is not used in the early stages of activation. The same applies for results observed by Spinelli and Alario (2002) who found that the representation of the masculine candidate “sel” was not activated given the input /lasel/. Their results suggest that at some point, gender incongruent competitors are discarded from the competition process, but again no indication of the exact timing is given.

However, Dahan et al.’ results suggested an early influence of gender on lexical access. They showed that the feminine cohort-competitor « bouteille » was not activated given the input /ləbutɔ/ while our results suggested that gender information has no influence on the activation of competitors. However, this discrepancy can be explained by the fact that the phonological cohort in Dahan study was composed of only two competing candidates (*bouton* and *bouteille*) whereas it was open to all phonologically related candidates in our study. Then one might hypothesize that gender information could efficiently be used when it allows to select the right candidate among a restricted choice.

When the cohort is open to all related candidates, gender information might not be used early to constrain the activation process because it is not efficient enough to rapidly narrow down the search space. Phonological information is surely the most efficient information to do so. The gender information could then take place during the selection phase following the initial activation phase constrained by phonological information only.

Because our interpretation of the data is so far mainly based on no-differences, further research is needed to evidence a late use of gender information distinct from an early use of phonological information, for example with a full priming (instead of fragment priming) design.

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