Doctoral Dissertation

Sex and Gender Dimension over Language Processing

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May 2017

Editor: Universidad de Granada. Tesis Doctorales
Autora: Alba Mónica Casado Ramos
ISBN: 978-84-9163-327-3
URI: http://hdl.handle.net/10481/47532

Acknowledgments

A toda mi familia quiero agradecer el apoyo incondicional que me han dado siempre, y especialmente durante este duro proceso. Sin ellos, ni la mitad de este trabajo hubiera sido posible, y hoy no estaría donde me encuentro. Gracias hoy y siempre por enseñarme tantas cosas, y hacerme como soy.

También quiero agradecer a Adri sus ideas brillantes, su ánimo y sus abrazos que me han dado fuerza para seguir adelante a pesar de todas las inconveniencias habidas y por haber.

A mis amigos, su amor y motivación para conseguir lo imposible, por enseñarme a disfrutar de todos los pequeños momentos.

A mis compañeros, por entenderme y ayudarme a comprender y aceptar en qué consiste investigar sin perder la cabeza.

A mis mentores, por prestarme toda su sabiduría y calma, especialmente quiero agradecer a Daniela Paolieri, a Angèle Brunellière, y a Alfonso Palma su paciencia.

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CHAPTER 1.- INTRODUCTION

The word 'gender' derives from Latin genus via Old French 'gendre', originally meaning 'kind' or 'sort'[...]. Actually, the noun inventory is divided into different kinds, or genders, according to the different agreements they take. When this is done, we find that in the more familiar languages, the different kinds or genders have a semantic core based on sex (Corbett, 2006, p.794).

Grammatical Gender

Linguistics

Grammatical gender is an intrinsic and arbitrary property of nouns existing in many languages that allows them to be classified in different categories (Corbett, 1991); according to Hockett (1958, p. 231) 'genders are classes of nouns reflected in the behavior of associated words'. The gender of the nouns is established by concordance, what means that formally the gender of a noun is manifested by the gender of the dependent words such as determiners, demonstratives, pronouns, adjectives, a few numerals and complementizers (Roca, 2005). The assignment of gender may depend on two basic types of information about the noun, its meaning (semantic) and its form, which can be divided into word-structure (morphology) or sound-structure (phonology). Nevertheless, all gender systems have a semantic core that overrides the other rules, such as when a noun have a masculine morphological/phonological gender but referrers to a female human, the concordance will be done as a feminine noun, or the other way around; for example the Spanish word "*marimacho*" (tomboy) is morphological/phonologically masculine but as it refers to woman, the concordance is made as a feminine noun. Concerning the assignment of gender according to the different types of information, we can find the example of semantic-natural gender system in Dravidian languages such as Tamil, in which nouns are assigned to gender according to their meaning. Thus, for example, one can be confident that a noun denoting a female will be feminine, and that a noun that is feminine will denote a female. The morphological gender systems works with rules such as nouns of declensional class, like in Russian. And finally, the phonological

gender systems also have rules by which gender can be established by reference to a single form; for example in Hausa where there are two genders, all the nouns ending in -aa are feminine meanwhile others are masculine (Corbett, 1991).

Gender in Romance languages, such as Spanish or French, have two categories of gender, masculine and feminine. As a general linguistic phenomenon, gender in Romance languages must be carefully distinguished from two related concepts (Comrie, 1999), one is natural gender or sex, which is a matter of semantics and biology, and the other is the declensional class defining the forms that a noun has, that is, the morphology of the individual items which have no explicit meaning (Harris, 1991). The two categories of gender, masculine and feminine, are abstract; the inanimate noun assignment to these categories in principle is arbitrary and the animate noun gender assignment otherwise largely overlap with sex. Usually there is a correspondence such as the nouns referring to males have masculine gender meanwhile the nouns referring to females have feminine gender, nevertheless there are some exceptions like the epicene names (e.g., *persona*— person is invariably feminine regardless of the sex of its referent). For Harris (1991), in Spanish only exists a mark of gender, the feminine, because the masculine works as the generic gender. This author explains how gender is formed on three autonomous domains. The first domain is ‘sex’, a marker of semantic and biology; the second domain is ‘gender’, involved in syntax and necessary for concord, and the third one, ‘form class’, the morphology of individual lexical items. Moreover, he proposes three groups of gender words, the 'inner core', the 'outer core' and the 'residue'. The first two groups are the regular cases. The inner core contains the typical forms of word markers for masculine (-o) and for feminine (-a), in words of both animate and inanimate reference, such as *hijo/hija*— son, daughter, or *puerto/puerta*— harbour, door. Words in the outer core are those without word markers for gender, or an –e ending for syllabicity. There is no correlation between word marker and gender; masculine and feminine words are approximately the equal number, as well as words without a marked gender; some examples are *padre/madre*— father, mother, and *mar/serpiente*-- *s*ea (masculine or feminine), snake (feminine). The residue collects all the irregular cases, that is, all the words not included in the core, like masculine words ended in –a or other desinences, such as *poeta/mano*— poet (masculine), hand (feminine), or *tribu*— tribe (feminine).

According to the research done in the linguistic field, independently of the type of gender (arbitrary or semantic), the gender feature needs to be specified in the lexicon as part of the information which enables each lexical piece (Carstens, 2000; Harris, 1991; Ritter, 1991; Roca, 2005), but how is gender really processed by speakers and listeners? There is an extensive psycholinguistic approach regarding gender processing which will be enlightened in the following section.

Psycholinguistics

There are a lot of psychological studies trying to explore how the grammatical gender is represented and selected by the mental lexicon, whether the gender information is part of the lexical information, and if the grammatical gender is part of the semantic meaning of the words. Most of the prominent models of language production agree that grammatical gender is represented as a property of nouns stored at a different level from those specifying conceptual and phonological information, such as the one presented by Caramazza and Miozzo (1997) called the Independent Network (IN) model. In the framework of the IN model, the selection of a noun's grammatical gender is automatic, a non-competitive process that follows the selection of the lexical form node. It claims that in order to correctly perform syntactic operations involving gender information is necessary the recovery of the surface from of a noun, that is the morphology related to gender which is available at the same time as the semantic representation. In contrast to the IN model, Levelt, Roelofs, and Meyer (1999) proposed the model WEAVER++ (Word-form Encoding by Activation and VERification) which claims that the linguistic information is processed in a strictly serial way, from conceptual-semantic nodes via lexical-syntactic nodes to word form representations. According to the WEAVER++ model, the connections between conceptual-semantic nodes and lexical nodes are bidirectional, thus allowing for feedback from lexical nodes to conceptual-semantic representations. In this model, the gender is an abstract information collected in a node at the lemma level, the one which mediates between the conceptual and the phonological information and the gender node is only selected but not activated when nouns have to be produced in isolation.

Opposite to the hierarchize models of language production, the more recent models propose a more flexible access to the grammatical gender feature. For instance, Gollan and Frost (2001) propose a dual route model of gender processing in which two separate mechanisms for accessing gender information are available; the first route derives gender from its correlation with gender marking at the level of the morphology, and the second route incorporates an abstract representation of grammatical gender, situated at the lexical level. According to this model, when the two sources of information coincide, nouns are accessed more quickly and accurately; on the contrary, the presence of a conflict between the two sources of information inhibits the lexical processing of nouns. An other example of recent models of grammatical gender processing during production is the one proposed by Duràn and Pillon (2011), which suggests that there is a top-down and bottom-up influences of several levels, such as the level of activation of a category node (like the node for nouns) could influence the activation and selection of a lexical node with bidirectional links between lexical and category nodes. Furthermore, the increased level of activation of a grammatical category node such as gender might facilitate either the selection of the category-specific morphophonological processes or the retrieval of category-specific morphemes of gender. Due to the great number of models, several psychological studies tried to explore how the proposed architectures fitted best.

Otherwise, Cubelli, Lotto, Paolieri, Girelli, and Job (2005) consider that in order to produce a given noun, is necessary to activate both the corresponding lexical-semantic and lexical-syntactic representations, prior the selection of the phonological form. In this proposal, the grammatical gender is stored at the lexical level, that is, it is a lexical property and its selection is mandatory even in bare noun production, at least in Italian and in languages with similar morphological structure like Spanish (Paolieri, Lotto, Morales, Bajo, Cubelli, & Job, 2010).

There have been many attempts to explore when the activation of grammatical gender takes part in production; the most common task used for this propose is the picture-word interference paradigm (Rosinski, Golinkoff, & Kukish, 1975). In this task, participants are

required to name a picture while ignoring a distracter word printed on it with the same or different gender than the target word (the picture). The available data with Romance languages (Italian, French and Spanish) points to the grammatical gender as an intrinsic lexical property which effects can be detected with single or bare nouns production and it is not a pure syntactic feature to be processed only in noun phrase production (Cubelli et al., 2005; Paolieri et al., 2010; Paolieri, Loto, Leoncini, Cubelli, & Job, 2011). Furthermore, other tasks also were used to demonstrate that gender is a lexical property whose selection is mandatory during production to cite some instance with a picture naming task with added interference (Alario, Ayora, Costa, & Melinger, 2008), a reading aloud task (De Martino, Bracco, & Laudanna, 2011) and a word repetition task (Bates, Devescovi, Pizzamiglio, D'Amico, & Hernandez, 1995 for Italian). In addition, Ganushchak, Christoffels, and Schiller (2011) performed a review of different studies of word production using event related potentials (ERP) and summarized that the brain engages in lexical selection around 200 ms after picture onset (e.g., Aristei, Melinger, & Abdel Rahman, 2011; Costa Strijkers, Martin, & Thierry, 2009; Hirschfeld, Jansma, Bölte, & Zwitserlood, 2008; Strijkers, Costa, & Thierry, 2010), phonological encoding between 275 and 400 ms (Eulitz, Hauk, & Cohen, 2000), and morphological processes starting around 350 ms after the picture onset (Koester & Schiller, 2008). Actually, the use of electrophysiological techniques for studying the phenomenon of word production have mainly focused on the lexical access (Aristei et al., 2011; Costa et al., 2009; Dell'Acqua et al., 2010; Hirschfeld et al., 2008; Strijkers et al., 2010) even though to our knowledge, there are not electrophysiological studies exploring explicitly the grammatical gender during language production.

As well as in production, several models try to account for the gender selection during language comprehension. There are some classical studies exploring the role of grammatical gender on lexical processing behaviorally. For example, Colé and Segui (1994) designed a lexical decision study in French to explore the role of grammatical congruency on lexical decision times; along three experiments with a double lexical decision task and two primed lexical decision tasks found that the when the two words (presented at the same time or one priming the other) were in full grammatical agreement, thus, agreed in gender and number, were associated to faster lexical decision times. Much the same, there is a study performed in

Italian to explore whether the orthographic-phonological information about grammatical gender, that is, whether the desinence of gender is transparent or irregular, influences the processing of bare nouns (De Martino et al., 2011). They employed three tasks with different attentional levels of access to the grammatical gender feature, a reading aloud task and a lexical decision that did not require any proper decision about the grammatical gender of the nouns, and an on-line inflection task, for which the access to the grammatical gender feature is mandatory in order to produce the plural form of a noun presented in the singular from, or vice versa. The results showed that actually, the transparent nouns were processed faster in comparison to the irregular nouns because the way grammatical gender morpho-phonologically is expressed influence the pure lexical processing. Looking for the importance of the morphology, Meunier, Seigneuric, and Spinelli (2005) found out that when the recognition of the gender of the words is morphologically complex, the gender decision task is achieved through the activation of the stem directly.

Apart from behavioral studies, some of the studies use electrophysiological techniques in order to explore the brain activity during language gender processing. The majority of ERP studies are mainly focused on agreement process (Barber & Carreiras, 2005; Deutsch & Bentin, 2001; Friederici, 2002; Gunter, Friederici, & Schriefers, 2000; Hagoort & Brown, 1999; Osterhout, McLaughlin, Kim, Greenwald, & Inoue, 2004); the common theory that emerges from these studies is that gender is represented syntactically, and that the online processing of grammatical gender is not a conceptual and/or semantic, but a syntactically driven process. It is to be said that those effects are obtained regarding gender agreement in which grammatical gender takes an important role in the processing of the associated words and in the coherence of the sentence, therefore is needed to complete the syntactic context. Nonetheless, apart from helping to build the syntax relationship in the sentence, the grammatical gender is a lexical property of the nouns, and using different kinds of task for which bare nouns have to be processed, it is possible to have different results. In fact, Thierry, Cardebat, and Démonet, (2003) proposed that although sentence processing offers a ‘natural’ context for language presentation, the use of violations might reveal the neural correlates of error detection, attentional shifts and repair processes rather than those relating to the targeted psycholinguistic processing. They designed a sequential processing task in which participants

had to decide whether two words presented sequentially in isolation belonged to the target category presented; the target category was related to semantic judgement about natural or artifacts categories (i.e., “two natural objects”) or to grammatical gender judgment about masculine or feminine categories (i.e., “two feminine nouns”). The ERP was observed in two conditions, the release condition derived the first noun judgement and the hold condition, derived from the second noun judgment. In general, the behavioral results showed that the response times (RT) were faster for gender release and that the completion for gender categorization occurred earlier compared to semantic release, although the accuracy was higher for the semantic release. Whats more, the onset of the ERP response derived from the semantic information was available 80 ms before the grammatical gender information, suggesting that semantic information is processed earlier but recovered later than the grammatical gender analysis, maybe because it is a more complex processing and it requires access to other types of lexical information during word comprehension. Other authors such as Müller and Hagoort, (2006) used two different tasks to explore the processing of semantic information as well as the processing of grammatical gender information; in their experiment, Dutch participants saw nouns on a computer screen and performed push-button responses. In one task, grammatical gender determined response hand (left/right) and semantic category determined response execution (go/no-go). In the other task, response hand depended on semantic category, whereas response execution depended on gender. The results showed that there was a measurable time difference in the availability of semantic category and grammatical gender information, being the information about semantic categories of visually presented words available earlier than their grammatical gender properties. This excludes a serial discrete architecture where first retrieval of syntactic information has to finish before retrieval of semantic information can begin, and the results seems to proof the existence of a serial discrete system with retrieval of semantics before syntax as well as for a parallel system, with semantic retrieval being faster than syntactic retrieval. More over, in a very similar task, Schiller, Schuhmann, Neyndorff, and Jansma (2006) found that the semantic information can prime the syntactic decisions (Friederici & Jacobsen, 1999), postulating than when a group of semantic members share some syntactic features such as grammatical gender, the syntactic nodes are primed by the mere exposition to these specific semantic group.

To sum up, the psycholinguistic studies conclude that the grammatical gender is a lexical feature selected in bare noun production, that in comprehension precedes and it is affected by the retrieval of semantic information and its access is also possible via the morphological cues. Thereupon, we will explore the neural basis of the grammatical gender processing introducing some neuropsychological studies.

Neuropsychology

Establishing the neural basis of the processing of gender has produced many research in the field by using different neuroimage techniques, as well as the study of patients with linguistics impairments. In 2003, the journal Cortex published a special number called "the neuropsychology of grammatical gender", introduced by Cacciari and Cubelli, where the following original research works were presented. Paganelli, Vigliocco, Vinson, Siri, and Cappa (2003) found that Alzheimer patients did not show a gender congruency effect because they failed to retrieve the concept with their syntactic representations. Friedman and Biran (2003) exposed that the tip-of-the-tong states reflex that the participant access to partial knowledge about the word such as the grammatical gender in languages like Italian, Dutch, Arabic and Spanish, because gender is accessed at an early stage (see also Vigliocco, Antonini, & Garrett, 1997, and Cuntrín & Vigliocco, 2007); in contrast, the authors failed to find the same effect with Hebrew-speaking aphasics, because Hebrew incorporates the gender at a late stage and is only accessed if the noun is involved in agreement; the same authors (Biran & Friedman; 2012) also proposed that the lexical-syntactic information is stored individually in a different node than the semantic lexicon. Bastiaanse, Jonkers, Ruigendijk, and Van Zonneveld (2003) showed that agrammatism is a deficit in syntactic processing that follows Broca's aphasia, and is not related to morpho-lexical impairment. Using a lexical decision paradigm with aphasic patients speakers, Perlak and Jarema (2003) found that gender is in fact retrieved at the moment of lexical access being an intrinsic property of nouns. Barber and Carreiras (2003) found that the grammatical gender could be retrieved at the moment of lexical access and also at the moment of syntactic integration when an inconsistency appeared (see also Barber & Carreiras, 2005). Finally, Wicha, Moreno, and

Kutas (2003) discovered that the context could create expectation about a word's grammatical gender using ERP (see also Wicha, Moreno, & Kutas, 2004). Furthermore, the grammatical gender can be accessed by two different routes, depending on the transparency of the desinence (morphological ending) of each word (Caffarra, Janssen, & Barber, 2014; Caffarra, Siyanova-Chanturia, Pesciarelli, Vespignani, & Cacciari, 2015; Hernández et al., 2004; Padovani, Calandra-Buonaura, Cacciari, Benuzzi, & Nichello, 2005), as the dual route model proposed (Gollan & Frost, 2001), a lexical route which retrieves grammatical properties stored in the lexicon without reliance on formal cues, and a form-based route that takes advantage of sub-lexical units strongly related to a specific grammatical class.

To sum up, according to the neuropsychology data, it seems that in Romance languages the grammatical gender is accessed at an early stage, that is, when the lexical access takes part because is stored at the lexical level as part of the noun representation although it exists an alternative route based on the form of the desinence closer to the syntactic features to recover the grammatical gender. But how does the grammatical gender interact with the meaning of the words? How is the relationship between the lexical level and the semantic level?

Grammatical Gender and Semantics

As it was exposed above, all gender systems have semantic gender assignment that makes reference at least at the nouns representing humans. The grammatical gender appears as a need to distinguish between male and female groups according to biological sex (Arias, 1990) and there is an extended rule in Romance languages which have two genders that claims that the male entities are assigned a masculine gender meanwhile the female entities are assigned a feminine gender although there exists some exceptions. The epicene names for instance represent animate or biologically sexed entities but have an invariable grammatical gender assignment; by a way of illustration, the Spanish word *jirafa* FEM— giraffe is a feminine word and designates either male or female giraffes. Regarding the interaction between the biological sex and the gender assignment there is a developmental hypothesis called the sex and gender hypothesis (Vigliocco, Vinson, Paganelli, & Dworzynski, 2005) by

which children first associate the name of the human referents with the different genders (masculine for males, and feminine for females), and then they extend the distinction to other biological entities, that is, animals. In a less constraint version of this hypothesis, people end up extending the male and female-like conceptual properties to inanimate objects referred by with masculine or feminine nouns, that is, if people associate the gender of the nouns with the conceptual features establishing the difference between males and females, the different grammatical gender labels (masculine, feminine) will link together concepts related (i.e., *chica*— girl - *abuela* FEM— grandmother) and unrelated to biological sex (*chica* FEM— girl - *falda* FEM— skirt). In fact, many studies have attempted to explore whether the nature of the grammatical gender, which appears as a need to represent in language the difference between male and female entities, is extended to the conceptual representation of the arbitrary words, especially in Spanish (Boroditsky, Schmidt, & Phillips, 2003; Boutonnet, Athanasopoulos, & Thierry, 2012; Flaherty, 2001; Forbes, Poulin-Dubois, Rivero, & Sera, 2008; Konishi, 1993; Martinez & Shatz, 1996; Sera, Berge, & del Castillo Pintado, 1994). These studies concluded that the grammatical gender feature is represented at the lexical level and appears to have partial effects at the semantic level.

It is interesting to look for the effect of grammatical gender on categorization with young children because the effect might be due to an implicit knowledge derived from language use, meanwhile the adults could be using an explicit strategy based on acquired metalinguistic competence (Belacchi & Cubelli, 2012). In fact, several studies demonstrated that that children can use grammatical gender for categorization (Flaherty, 2001; Martinez & Shartz, 1996; Sera et al. 1994, 2002; Seigneuric, Zagar, Meunier, & Spinelli, 2007). Specifically, Bellacchi and Cubelli (2012) found that adults and pre-school children tended to classify epicene animals (which design both males and females and do not specify the biological sex of the referent, such as *pantera* —FEM, panther) according to their grammatical gender, suggesting that linguistic cues for grammatical gender influence semantic judgments (Cubelli et al. 2011). In a study using similarity judgements and substitution errors tasks in Italian adults, Vigliocco et al., (2005) showed that the sex of the referent and the given gender to the word influences the concept structure, what is an evidence of a link between sex and gender dimensions. In addition, Cubelli et al., (2011) used categorization judgments as well

as Vigliocco et al. (2005). For the task, the participants had to judge whether the two presented pictures belonged to the same semantic category; half of the pairs shared the grammatical gender feature meanwhile the other half of pairs were composed of incongruent grammatical gender pairs. Both Italian and Spanish monolingual speakers showed a main effect of semantic relatedness (i.e., faster responses to semantically congruent pairs) and a gender congruity effect, that is, faster responses to the congruent pairs for gender were given in comparison to the incongruent pairs. However, the gender congruity effect disappeared when the participants had to perform an articulatory suppression task (repeat continuously "bla bla bla") at the same time as the judgment task; in this case, the semantic relatedness effect remained but the gender effect disappeared. It seems that the grammatical gender does not take part of the semantic representation but rather it is accessed spontaneously, and the lexico-syntactic cues when accessed influence the semantic processing. Likewise, Vuksanović, Bjekić, & Radivojević (2015) found that when participants had to describe pseudowords describing musical instruments with adjectives previously related to male or female gender, in the absence of other information, grammatical gender dominantly shaped the way participants formed concepts about musical instruments. This confirms the existence of a relationship between the lexical-grammatical properties of each particular language and the semantic processing. Besides, Boutonnet et al. (2012) using an ERP design found that Spanish-English bilinguals only exposed to English language showed a gender consistency effect in a free classification task (where picture triads were presented and the participants had to decide which two out of the three were more similar), although the effect did not manifest itself behaviorally, the results indicate that the grammatical gender information can affect the semantic processing, even when it is not explicitly required (Strijkers, Holcomb, & Costa, 2011).

In conclusion, the available data shows that semantic features of objects are spontaneously retrieved together with semantically irrelevant information such as grammatical gender (Friederici & Jacobsen, 1999; Schiller et al., 2006) and this information likely contributes to participants' mental representations of these objects (Lupyan, 2012). As a matter of fact, there is a direct link between the biological sex and the grammatical gender assignment for the semantically gendered nouns that contribute to the conceptual

organization of masculine words as related to the male concept, and the feminine words as related to the female concept; this categorization seems extended to arbitrarily gendered words with the grammatical gender becoming a semantic classifier (Saalbach & Imai, 2007).

Interestingly, there is a special group of words that have purely arbitrary gender but are associated to male and female figures, known as stereotypical words. These words have an assigned grammatical gender that can match the stereotypical gender (such as *falda* FEM— skirt, associated to females) or mismatch the stereotypical gender (i.e., *corbata* FEM— tie, associated to males). The stereotypical gender is an implicit knowledge which includes cognitive representations associated to male or female roles, and are emotionally relevant (Norris, Chen, Zhu, Small, & Cacioppo, 2004), and even they could change depending on the experience, the stereotypical gender is typically incorporated into the mental representations and it is difficult to suppress (Oakhill, Garnham, & Reynolds, 2005). There have been many attempts to explore the role of the stereotype using semantically gendered words, specifically role-nouns or contextual sentences in formal gender system languages and the results have shown that the stereotype knowledge is available at very early stages of processing and that the associated gender stereotype interacts with other gender information such as the grammatical gender (Cacciari & Padovani, 2007; Carreiras, Garnham, Oakhill, & Cain, 1996; Esaulova, Reali, & von Stockhausen, 2014; Gygax, Gabriel, Sarrasin, Oakhill, & Garnham, 2008; Molinaro, Su, & Carreiras, 2016; Oakhill et al., 2005; Reali, Esaulova, & Von Stockhausen, 2015). Moreover, according to Molinaro et al. (2016), the stereotypical gender have a stronger weight compared to the grammatical gender and it overrides its processing, because the stereotypical gender is directly linked to the noun's mental representation (Cacciari & Padovani, 2007) in a similar way as the biological gender, meanwhile the grammatical gender link to the sex roles is more secondary.

To sum up, gender is an important cognitive category that in language represents the sex concept, that gathers the distinction between male and female groups. It could be expressed by various means such as biological gender (men/women), grammatical gender (masculine/feminine), and stereotypical gender (semantics associations to the male or female roles) (Irmen, Holt, & Weisbrod, 2010); in any case, the semantic representation of sex is

associated to the given gender and both categories interact, with different strength according to the type of gender.

The Role of the Sex of the Addressee

During this section, we are going to explore the role of the sex of the addressee, that is, whether the listener, the reader, or in general the person receiving the message when processing grammatically gendered words is a men or a woman. The person receiving the message always does it inside a determinate context that may influence the words' processing. The concepts represented by words are stored and organized within the individual's lexical representation, also known as the mental lexicon. Every word in the lexicon is represented by connected assemblies of cortical neurons, which are known as memory traces (Pulvermüller et al., 2001; Pulvermüller, Shtyrov, Kujala, & Näätänen, 2004); the activation speed and magnitude of the memory traces depends on the strength of the connection within each network, determined by everyday language use. Following this rationale, each person will have specific representations of concepts that are different from those of other people due to their own personal experiences, therefore, the previous knowledge the listener has stored, can influence how he or she processes language (Barsalou, 2008; Wilson, 2002). In particular, the acquisition of sex role knowledge appears during the third year of life (Weinraub et al., 1984), which comes together with gender labeling (classifying people into sex groups) and gender identity (the inclusion of her/himself into a specific sex group), and can be observed in children as young as 2 years old. Moreover, as Belacchi and Cubelli (2012) summarized, children acquire the notion of biological gender around the age of 2 and a half years (Fagot, Leinbach, & Hagan, 1986) and the ability to recognize the invariance of gender identity between the age of 5 and 7 years old (Wehren & De Lisi, 1983). What's more, when children learn to speak with a gendered language, such as Hebrew, they are able to recognize their own and other sexual identities earlier than children learning languages with no gender, such as English or Finnish (Guiora, Beit-Hallahmi, Fried, & Yoder, 1982).

Bem (1983) proposed the gender schema theory, according to which children use the information about the sex role to create the self-concept. The sexual classification of the world, that is, sex typing, derives in from gender-schematic processing, from a generalized readiness on the part of the child to encode and to organize information, including information about the self, according to the culture's definitions of maleness and femaleness. Like cognitive-developmental theory, then, gender schema theory proposes that sex typing is mediated by the child's own cognitive processing. However, gender schema theory further proposes that gender-schematic processing is itself derived from the sex-differentiated practices of the social community. Thus, like social learning theory, gender schema theory assumes that sex typing is a learned phenomenon and, hence, that it is neither inevitable nor unmodifiable. As a result, people organize part of their world around the learned sexual distinction between male and female categories. Furthermore, certain types of experiences are shared between members of the same group or community. For example, the inclusion of people in sex groups is similar among males and females who share the sex role identification, and the people who share the sex role may have the same kind of experiences such as the use of language, that lead to a similar representation of concepts. On the whole, it seems that on the one hand the language system can modulate the way people categorize sex information and on the other hand, concept organization may depend on the sex role such as the people whose sex role is female, will have more similar life experiences among them.

Similarly, sex information is used to discriminate other conceptual representations that primarily have no direct relationship with the purely biological sex, such as the sex role stereotypes (Cacciari & Padovani, 2007; Kreiner, Sturt, & Garrod, 2008; Ma & Woolley, 2013; Siyanova-Chanturia, Pesciarelli, & Cacciari, 2012); for instance, Osterhout, Bersick, and McLaughlin, (1997) studied whether for the sex role stereotypical gender there were differences between male and female participants during anaphors processing using ERP. Specifically, they showed that the female participants of their study had a larger P600 component when processing definitional and stereotypical gender violations compared to male participants. The sex of the listener has also been studied during the processing of grammatical gender (Andonova, D'Amico, Devescovi, & Bates, 2004). In particular, Andonova et al. (2004) studied the influence of the listeners' sex on the processing of

gendered words presented aurally, that is, whether male and female listeners had different ways of processing gendered words in Bulgarian, a language with three categories of gender (masculine, feminine and neuter). They used a word repetition task where the participants had to repeat the word they heard and a gender decision task in which the participants had to decide the grammatical gender of words. The findings in the gender decision task showed a facilitation of the selection of the grammatical gender when there was a match between the sex of the listener and the gender of the word. Furthermore, the authors carried out a reanalysis of the data of another study that used the same methodology, but conducted in Italian (Bates et al., 1995) and found the same pattern of results. They suggested that people are more accustomed to producing words in the first person and listening to words in the second and third person belonging to their own gender, and this fact enhances the salience of words related to their own gender in comparison with words related to the opposite gender. It seems that the grammatical gender is encoded as related to the sex concept but also to the biological sex of the listener processing the noun (Belacchi & Cubelli, 2012). In that way, the listeners will have specific memory traces (Pulvermüller et al., 2001; Pulvermüller et al., 2004) for the sex concept, which depends primarily on their own sex role group (Bem, 1983); that certain types of experiences are shared between members of the same group or community such as the personal identification with a certain sex role (male or female), what makes the people included in such groups (male sex role vs female sex role) to have a similar representation of the concept of sex. When a person classifies herself into the female group, the memory traces of feminine words would be more strongly connected than the masculine words due to the frequent use of words related to the self-sex (see Andonova et al., 2004) creating particular linguistic processing for the grammatical gender.

Apart form the grammatical gender processing, the sex of the addressee can also modulate how people process voices or faces of their own sex or of the opposite sex, that is, depending on the sex of the addressee, the voices or faces of the two sex groups (males and females) will be processed differently. The behavioral studies reviewing differences between sexes (women and men) while processing the sex of the speaker are classical. There is a key study carried by Lee, Liao, and Ryu (2007) into the topic in which children from 5th-grade elementary school had to listen to several passages talking about a new topic said with a

synthetic voice created by the computer simulating a male or female speaker. After, they had to evaluate how much had they learned and some questions about the voice. The experimental design was made to evaluate the gender matches between the gender of the participant, the gender of the synthetic voice and the stereotypical gender associated with the content of the passage. Results showed that children apply gender-based social rules to synthesized speech, as the gender schema theory proposes (Bem, 1983). More specifically, children evaluated synthesized speech more positively, trusted the speech more, and learned more effectively when voice gender matches either content gender (consistency attraction) or their own gender (similarity attraction). Other behavioral studies exploring the influence of the sex of the listener when processing voices of different sex are those presented by Coleman (1978) and by Wilding and Cook (2000); the first one found that when the fundamental frequency (F0, the main acoustical feature to disentangle the sex of the speaker) was ambiguous, female listeners tended to classify those voices as male voices. The second study carried by Wilding and Cook (2000), who studied the interaction between the sex of the listener and the sex of the speaker in a recognition task, showed that women were better than male identifying female voices. The more recent studies are based on neuroimage techniques; in particular, Li et al. (2014) performed two ERP experiments to explore the processing of opposite-sex voices compared to same-sex voices regarding the sex of the listener. In the first experiment, the participants had to indicate the sex of speakers producing a Chinese monosyllabic word (/hie4/, hey). They found that the ERP amplitude of a positive deflection elicited by the opposite sex voices was stronger than that to the same-sex voices over parieto-occipital recording sites around 750 ms after the voice onset. In their second experiment during which participants were not require to pay attention to the sex of the speaker but to a pure tone intercalated among the repeated presentation of the mono-syllabic word. In the latter case, no significant ERP differences were found for the opposite sex voices as compared to the same-sex voices. Similarly to the first experiment in the study by Li et al. (2014), Junger et al., (2013) used a task in which participants were asked to indicate the sex of the speakers during the listening of words. By designing a functional magnetic resonance imaging (fRMI) experiment, they found stronger activation in a fronto-temporal network in response to voices of the opposite sex compared to voices of the same sex. Sokhi, Hunter, Wilkinson, and Woodruff, (2005) also used fMRI with a gender attribution task in a group of

male participants. They found that the perception of male and female voices activated different brain regions; specifically, the perception of female voices created a greater activation of the right anterior superior temporal gyrus, near the superior temporal sulcus meanwhile the male voice perception activated the mesio-parietal precuneus area. More over, Proverbio, Riva, Martin, and Zani (2010) found that the neural markers of opposite-sex vs. same-sex bias in face processing included larger and earlier centro–parietal N400 in response to faces of the opposite sex and a larger late positivity to same-sex faces.

In short, the results from these studies showed a greater activation at brain level when voices or faces of the opposite sex were presented in comparison to the processing of voices belonging to the addressees' sex group. On the whole, it appears that the sex of the listener influences the categorization of gendered words as well as the processing of male and female voices.

The Role of Sex of the Speaker

The human voice is the main and oldest transport of language; it is the most important sound of our environment, and probably the most heard sound along our lives. Consequently, our brain is prepared to process voice sounds in a specific way. In fact, the brain organizes a neuronal ensemble activated selectively with vocal sounds (having or not semantic information) situated in the "Temporal Voice Areas" (TVA) along the anterior and medial Superior Temporal Sulcus and Superior Temporal Gyrus in both hemispheres (Belin, Bestelmeyer, Latinus, & Watson, 2011). In addition, there is a "voice-sensitive response" which appears only in the presence of vocal sounds compared to other natural sounds that can be recorded by electrophysiological techniques (Charest, Pernet, Crabbe, & Belin, 2009).

Speech is a multifaceted process, that is, several processes are activated in relation to the vocal speech signal. The first one is the no-linguistic stream of process, that is, when hearing a vocal speech sound we can extract information about the speaker physical features even when the language is not the same, even when hearing just vocal sounds, no-linguistic utterances or whispered sounds. We can identify the source producing the sound even when

we cannot see it. The second one is the linguistic stream of process, where the meaning of the linguistic elements and the prosodic elements are extracted. The no-linguistic process is complex and needs different subprocesses. When the air goes through the vocal cords of the larynx produces a vibration on the cords, resulting in a complex sound composed by a fundamental frequency which depends on the length and the thickness of the cords. In addition, this basic sound reverberate along the superior cavities —pharyngeal, nasal and oral —, gathering the sound's energy in some frequency bands, resulting in the formants (F1, F2, F3…). Analyzing these parameters we could make two different analyses, a voice acoustic analysis and a voice identity analysis. That is, we can just process the general acoustic features such as the fundamental frequency, formant frequency, and then use these informations to extract speaker features such as the sex of the speaker, the average age, weight and height, even his race (Bishop & Keating, 2012; Fellowes, Remez, & Rubin, 1997; Honorof & Whalen, 2010; Kovačić & Balaban, 2009; Lass & Davis, 1976; Lass et al., 1976; Lattner & Friederici, 2003; Lattner, Meyer, & Friederici, 2005; Mullennix et al., 1995; Murry & Singh, 1980; Owren, Berkowitz, & Bachorowski, 2007; Perry, Ohde, & Ashmed, 2001; Van Dommelen & Moxness, 1995; Von Kriegstein et al., 2006; Whiteside, 1998). We can also make another identification process, that is, recognize whether the speaker is a familiar person, a famous one, or either we are hearing our own voice (Belin et al., 2011; Burton & Bonner, 2004; Kaplan, Aziz-Zadeh, Uddin, & Iacoboni, 2008; Nakamura et al., 2001; Rosa, Lassonde, Pinard, Keenan, & Belin 2008; Skuk & Schweinberger, 2013). Essentially, apart from the linguistic information, the voice carries information about the physical features and emotional states of the speaker. In some way, the voice works as an "auditory face". Each speaker has his own specific acoustic features marked by his vocal system; nevertheless, in the majority of social communicative interactions, the auditory and visual information are presented together. From these modalities, the key elements to pursue the identification of the speaker are the voice and the face; the integration of the two sources leads to an advantage of processing and to avoid the redundant information and maximize the gathered information (Campanella & Belin, 2007). The model of people identification through voice proposed by Belin, Fecteau, and Bedard (2004) is inspired in the Bruce and Young model (1986) for the face processing, and take into account the interaction between the auditory and visual information (see Figure 1). Furthermore, González et al., (2011) using electrophysiological

techniques, have found that the integration of the information from the two modalities, voice and face, is made from the first stages of processing (voice and face recognition units) until the person identity nodes (PIN), as Belin et al. (2011) predicted in their model.

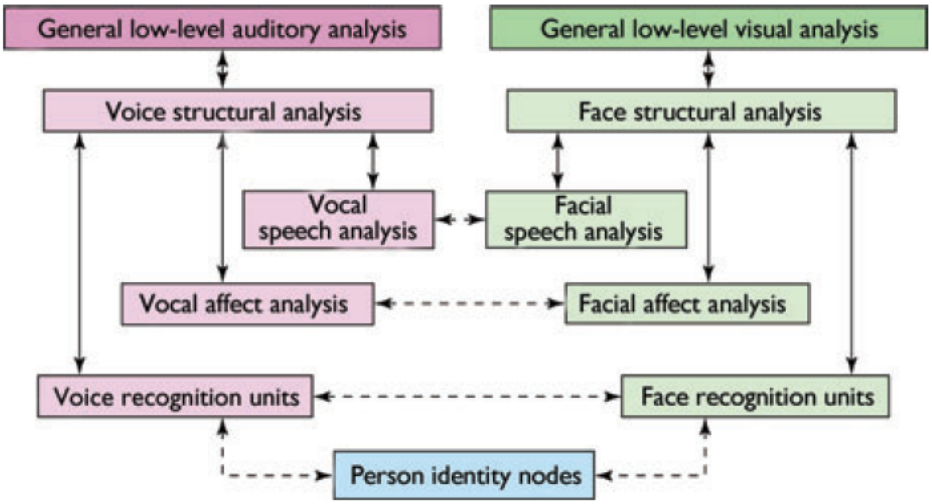

Figure 1. Belin, Fecteau, and Bedard (2004) voice perception model. The vocal information processing is dissociated in three independent systems: the semantic system, the emotional system and the identity system. Those systems are always interacting with their homologous of the face processing. In the figure the main cerebral structures of the processing phases are also represented.

There have been several studies trying to answer when and where the gender identification from voice gender takes part. For instance, Latinus and Taylor (2012) studied the discrimination of male and female voices processing using ERP in order to find out when the pitch and the gender discrimination take part. They conclude that pitch processing (F0 cues) starts very early and it is modulated by attention; the resulting component is the N1, a negative deflection that appears around 100 ms after the stimulus onset. Nonetheless, the specific gender processing of voices occurs around 200 ms, as the P2 component indicates with a positive wave. Apart from ERP data, there is also another study using fMRI in order to determine where the gender of the speaker was processed by auditory modality and a mix; Joassin, Maurage, and Campanella (2011) found that when judging the sex the speaker from the voice, several areas were activated, such as the left and right superior temporal gyrus, the right inferior frontal gyrus and the bilateral regions of the cerebellum.

The information about the sex of the speaker may be accessed almost at the same time as the meaning of the linguistic elements and both kind of information can be integrated at early stages of processing (Belin et al., 2004; Belin et al., 2011). Lattner and Friederici (2003) investigated the influence of speaker information on the sentence interpretation; they presented sentences stereotypically related to men (e.g., 'I like to play soccer') and stereotypically related to women (e.g., 'I like to use make-up') spoken by male and female speakers, creating congruent and incongruent conditions regarding the stereotypical information and the sex of the speaker. The ERP results exhibited a P600 for the incongruent condition for listeners of both sexes. Similarly, Van Berkum, Van den Brink, Tesink, Kos, and Hagoort (2008) used ERP in order to explore how listener reacted to social stereotypes with utterances whose content sometimes did not match inferences based on the identity of the speaker (e.g., 'If only I looked like Britney Spears' in a male voice, or 'I have a large tattoo on my back' spoken with an upper-class accent). They found that the information about the speaker's identity is available at 200–300 ms after the onset of a spoken word; listeners rapidly classify speakers on the basis of their voices and activate the associated social stereotypes. Furthermore, Brunellière and Soto-Faraco (2013) found that the regional accent influenced the computation of the linguistic information, leading to modulate the incoming lexical and semantic processing. These ERP experiments showed that the indexical information about the speaker and the meaning of the linguistic elements are accessed nearly at the same time (Belin et al., 2004, Belin et al., 2011) and are integrated at early stages of processing (Lattner & Friederici, 2003; Van Berkum et al., 2008), and that the contextual information coming from the indexical information can constrain the lexical and the semantic processing (Brunellière & Soto-Faraco, 2013; Van Berkum et al., 2008). More over, there is a series of experiments using the stroop paradigm in the auditory modality (Christensen, Lockwood, Almryde, & Plante, 2011; Gregg & Purdy, 2007; Haupt, Axmacher, Cohen, Elger, & Fell, 2009; Most, Sorber, & Cunningham, 2007) in which a male or a female speaker produced some stereotypical words from the associated to masculine stereotype (football) or associated to the feminine stereotype (doll), and the participants had to pay attention to the sex of the voice or to the gender of the word. For instance, Gregg and Purdy (2007) found that when there were congruency between the sex of the speaker and the gender of the word, the participants performed the stroop task faster compared to when there was a mismatch in

both conditions. Albeit, they found that there was a gradient of relation power between these gender variables by which the more semantic content the words had, the most influenced by the sex of the speaker was. Following a similar rationale, in a behavioral study it was tested specifically whether the sex of the speaker could influence the grammatical processing instead of the stereotypical gender. Vitevitch, Sereno, Jongman, and Goldstein (2013) used a gender decision task during which participants heard grammatically masculine and feminine Spanish words, and they were required to decide the gender of the word they heard. The words were mostly arbitrary gendered (73 arbitrary and 7 semantically gendered) and were presented by a male or a female speaker. The results showed that when there was a match between the sex of the speaker and the gender of the word, participants produced faster and more accurate responses than when there was a mismatch between the sex of the speaker and the grammatical gender of the word. It is to be reminded that the majority of the presented words referred to inanimate entities and the gender assignment was not related to sex. Therefore, they interpreted their results as the acoustic information about the sex of the speaker influencing the processing of high-level information related to the gender feature per se. In the same way as inferences driven by the features of voice influences the processing of the upcoming words (Brunellière & Soto-Faraco, 2013; Van Berkum et al., 2008), during the activation and the selection of lexical candidates, the sex of the speaker seems to bias the access to words that vary in gender, such that when the information is said by a female speaker the feminine words are more activated, as compared to the masculine words.

Aims and Organization of the Experimental Section

The aim of the present dissertation is to explore the interaction between sex and grammatical gender. The two dimensions are closely related in Romance languages, such as the gender is used to represent sex and this relation is further extended to concepts whose grammatical gender assignment is arbitrary (Boutonnet et al., 2012; Cubelli et al., 2011; Vigliocco et al., 2005; Vuksanović et al., 2014). It seems that the grammatical gender feature is stored at the lexical level and it can be retrieved in bare noun production as well as during the processing of isolated words (Cubelli et al., 2011). Furthermore, the processing of the grammatical gender could be influenced by the semantic information carried by the nouns;

the semantic information is accessed before the lexico-syntatic information (like the grammatical feature), and when a group of words that share the semantic meaning and agree in a given lexico-syntactic feature, the exposition to the specific semantic group of words will prime the shared lexico-syntatic feature (Schiller et al., 2006); in that case, if a group words share a semantic feature, for example, “able to give birth” as in the case of the words “mother, woman, female”, they usually share as well other lexico-syntactic features such as “feminine grammatical gender”. In addition, the grammatical gender can work as a semantic classifier of conceptual categorization (Saalbach & Imai, 2007) what means that people use the grammatical gender distinction to organize and categorize concepts, according to the culture's definitions of maleness and femaleness and to the representation of their own sex role (Bem, 1983); the words that share the grammatical gender feature with the sex of the addressee (listener or reader) will be strongly activated and its access will be easy as compared with the words of the opposite gender (Andonova et al., 2004). The sex of the addressee could also modulate the way people process the information given by speakers which belongs to the same sex group or to the opposite sex group (Junger et al., 2013; Li et al., 2014; Proverbio et al., 2010; Sokhi et al., 2005). Moreover, the sex of the speaker could modulate the access to gender information working as a context clue, such as the acoustic information about the sex of the speaker influence the processing of high-level information related to the gender feature (Van Berkum et al., 2008; Vitevitch et al., 2013).

Exploring the role of the agents’ sex (addressee and speaker) and the type of gender (sex related — biological/semantic gender—, sex stereotyped —stereotypical gender—, and sex unrelated —arbitrary gender—) on the processing of grammatically gendered words will allow us to study the interaction between sex and gender at different levels.

First of all, we will explore the influence of sex during the lexical retrieval of isolated words processing with semantic and arbitrary gender. Then, we will explore whether other kinds of sex information available during the processing of speech communication such as the sex of the listener and the sex of the speaker could influence the processing of gendered words. After that, we will study to what extent sex modulate the processing of a special group of words denominated stereotypically gendered words, which have an arbitrary grammatical

gender assignment, but are directly associated to male or female roles. Finally, using electrophysiological techniques we will see at brain level the impact of sex on gender processing.

The first Experimental Series (Experiments 1, 2 and 3) will explore the role of the sex of the speaker and the sex of the addressee when processing semantically and arbitrarily gendered Spanish words with three task in which the focus of attention on the gender feature changes. The first experiment includes a word repetition task in which the participants have to repeat the word they heard spoken by a male or by a female speaker; with this experiment we will explore whether the sex of the speaker and the sex of the participant influence the processing of the gender of the word in a task that has been shown to be sensitive to the index of semantic priming and which, in addition, requires limited metalinguistic reflection. In the second experiment, the participants have to perform a lexical decision task, in which they decide whether the stimulus presented is a word or a pseudo word. The task will be presented in the visual and in the auditory modalities; the first condition is called “comic”, and the words are presented visually written inside a speech bubble that joined a drawing of a figure of a man or a figure of a woman. The second condition is the auditory one, where the words are presented spoken by either a male or a female speaker. During the lexical decision task there is no need for higher-level access such as the grammatical gender feature in order to perform the task, what makes it a good task to explore the role of the agents’ sex on the grammatical gender processing when no direct attention to the gender feature is payed; moreover, comparing the comic and the auditory conditions we could explore whether the representation of the sex of the speaker is accessed similarly by the two sensory modalities, and whether the expected effects are shared by modalities. Finally, the third experiment is a gender decision task, in which participants will have to explicitly pay attention to the gender feature in order to decide whether the word is masculine or feminine gendered. The words are presented in the comic and in the auditory modalities. This task has been used before to explore the sex of the participant and the sex of the speaker separately (Andonova et al., 2005; Vitevitch et al., 2013); here we will explore jointly the two variables and see whether there is any interaction between them. Furthermore, we make an explicit distinction between the semantic and the arbitrary gender, and we will explore the weight of the agents’ sex

influence on the different kinds of gender. Besides, exploring different levels of linguistic processing let us see the strength of the bias produced by the sex dimension.

The second Experimental Series (Experiments 4, 5 and 6) are designed to explore the role of the agents' sex on a specific set of words denominated stereotypical gendered words, which have an arbitrary gender distinction but are associated to male or female roles. The stereotypical knowledge is considered to be part of the mental representation of a noun and thus to have a stronger influence compared with the grammatical gender regarding the sex feature. Like in Experiment 3, we designed a gender decision task in Spanish, which allow us to directly compare the relationship between stereotypical and grammatical gender, whilst analyzing separately the influence of the sex of the participant and the sex of the speaker on grammatical gender and stereotypical gender processing. We will conduct two gender decision tasks, the first of which (Experiment 4) used the visual modality in which the words appear written on the screen, in order to directly observe the interaction between stereotypical and grammatical gender without any clues about the sex of the speaker; the second (Experiment 5) will be conducted in the auditory modality in order to include the sex of the speaker as an independent variable. Furthermore, in order to explore whether the sex of the agent's effects appeared when no direct attention to the gender feature was payed, we designed a lexical decision task (Experiment 6), similar to the Experiment 2.

The last Experimental Series (Experiment 7) will explore the role of the sex of the speaker as well as the sex of the participant when unconsciously processing gendered French words. In a previous study, Boutonnet et al., (2012) reported that the grammatical gender was retrieved automatically and unconsciously as shown by the ERP effects rather than strategically and consciously during object categorization (the effect did not manifest itself behaviorally). With this study we want to make sure that the grammatical gender information and the sex of the agents are related by using EEG, a direct measure of the brain response where the gender effect has been shown before even the behavioral results were not reliable. For the present experiment, we will design an odd-ball paradigm, which is characterized by the presentation of sequences of repetitive stimuli (standard stimulus) that are infrequently interrupted by a deviant stimulus. The reaction of the participant to this "oddball" or deviant

stimulus is recorded by EEG and is supposed to induce a Mismatch Negativity (MMN) component. The MMN component derives from an oddball paradigm in which the critical stimulus is presented many times in a sequence, where a frequent so-called standard stimulus is randomly replaced by one or more rare deviant stimuli. The deviant stimulus elicits the MMN, which is calculated by subtracting the brain response of the standard from that of the deviant stimulus. It has a latency of 100–250 ms and a fronto-central maximum with major sources in superior-temporal cortex of both hemispheres (Näätänen, Gaillard, & Mäntysalo, 1978; Näätänen, Tervaniemi, Sussman, Paavilainen, & Winkler, 2001). The auditory stimuli selected for this study will be a masculine word (*chanteur* MAS— male singer) and a feminine word (*chanteuse* FEM— female singer) recorded by five different male speakers and by five different female speakers that will change the rate of presentation according to the different blocks. Whilst the sex of the speaker remains the same inside each block, the gender of the word is changing, being for instance the masculine word the standard stimuli (80% of presentations) and the feminine word the deviant stimuli (20% of presentations). The participants task is to listen to the sequence of auditory words while they watch a silent movie; in order to establish that the auditory processing is not totally conscious, the participants are asked to pay direct attention to the movie in order to answer some question after each essay. We will explore the reaction of the participants when the gender of the word changes and how the sex of the speaker influence the processing of gendered words.

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CHAPTER 2.- EXPERIMENTAL SECTION

Experimental Series I: The Influence of Sex Information on Gender Word Processing.[1]

The upcoming three experiments were designed to explore the relationship between the sex dimension and the grammatical gender feature. Reviewing the literature, it seems that grammatical gender is activated during noun processing in Romance language automatically even when the gendered word is presented without a linguistic context for which the grammatical gender access is needed (Cubelli, Lotto, Paolieri, Girelli, & Job, 2005; Paolieri, Lotto, Morales, Bajo, Cubelli, & Job, 2010). Giving this fact, we hypothesized four different predictions. The first hypothesis postulates that people use the grammatical gender distinction to encode and organize information related and unrelated to the biological sex. In that way, the definition of the self-sex role could create a default activation of words that match in gender due to the more frequent use of words related to the self-sex, represented by grammatical gender in language. The second hypothesis predicts that the words that agree in gender will be linked together because they belong to the same lexico-syntactic category (Schiller, Schuhmann, Neyndorff, & Jansma, 2006). In addition, the activation of the grammatical gender may be primed by information related to the sex dimension. In such way, our third hypothesis predicts that the sex of the speaker works as a semantic prime, biasing the pre-activation of words that match in gender with the sex of the speaker. Finally, the last prediction claims that those effects regarding the sex of the addressee (the person processing the message) and the sex of the speaker, are supposed to be stronger for the semantically gendered words, where there is direct relationship between the biological sex and the gender assignment and therefore a direct link between the two dimensions. More over, the identification of the sex of the speaker and its effect should be similar independently on the modality of presentation, visual or auditory.

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[1] Casado, A., Palma, A., & Paolieri, D. (submitted). The Influence of Sex Information on Gender Word Processing

Abstract

Three different tasks (word repetition, lexical decision, and gender decision) were designed to explore at different levels of linguistic processing the impact of the sex clues (sex of the speaker, sex of the addressee) and the type of gender on the processing of isolated Spanish gendered words. The findings showed that the grammatical gender feature was accessed when no mandatory attentional focus was required. In addition, the results indicate that the participants organize information according to their own sex role representation, which provides more salience to the words that match in grammatical gender with their own sex role representation, even when the gender assignment is arbitrary. Finally, the sex of the speaker biased the lexical access and the grammatical gender selection, serving as a semantic prime when the two dimensions have a congruent relationship. Furthermore, the masculine form serves as the generic gender representing both male and female figures.

Introduction

In many languages, grammatical gender is an intrinsic and arbitrary property of nouns, which allows them to be classified into different categories (Corbett, 1991). Specifically, gender in Romance languages, such as Spanish, has two categories, these being masculine and feminine. As a general linguistic phenomenon, gender in Romance languages must be carefully distinguished from two related concepts (Comrie, 1999), one is natural gender or sex, which is a matter of semantics and biology, and the other is declensional class, which has no explicit meaning (Harris, 1991). In addition, we would like to clarify that we will use the term sex when talking about biological dimension (i.e., defining the sex of the agents —addressees and speakers) and the term gender when referring to the lexico-syntactic feature. The two categories of gender — masculine and feminine — are abstract; the

inanimate noun assignment to these categories is, in principle, arbitrary and the animate noun gender assignment otherwise largely overlaps with sex. Usually there is some correspondence, such that the nouns referring to males have a masculine gender, whilst the nouns referring to females have a feminine gender. However, there are some exceptions such as epicene names (e.g., *persona* FEM— person), which is invariably feminine regardless of the sex of its referent. In particular, Vigliocco, Vinson, Paganelli, and Dworzynski (2005) distinguished between semantically gendered words (when the referent is a biological entity, and thus there is a direct relation between gender and sex distinction) and arbitrary gendered words (when there is no direct correspondence between the gender distinction and the sex dimension). According to research conducted within the field of linguistics, independently of the type of gender (semantic or arbitrary), the gender feature needs to be specified in the lexicon as part of the information that enables each word (Carstens, 2000; Harris, 1991; Ritter, 1991; Roca, 2005). In psycholinguistics, the focus has been to explore how grammatical gender is represented and selected by the mental lexicon. Some authors proposed that the gender is activated only when the syntactic context is required (i.e., Carammaza & Miozzo, 1997; Levelt, Roelofs, & Meyer, 1999). In contrast, other authors argue that grammatical gender is an intrinsic lexical property, that is automatically activated also in bare noun production (Cubelli, Lotto, Paolieri, Girelli, & Job, 2005; Paolieri, Lotto, Leoncini, Cubelli, & Job, 2011; Paolieri, Lotto, Morales, Bajo, Cubelli, & Job, 2010).

Regarding the relationship between grammatical gender and conceptual representations, the sex and gender developmental hypothesis (Vigliocco et al., 2005) claims that children first associate the name of the human referents of the different sex groups with the gender distinction (masculine for males, and feminine for females), and they then extend this distinction to animals. In a less constrained version of this hypothesis, if people associate the gender of the nouns with the conceptual features, establishing the difference between males and females, the different grammatical gender labels (masculine, feminine) will link together related concepts (i.e., *chica* FEM— girl — *abuela* FEM— grandmother) and those unrelated in terms of biological sex (*chica* FEM— girl — *falda* FEM— skirt). In fact, many studies have attempted to explore whether the nature of grammatical gender, which appears as a need to linguistically represent the difference between sexed entities —males and

females (Arias, 1990), is extended to the conceptual representation of arbitrary words, particularly in the case of Spanish (Boroditsky, Schmidt, & Phillips, 2003; Flaherty, 2001; Forbes, Poulin-Dubois, Rivero, & Sera, 2008; Konishi, 1993, 1994; Martinez & Shatz, 1996; Sera, Berge, & del Castillo Pintado, 1994). These studies demonstrated that the effects of grammatical gender at the semantic level are constrained by the activation of lexico-syntactic cues, which, when accessed, influence semantic processing. Similarly, Vuksanović, Bjekić, & Radivojević (2014) found that there is a relationship between the lexical-grammatical properties of each particular language and the semantic processing. In particular, they found that when participants had to describe pseudo-words characterizing musical instruments with adjectives previously related to the male or female sex distinction, in the absence of other information, grammatical gender dominantly shaped the way participants formed concepts about musical instruments. Moreover, Boutonnet, Athanasopoulos, and Thierry, (2012) found that grammatical gender information can affect semantic processing as well. Using an event related potential (ERPs) design they found that Spanish-English bilinguals exposed only to the English language showed a gender consistency effect in a free classification task (where picture triads were presented and the participants had to decide which two out of the three were more similar). Whilst the latter effect did not manifest itself behaviorally, the results indicate that grammatical gender information can affect semantic processing even when it is not explicitly required.

In short, the available data shows that when retrieving the semantic features of objects from the mental lexicon, spontaneously other types of irrelevant information such as grammatical gender are accessed as well. In addition, when we want to access to a specific word, a number of potential candidates are activated simultaneously, which share semantic features as well as other cues regarding the grammar and syntax with the targeted word. In order to select the specific word, we have to inhibit the rest of the activated lexical candidates that share semantic, phonetic, grammatical and syntactical features with the target word. On the other side, the cues activated when performing the lexical selection most likely contribute to the organization and encoding of the objects, and as a case in point, the grammatical gender can become a semantic classifier (Saalbach & Imai, 2007), such as those words which share the grammatical gender feature may be linked strongly among them and therefore

activated during the lexical selection, in comparison to the words that do not share the grammatical gender property. Tanking into account the existing links between the semantic level and the grammatical gender property during lexical activation and selection of words with grammatical gender, we wanted to explore whether other sex cues at the semantic level present during speech communication intervened in word processing. Concretely, the aim of the present study is to explore whether the sex of the agents (sender—speaker, and addressee —listener) influence the activation and selection of gendered Spanish words. As a matter of fact, the message sender and the addressee belong to either the male or the female sex group, and in addition, the message per se can refer to animate entities biologically sexed, which is expressed syntactically by grammatical gender (semantically gendered words), or to inanimate entities (arbitrarily gendered words). These three levels, that is the sex of the speaker, the sex of the addressee, and the type of gender may interact and modulate the processing of linguistic messages.

Firstly, the addressee is the person receiving the linguistic message. Each person has specific representations of concepts that are different from those of other people due to their own personal experiences. According to grounded cognition theories or the embodiment theoretical approach (Barsalou, 2008; Wilson, 2002), concepts are modality-specific representations grounded in perception and action and the representation of concepts depends on previous experience with the referent. For example, the people who share the sex role may have the same kind of experiences that lead to a similar representation of concepts (Bem, 1983). Actually, the acquisition of sex role knowledge appears during the third year of life (Weinraub et al., 1984), which comes together with classifying people into sex groups and the inclusion of her/himself into a specific sex group. With respect to the acquisition of the sex concept, Belacchi and Cubelli (2012) concluded that children acquire the notion of biological sex around the age of 3 years (Fagot, Leinbach, & Hagan, 1986). Moreover, when children learn to speak with a gendered language, they are able to recognize their own and other sexual identities earlier than children learning languages with no gender, such as English or Finnish (Guiora, Beit−Hallahmi, Fried, & Yoder, 1982). On the whole, it seems that on the one hand the language system can modulate the way people categorize information related to sex and on the other hand, the concept organization may depend on the sex role.

Secondly, thinking about concepts involves a partial reproduction or simulation of experiential, motor, or emotional states that occur when the person actually interacts with the object, experience, or feeling (Winkielman, Niedenthal, Wielgosz, Eelen, & Kavanagh, 2005). This simulation will change across different situations, and the activation of different lexical candidates will depend on the situational context in which the information is given. There are some studies showing the influence of contextual information (top-down information) on linguistic processing, specifically in word recognition (Brunellière & Soto-Faraco, 2013), and lexical access (Brunellère & Soto-Faraco, 2014; Penolazzi, Hauk, & Pulvermüller, 2007). Moreover, some studies have included the indexical information about speakers obtained by voice acoustic analysis and voice identity analysis (Belin, Fecteau, & Bedard, 2004), such as regional accent, age, social status and sex as context cues. For instance, Lattner and Friederici (2003) investigated the influence of speaker information on sentence interpretation using event related potentials (ERPs); they presented sentences that were either stereotypically related to men (e.g., *I like to play soccer*) or to women (e.g., *I like to use make-up*) spoken by male and female speakers, creating congruent and incongruent conditions regarding the stereotypical information and the sex of the speaker. The results showed a P600 component, typically associated to reanalysis of the incongruent information, when there were incongruences between the stereotypical information associated to a determinate sex group and the sex of the speaker. Similarly, Van Berkum, Van den Brink, Tesink, Kos, and Hagoort (2008) used ERPs in order to explore how listeners reacted to social stereotypes with utterances whose content sometimes did not match inferences based on the identity of the speaker (e.g., *If only I looked like Britney Spears,* in a male voice, or *I have a large tattoo on my back*, spoken with an upper-class accent). They found that the information about the speaker's identity is available at 200–300 ms after the onset of a spoken word; in fact, listeners rapidly classify speakers on the basis of their voices and activate the social stereotypes associated to the specific identity (i.e., biological sex). Furthermore, Brunellière and Soto-Faraco (2013) found that the regional accent influenced the computation of the linguistic information, which served to modulate the incoming lexical and semantic processing. Over all, these ERP experiments showed that the indexical information about the speaker and the meaning of the linguistic elements are accessed during

early stages of processing (Belin, Bestelmeyer, Latinus, & Watson, 2011; Belin et al., 2004) and likewise, both are integrated at the early stages of processing (Lattner & Friederici, 2003; Van Berkum et al., 2008). Further, the contextual information coming from the indexical information can constrain both the lexical and semantic processing (Brunellière & Soto-Faraco, 2013; Van Berkum et al., 2008). In short, it appears that the sex of the speaker can serve as a contextual cue that pre-activates the lexico-syntactic information related to grammatical gender, which is linked to the semantic information related to sex.

There are in fact several studies that have attempted to explore the interaction between the sex of the addressee and grammatical gender, and the sex of the speaker and the grammatical gender. In particular, Andonova et al. (2004) studied the influence of the addresses' sex on the processing of gendered words presented aurally, that is, whether male and female listeners had different ways of processing gendered words in Bulgarian, a Slavic language with three categories of gender. They used a word repetition task and a gender decision task in which the participants had to decide the grammatical gender of words. The main findings of the study showed that in the gender decision task there was a facilitation of the selection of the grammatical gender when there was a match between the sex of the listener and the gender of the word. Furthermore, the authors carried out a reanalysis of the data from another study that used the same methodology, but conducted in Italian (Bates, Devescovi, Pizzamiglio, D'Amico, & Hernandez, 1995) and found the same pattern of results. In view of the results, they suggested that people are more accustomed to producing words in the first person and listening to words in the second and third person belonging to their own gender, and this enhances the salience of words related to their own gender in comparison with words related to the opposite gender.

In addition, Vitevitch, Sereno, Jongman, and Goldstein (2013) explored the interaction between the sex of the speaker and grammatical gender processing. In particular, they tested whether the sex of the speaker could influence grammatical gender processing. Similar to Andonova et al. (2004) and Bates et al. (1995) they used a gender decision task during which participants heard masculine and feminine Spanish words, and they were required to decide the gender of the word they had heard. The words were predominantly

arbitrarily gendered (73 arbitrarily and 7 semantically gendered) and were presented by a male or a female speaker. The results showed that when there was a match between the sex of the speaker and the gender of the word, the participants produced faster and more accurate responses than when there was a mismatch between the sex of the speaker and the grammatical gender of the word. It is important to note that the majority of the presented words referred to inanimate entities and the gender assignment was not related to sex. They interpreted their results in terms of the acoustic information about the sex of the speaker influencing the processing of high-level information related to the gender feature per se.

Finally, the type of gender (semantic or arbitrary) seems to bias the processing of the grammatical gender feature. In particular, Bender, Beller, and Klauer (2011), using a gender decision task with different types of primes, explored whether semantic priming influenced semantically as well as arbitrary gendered words in German; they found that even faster responses to semantically gendered words were given compared with arbitrary gender words, the priming effects were extended to arbitrary gender words (non-animate target nouns). They suggested that the priming effects of grammatical gender were due to monitoring in language processing, which detects the incongruence, whereas the priming effects for animate nouns (semantic gender) were brought about by the activation of shared semantic properties such as sex. Furthermore, the same authors investigated the gender congruency effect using different types of gender, such as semantically gendered words and arbitrarily gendered words (Bender et al., 2016). They found a clear effect of gender congruency for the semantically gendered words (i.e., *hermano* MAS— brother) that was potentiated by the direct relationship between sex and gender dimensions. However, the gender congruency effect was not modulated by the animacy but by the grammatical gender assignment. In the case of the epicene names (i.e., *jirafa* FEM— giraffe), although they make reference to animate entities, they have an arbitrary grammatical gender assignment, and thus the gender congruency effect for this set of words is more similar to that evoked by the purely arbitrary gendered words (i.e., *casa* FEM— house), that is, weaker in comparison with the semantically gendered words, but still present.

Taking into account the previous data, it appears that, when paying direct attention to the grammatical gender feature, other levels of the information related to sex (addressee, speaker, and type of gender) have an impact on access to grammatical gender information in formal gender languages (Bulgarian, Italian, German, and Spanish). The aim of the present study is to create for the first time, to our knowledge, a complete view of the processing of Spanish gendered words, and to examine the extent of the influence of the different levels of information related to sex regarding implicit and explicit processing during three behavioral tasks. We designed three tasks that vary in the degree to which explicit attention to linguistic knowledge of gender is required and different levels of linguistic processing are accessed (De Martino et al., 2011). The first of these tasks is the *word repetition task*, which requires production mechanisms and does not compel any decision about the gender of the word; the second is the *lexical decision task*, which compels participants to access the internal lexicon, and no direct attention to grammatical gender feature is needed; the final task is the *gender decision task*, where participants are explicitly requested to access grammatical gender. In all three of the tasks, word recognition processes are called into play. Furthermore, including all the variables related to sex (sex of the addressee, sex of the speaker and type of gender) allows us to have a complete view of what might happen during usual speech processing, whilst exploring different levels of linguistic processing permits us to observe the strength of the bias produced by the sex cues.

From the Spanish set of words, we selected words belonging to the semantic and arbitrary gender, always with a transparent gender mark to avoid morphological influences on lexical access (Padovani, Calandra-Buonaura, Cacciari, Benuzzi, & Nichelli, 2005) and to control the lexical recognition point of the words selected (Marslen-Wilson & Welsh, 1978), which is crucial for an experimental design in the auditory modality. We therefore employed masculine nouns ending in –o and feminine nouns ending in –a. In addition, the designs of the lexical decision task and the gender decision task included two modalities of presentation, auditory and visual. Given that (to our knowledge) studies exploring the impact of the sex of the speaker on word processing have always been conducted in the auditory modality in which the words were presented aurally by male or female speakers, we wanted to include a condition for which the sex of the speaker was also represented visually in order to extend the

findings. For that reason we created the comic modality, simulating a visual situation of oral communication in which the words were presented visually inside a speech bubble that joined a drawing of a figure of a man or of a woman.

The predictions in relation to the influence of the sex cues on grammatical gender are based on whether the relationship between the two dimensions is congruent or incongruent. The first prediction suggests that the sex of the addressee modulate the processing of gendered words, facilitating the lexical selection of candidates that agree in grammatical gender with the sex of the addressee, in comparison with words that disagree in grammatical gender. The prediction regarding the interaction between the sex of the speaker and the gendered words suggest a facilitation processing of those words that have a congruent relationship between the grammatical gender assignment and the sex of the speaker compared with the case in which there is an incongruent relationship. Furthermore, we expected that the effects regarding the sex of the addressee and the sex of the speaker to be stronger for the semantically gendered words, which represent biologically sexed entities (alive and animate) in comparison with the arbitrarily gendered words, which represent inanimate (non-living) objects.

Experiment 1. Word Repetition Task

Method.

Participants. Sixty-four native Spanish speakers from the University of Granada took part in the experiment (32 females and 32 males; mean age: 20.81, SD age: 2.92). As a reward they obtained either free credits for the university courses or money. The participants did not have any kind of hearing impairment, uncorrected visual impairments, or language and neurological impairments.

Material. To avoid morphological influences on lexical access (Padovani et al., 2005) we chose 144 transparent gendered words (nouns - See Appendix 1 for the complete list of the stimuli). We also controlled other relevant variables such as the frequency of use, the number of phonemes, the familiarity and the imageability using EsPal database (Duchon, Perea,

Sebastián-Gallés, Martí, & Carreiras, 2013). Furthermore, we controlled the sound file duration (ms) and the phonological recognition point (ms) of the aurally presented words by the sex of the speaker and by the gender of the word. In addition, we checked that the masculine and the feminine gendered words had a similar phonological neighbors, $t(102) = -0.15$; $p = .881$, (mean feminine = 21.5 (16.28); mean masculine = 22 (17.69)) according to the EsPal database (Duchon et al., 2013), and we also checked that the age of acquisition was comparable between the masculine and the feminine gendered words, $t(72) = -1.218$; $p = .227$, (mean feminine = 4.74 (1.7); mean masculine = 5.304 (2.1)) according to the data base created by Alonso, Fernandez, and Díez (2015). Furthermore, we avoided the use of words that begin with phonemes for which the voice onset time could be detectable at different times regarding the listener's detection threshold, such as /s/, /tʃ/, /θ/, and /'k s/. Half of the words belonged to the semantic gender (with a biologically sexed referent), and the other half to the arbitrary gender; 72 of the selected words were masculine gendered and 72 were feminine gendered. In order to create the target stimuli, all the words were recorded with a male and a female voice. The speakers were dizygotic twin siblings, with very similar dialectic voices due to their origin and family environment. The words were recorded in mono, 26 bits and with a frequency of 44100 Hz. The mean fundamental frequency (F0) of the male voice was 120.3 (10.61) Hz, while the female voice F0 mean was 183.7 (11.81) Hz (see Table 1 for the characteristic of the stimuli). The words were recorded with a neutral emotional tone, and were filtered from environmental sounds. The sound recording was time framed, in order to control the duration of the word and its recognition point for each word spoken by the two speakers.

For filler trials, we used verbs, which have no gender distinction (Corbett, 1991). In Spanish, regular verbs of the first conjugation, in the first singular person of the present indicative end in –o, and in the third singular person end in –a. In order to avoid ambiguity, we excluded words that can simultaneously be nouns and verbs (e.g., *el camino / yo camino* - The way / I walk). Four experimental conditions were created, in each of which half of the words were presented with a male voice and the other half with a female voice. All the conditions were seen by the participants although one participant was just exposed to one of the conditions. The same stem of a word was used in the four conditions. For example, the

stem *gat-* in Condition 1 was *gato* (male cat) spoken with a male voice, in Condition 2 this was *gato* but spoken with a female voice. In Condition 3 the word was *gata* (female cat) spoken with a male voice and finally, in Condition 4 the word *gata* was spoken with a female voice (for an example see Table 2). The participants were only exposed to one of the conditions such as participant number 1 saw condition 1, participant number 2 saw condition 2, participant number 3 saw condition 3, and participant number 4 saw condition 4.

Table 1. *Characteristics of Words Used in the Study*

	Type of Gender		Grammatical Gender		
	Arbitrary	Semantic	Feminine	Masculine	
Frequency Log $t(102)= -0.084$; $p= .93$	3.49 (0.071)	3.51 (0.71)	3.39 (0.1)	3.6 (0.6)	Frequency Log $t(102)= -1.5$; $p= .10$
Number of Phonemes $t(238)= -1.5$; $p= .13$	5.13 (1.31)	5.36 (1.08)	5.25 (1.2)	5.25 (1.2)	Number of Phonemes $t(238)= 0$; $p= 1$
Familiarity $t(72)= -0.408$; $p= .68$	5.63 (0.97)	5.72 (0.97)	5.73 (0.95)	5.62 (1)	Familiarity $t(72)= 0.51$; $p= .606$
Imageability $t(69)= -0.251$; $p= .80$	5.57 (0.83)	5.52 (0.78)	5.63 (0.61)	5.47 (0.79)	Imageability $t(69)= 0.83$; $p= .40$
	Sex of the Speaker		Grammatical Gender		
	Female	Male	Feminine	Masculine	
Sound File Duration (ms) $t(238)= 0.46$; $p= .64$	679 (131)	670 (141)	677 (139)	672 (134)	Sound File Duration (ms) $t(238)= 0.24$; $p= .82$
Phonological Recognition Point (ms) $t(238)= 0.13$; $p= .89$	479 (124)	477 (124)	479 (128)	478 (120)	Phonological Recognition Point (ms) $t(102)= 0.05$; $p= .96$

Procedure. The presentation of the stimuli was conducted on a laptop computer using E-Prime version 2.0 (Psychology Software Tools, Pittsburgh, PA). The participants listened to the stimuli via headphones. The researcher gave them oral and written instructions; they had to listen carefully to each word and repeat it as soon as possible whilst directing the mouth

towards a unidirectional microphone. Each trial began with a warning signal (a pure tone with an equivalent frequency to the overall average F0 of the male and female speaker) of 500 ms in duration, followed by a 250 ms wait interval. Following this, the target word was presented via a recorded file and the participant had 2000 milliseconds to produce a response. The microphone was connected to the computer presenting the word, and detected at a rate of milliseconds from the onset of the participant's production. The experimenter monitored the accuracy of the word repetition. In order to avoid the fatigue effect and give the participants a short break, the experiment was divided into three blocks of 32 trials. The presentation of the trials and the presentation of the blocks were randomized in each condition. The experimental session lasted approximately 20 min. The dependent variable derived from the participants' performance was the reaction time (RT) calculated from the onset of the uniqueness recognition point. This allowed us to control the influence of the duration of each word, and the measure we obtained reflected the reaction time from the recognition point of the word (Marslen-Wilson & Welsh, 1978).

Table 2. *Example of an experimental condition*

	Steam	**Word**	**Type of Gender**	**Grammatical Gender**	**Sex of the Speaker**
condition 1	hij-	hijo	semantic	masculine	male
condition 2	hij-	hijo	semantic	masculine	female
condition 3	hij-	hija	semantic	feminine	male
condition 4	hij-	hija	semantic	feminine	female
condition 1	puert-	puerto	arbitrary	masculine	male
condition 2	puert-	puerto	arbitrary	masculine	female
condition 3	puert-	puerta	arbitrary	feminine	male
condition 4	puert-	puerta	arbitrary	feminine	female

Data analysis. The results were measured in terms of response times over the accurate trials. We performed a subtraction in order to have a more realistic score of time (total response times - uniqueness recognition point); at the total response times score for every word we subtracted the milliseconds corresponding to the uniqueness recognition point (see Figure 1). For the response times, a mix-model with the software R statistics (R Core Team, 2015) was

implemented by using the ANOVA function with a “Kenward-Roger" modification for F-tests (Halekoh & Højsgaard, 2014; Kenward & Roger, 1997). Each ANOVA was conducted with the fitted factors, Sex of the Participants (male vs. female), Sex of the Speakers (male vs. female), Type of Gender (semantic vs. arbitrary) and Grammatical Gender (masculine vs. feminine), and with the random effects, participants, and items. When a significant interaction was found, this was further explored using post-hoc *t*-tests with Tukey’s multiple comparison correction. When the accuracy of one item was lower than 50% within the total item presentation, we discarded that item from the final analysis. Furthermore, when the response time score was 2.5 SD higher or lower than the total mean, we eliminated it from the analysis.

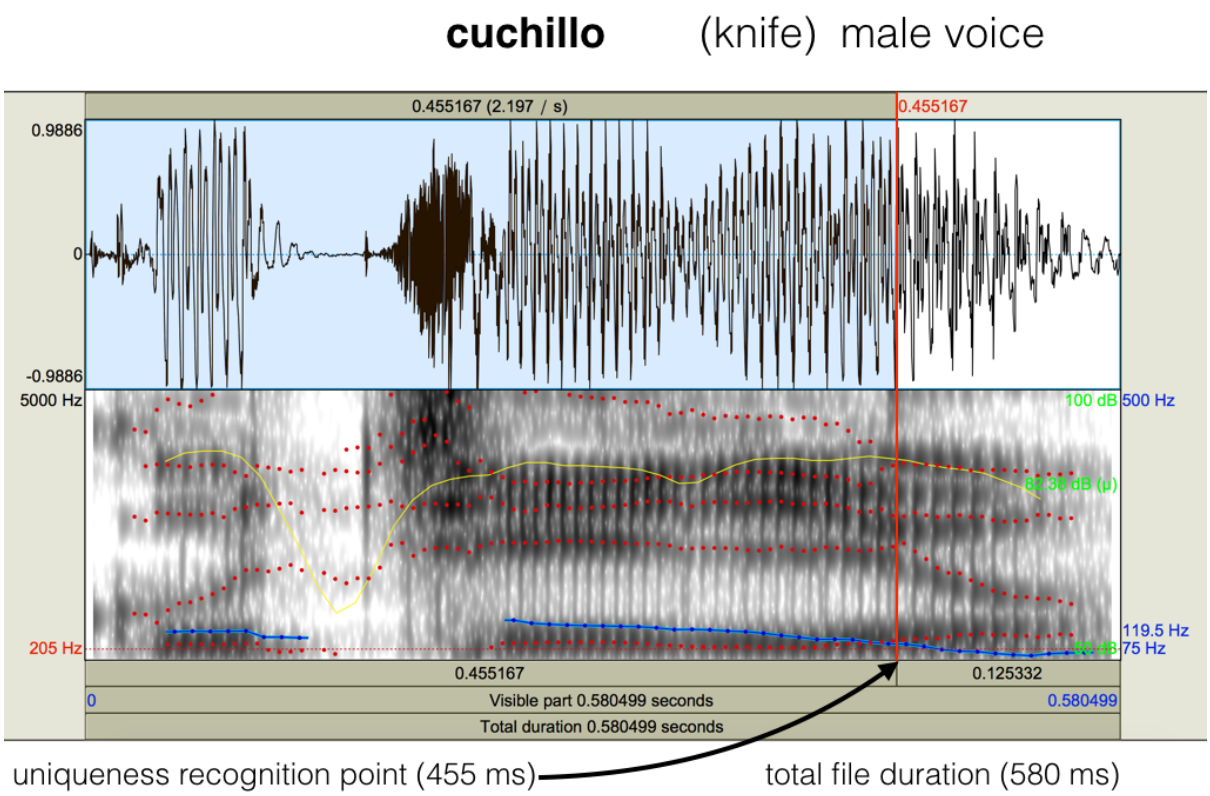

Figure 2: Oscillogram of the word “cuchillo” -knife produced by the male speaker. The red line marks the uniqueness recognition point (455 ms) based on the formant fluctuations, represented with the red spots.

Results.

There was a main effect of the Type of gender, $F(1, 123) = 4.14$, $p = .04$; words with semantic gender were repeated faster (mean = 562 ms) than words with purely arbitrary gender (mean = 592 ms). The rest of variables did not reach statistical significance as main effects: Sex of the Participant $F(1, 13) = 1.97$, $p = .18$; Sex of the Speaker, $F(1, 752) = 2.88$, $p = .09$; Grammatical Gender, $F(1, 123) = 0.29$, $p = .58$; neither participated in any interaction.

Discussion.

This experiment was designed in order to explore whether with implicit reflection we could observe the effects of the different sex cues when processing and producing masculine and feminine words. The results of the word repetition task revealed a main effect of the type of gender, reflecting faster processing of the semantically gendered words, which make reference to biologically animate entities, compared with the arbitrarily gendered words, which make reference to inanimate entities. According to the animate-monitoring hypothesis (New, Cosmides, & Tooby, 2007), there is an early detection of animacy, which is faster to the detection of inanimate objects (Altman, Khislavsky, Coverdale, & Gilger, 2016; Calvillo & Jackson, 2014) because of the importance of the detection of animate objects in ancestral hunter–gatherer environments. In our case, the advantage of processing and production of the semantically gendered words may be due to the animacy of the referent in comparison with the inanimate objects to which the words with arbitrary gender refer.

Experiment 2: Lexical Decision Task

Method.

Participants. Sixty-four participants (mean age: 20.75; SD. age: 3.06) from the University of Granada took part in the experiment following the same selection criteria as in Experiment 1. For half of the participants (32 participants: 16 males and 16 females) the stimuli were presented in the comic modality where the word was presented inside a speech bubble that joined a drawing of a figure of a man or of a woman (see Figure 2), whilst the other half (32 participants: 16 males and 16 females) were assigned to the auditory modality where the words were presented spoken by either a male or a female speaker.

Material. The target words used in this experiment were the same as in Experiment 1. We used the Wuggy software to create 144 pseudo words (Keuleers & Brysbaert, 2010) used as fillers, created from the target words maintaining the same syllable number and the Spanish syllabicity structure.

Figure 3. Example of comic the modality; at the left side appears the picture of the male speaker and at the right side the picture of the female speaker used.

Procedure. The participants sat in front of a laptop with headphones in the auditory modality. The participants had to read or listen carefully to each word and give the response using a key board. Each trial had the same structure. In the visual modality, the participants saw a fixation cross for 500 ms, followed by a 250 ms wait interval. Following this, the target word was presented on the screen. The participant then had 2000 milliseconds to decide how to classify the word by pressing key “1” for words and key “2” for pseudowords. The auditory modality was almost identical, except that instead of a fixation cross they heard a warning signal, a pure tone of 500 ms in duration, with the stimulus being presented via a recorded file. To

avoid the fatigue effect and give the participants a short break, the experiment was divided into three blocks of 40 trials (20 targets and 20 fillers). The presentation of the trials and the blocks in each version was randomized. The experimental session lasted approximately 20 minutes.

Data analysis. The results were measured in terms of response times and accuracy. For the analysis of accuracy and the analysis of the response times in the comic modality we used the direct score, while for the analysis of response times in the auditory modality we subtracted at the total response times score for every word the milliseconds corresponding to the uniqueness recognition point (total response times - uniqueness recognition point). Four mix-models were implemented, two for the accuracy in both modalities, and two for the response times in both modalities. Each ANOVA was conducted with the fitted factors, Sex of the Participants, Sex of the Speakers, Type of Gender, and Grammatical Gender, and with the random effects, participants, and items. When a significant interaction was found, this was further explored using post-hoc *t*-tests with Tukey's multiple comparison correction. When the accuracy of one item was lower than 50% within the total item presentation, we discarded that item from the final analysis. Furthermore, when the response time score was 2.5 SD higher or lower than the total mean, we eliminated it from the analysis.

Results.

Accuracy (ACC).

Auditory modality: There was a main effect of the Type of Gender, $F(1, 115) = 5.15$, $p = .02$; in this case, more accurate responses were given for the semantic words (mean = 0.98) than for the arbitrary words (mean = 0.96). However, there was not a main effect of the Sex of the Participant, $F(1, 30) = 1.54$; $p = .22$, not a main effect of the Sex of the Speaker, $F(1, 1613) = 1.78$; $p = .18$, neither a main effect of the Grammatical Gender, $F(1, 114) = 1.26$; $p = .26$. There were not any interactions either.

Comic modality: The results did not show any main effect: Sex of the Participant, $F(1, 29) = 1.85$; $p = .12$, Sex of the Speaker, $F(1, 1768) = 0.13$; $p = .72$, Grammatical Gender, $F(1, 117) = 0.12$; $p = .73$, Type of Gender, $F(1, 117) = 0.79$; $p = .37$. However, there was an interaction between the Sex of the Participant and the Grammatical Gender of the word, $F(1, 1756) =$

3.64, p = .05. The t-test revealed that the masculine words were processed more accurately by the male participants (mean = 0.94) compared with the female participants (mean = 0.91), $t(86) = -2.26$, p = .02, while there were no differences for the feminine words, $t(86) = 0.14$, p = .88. No other significant interactions were found.

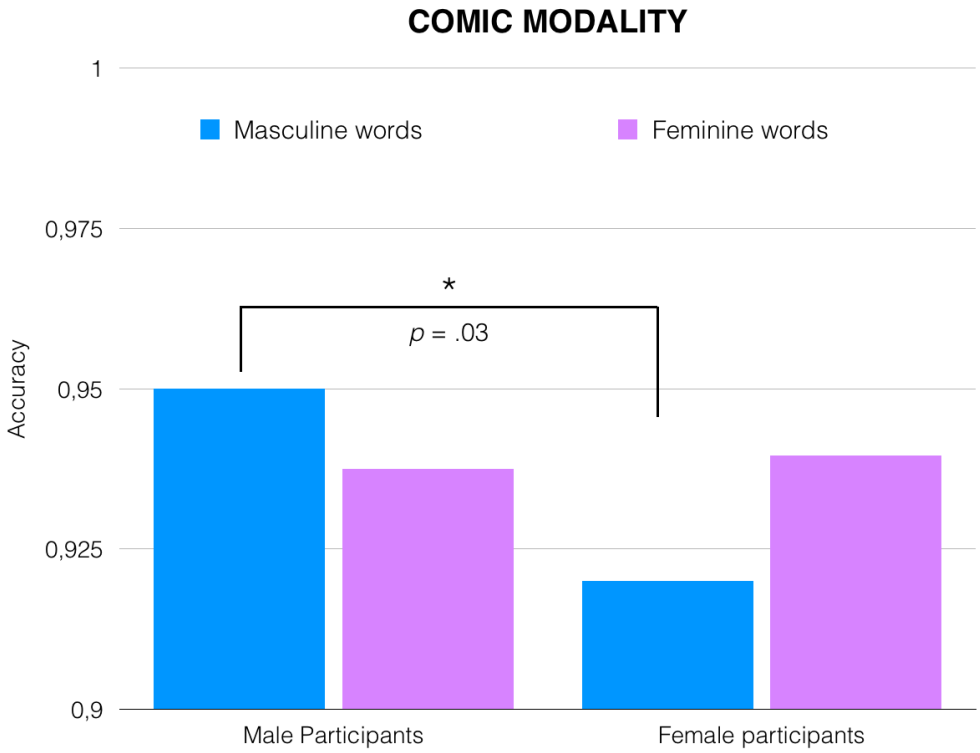

Figure 4. Lexical decision experiment: Representation of the interaction between the sex of the participant and the gender of the word for the accuracy analysis in the comic modality.

Response times.

Auditory modality: There was a main effect of the Type of Gender, $F(1, 115) = 5.53$, p = .02; the semantically gendered words were faster (mean = 549 ms) compared with the arbitrarily gendered words (mean = 581 ms). No other main effects were found: Sex of the Participant, $F(1, 30) = 0.72$; p = .40, Sex of the Speaker, $F(1, 1554) = 1.15$; p = .28, Grammatical Gender, $F(1, 115) = 0.02$; p = .87. In addition, there was an interaction between the Type of Gender and the Sex of the Speaker, $F(1, 1551) = 4.32$; p = .03, that was modulated in a three way interaction by the Grammatical Gender, $F(1, 1556) = 4.65$; p = .03. During the processing of arbitrarily gendered words, the masculine words were faster when presented by the male

speaker (mean = 569 ms) compared with when presented by the female speaker (mean = 598 ms), $t(1577) = 2.72$, $p = .03$. The opposite patter of responses regarding the arbitrarily feminine words did not appear, $t(1582) = 0.37$, $p = .98$. The rest of interactions did not reach statistical significance.

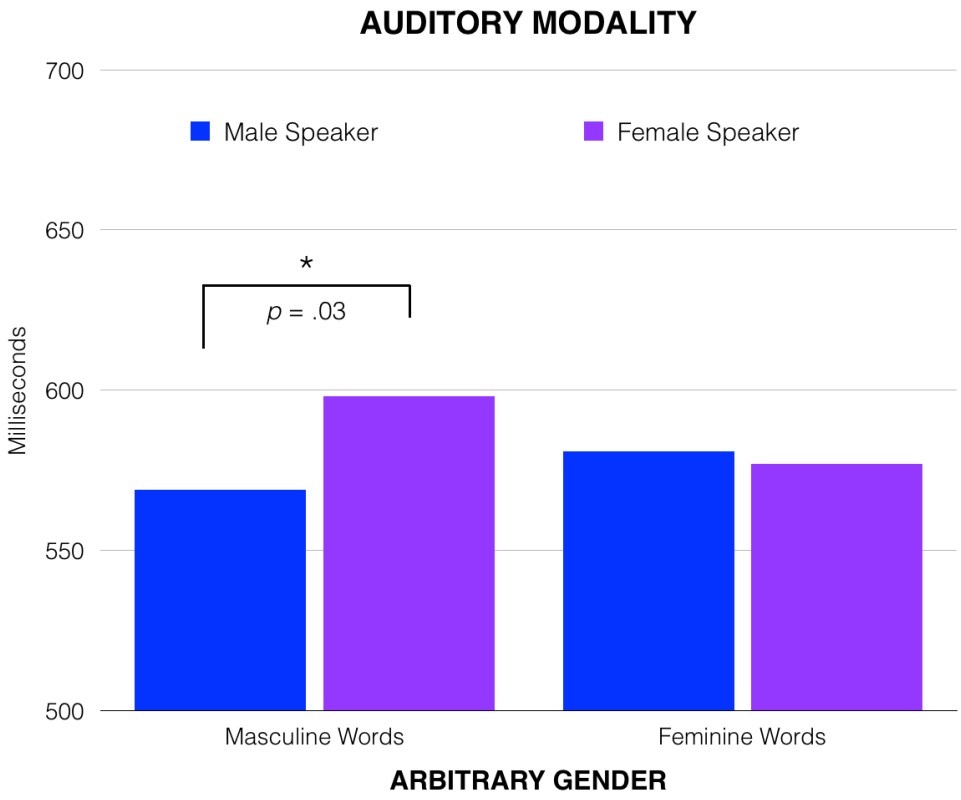

Figure 5. Lexical decision experiment: Representation of the interaction between the sex of the speaker and the gender of the word for the response times analysis in the auditory modality.

Comic modality: There was a main effect of the Type of Gender, $F(1, 113) = 8.91$; $p = .003$, with the semantically gendered words being processed faster (mean = 761 ms) than the arbitrarily gendered words (mean = 798 ms). No other main effects were found: Sex of the Participant, $F(1, 30) = 0.00$; $p = .95$, Sex of the Speaker, $F(1, 1664) = 0.09$; $p = .75$, Grammatical Gender, $F(1, 113) = 0.01$; $p = .90$. Nevertheless, there was an interaction between the Sex of the Participant and the Sex of the Speaker, $F(1, 1649) = 5.24$; $p = .02$, although the planned comparison showed that there were no differences between males and females participants when processing the words spoken by the female speaker, $t(36) = 0.44$, p

= .65, neither when they were presented by the male speaker, $t(36) = -0.33$, $p = .74$. In addition, there was another interaction between the Sex of the Speaker and the Grammatical Gender of the word, $F(1, 1663) = 6.20$; $p = .01$; there were no differences regarding the Grammatical Gender when the words were presented by the female speaker, $t(360) = 1.54$, $p = .12$ neither when the words were presented by the male speaker, $t(357) = -1.73$, $p = .08$.

Discussion.

This experiment was designed in order to explore whether the sex role of the participant and the sex of the speaker have an impact during lexical access, where the gender feature is supposed to be activated even when no direct attention was required. First of all, the results showed an advantage when processing the semantically gendered words in comparison with the arbitrary words, similar to the findings of the word repetition task. It is important to note that the semantically gendered words make reference to animate entities, and that they capture a higher amount of attention in comparison with the inanimate entities represented by the arbitrarily gendered words, as explained by the animate-monitoring hypothesis (New et al., 2007).

In addition the results of the comic modality during the accuracy analysis revealed a significant interaction between the sex of the participant and the gender of the word (see Figure 3). Thus, the male participants processed the gendered words that matched their own sex representation (the masculine words) more accurately than when there was a mismatch with the gender of the word (feminine words). Furthermore, even though the difference failed to reach significance, the data showed a tendency for the female participants to a facilitation processing of the congruent gendered words (feminine words) in comparison with the incongruent gendered words (masculine words). This facilitation effect, when there is a match between the sex of the participant and the gender of the word is in accord with the results reported by Andonova et al. (2004) during the gender decision task of their study in Bulgarian and also with the results of the study in Italian (Bates et al., 1995). It appears that the words that agree with the sex representation of the participant are either pre-activated by default or have more salience than the words that disagree in gender with the sex representation of the addressee, showing that the concept organization may depend on the sex role.

More over, during the lexical decision task we could observe that the gender feature is activated, even it is not explicitly required by the task. Particularly, during the response times analysis in the auditory modality, we found that when the words have an arbitrary gender assignment as compared with when they have semantic gender, the masculine words are processed faster when presented by the male speaker than when presented by the female speaker, that is, when the two dimensions agree there is a facilitation effect when selecting lexical candidates. However, the same congruency effect was not found for the feminine words. These results showed that the identification of the sex of the speaker can influence the way gendered word are processed; the information related to sex obtained by a mere acoustic analysis activates semantic information related to sex cues, which are able to pre-activate words that agree in grammatical gender (particularly, when the gender assignment is completely arbitrary). The same results have been shown before by Vitevitch et al. (2013) when using a gender decision task, which requires explicit attention to the gender feature. However, this is the first time that an effect of the sex of the speaker on the processing of gendered words is shown behaviorally using an implicit task (see Figure 4).

In addition, we have to point out that the effects regarding congruency were found only for the masculine words. However, the masculine and the feminine gender words are controlled by phonological and lexical factors. One possibility may be that in Spanish, the masculine gender represents the generic or default gender for the semantically gendered words representing humans and the majority of animals (Meseguer, 1991). Despite the generic form only works for the semantically gendered words, it may give the category of masculine gender a more salient role compared to the category of the feminine gender, which has a specific mark of gender (Harris, 1991) and it is almost exclusively used to designate female entities.

Experiment 3: Gender Decision Task

Method.

Participants. Ninety-six participants (university students) took part in the experiment (48 females), following the same selection criteria as in Experiments 1 and 2. Thirty-two participants were assigned to the auditory modality (16 males, 16 females), and sixty-four participants, (32 males and 32 females, mean age: 20.55; SD. age: 2.42) were presented with the stimuli in the comic modality. In order to make sure that the order in which the image is composed did not affect the results, we presented to half of the participants the picture of the speaker at the right and the bubble speech at the left of the image, meanwhile the other half of the participants saw the picture of the speaker at the left and the bubble speech at the right.

Material. The materials used in this experiment were the same as in Experiments 1 and 2. In addition, the participants of this study were asked to respond on a Likert-type scale from 1 to 7 one question, how masculine (1) or feminine (7) they rated the items. The mean score of the female participants for the feminine items was 5.42 (SD. = 1.17) and for the masculine items 2.4 (SD. = 1.10); the mean score of the male participants for the masculine item was 5.03 (SD. = 1.05) and for the feminine item was 2.93 (SD. = 1.33). No differences were found for the congruent condition (female-feminine vs male-masculine) or for the incongruent condition (female-masculine vs male-feminine).

Procedure. The participants' task was to read or listen carefully to each word and press certain computer keys depending on whether the stimulus was a masculine noun, a feminine noun, or a verb. Each trial had the same structure as in Experiments 1 and 2. To avoid the fatigue effect the experiment was divided into three blocks of 32 trials. The presentation of the trials and the blocks in each version was randomized. The experimental session lasted approximately 20 minutes.

Data analysis. The results were measured in terms of response times and accuracy. For the analysis of response times, in the auditory modality we subtracted the duration of the sound file until the lexical recognition point (total response times - lexical recognition point) from the total response times for every word whilst in the comic modality we took the total response times. For the accuracy analysis, the direct score was used. Four different mix-models for the response times and accuracy and for the different modalities were

implemented. Each ANOVA was conducted with the fitted factors, Sex of the Participants, Sex of the Speakers, Type of Gender and Grammatical Gender, and with the random effects, participants, and items. When a significant interaction was found, this was further explored using post-hoc *t*-tests with Tukey's multiple comparison correction.

Results.

Accuracy.

Auditory Modality: There was a main effect of the Type of Gender, $F(1, 115) = 50.08$, $p < .0001$; the arbitrary words were processed less accurately (mean = 0.82) than the semantic words (mean = 0.95). In addition, there was a main effect of the Sex of the Speaker, $F(1, 1687) = 6.93$, $p = .008$; when the words were presented by the male speaker, more accurate responses were given (mean = 0.90) compared with when the words were presented by the female speaker (mean = 0.87). Nevertheless, the Sex of the Participant, $F(1, 30) = 1.37$, $p = .25$, and the Grammatical Gender, $F(1, 115) = 0.42$, $p = .52$, were not significant as main effects. The analysis also revealed an interaction between the Sex of the Speaker and the Type of Gender, $F(1, 1686) = 7.57$, $p = .006$, showing that only during the processing of words with arbitrary gender the male speaker provoked more accurate responses (mean = 0.85) in comparison with the arbitrary words presented by the female speaker (mean = 0.78), $t(1710) = -3.77$, $p = .0002$; during the processing of semantically gendered words there were no differences between speakers, $t(1707) = 0.08$, $p = .93$. In addition, there was an interaction between the Sex of the Participant and the Grammatical Gender of the word, $F(1, 1688) = 14.97$, $p = .0001$, that was modulated in a three way interaction by the Type of Gender, $F(1, 1690) = 7.57$, $p = .006$. Specifically, when the words were arbitrarily gendered, the female participants processed more accurately the words in agreement with their gender (feminine words, mean = 0.88) compared with the words that disagree (masculine words, mean = 0.79), $t(282) = 2.95$, $p = .01$. In addition, approaching significance, the male participants processed more accurately the words that matched their own sex (masculine words, mean = 0.84) compared with the words that mismatched (feminine words, mean = 0.76), $t(275) = -2.43$, $p = .07$. No differences were found regarding the semantically gendered words, neither other interactions.

Comic Modality: There was a main effect of the Type of Gender, $F(1, 115) = 24.97$, $p = .02$; the words with arbitrary gender were processed less accurately (mean = 0.95) than the semantically gendered words (mean = 0.97). No other main effects were significant: Sex of the Participant, $F(1, 61) = 1.75$, $p = .18$; Sex of the Speaker, $F(1, 3075) = 0.00$, $p = .99$; Grammatical Gender, $F(1, 115) = 0.45$, $p = .51$. Further, the analyses revealed an interaction between the Sex of the Participant and the Grammatical Gender of the word, $F(1, 3077) = 4.15$, $p = .04$; there was an approaching significance showing that the male participants responded more accurately to the masculine words (mean = 0.98) than the feminine words, (mean = 0.96), $t(315) = -1.77$, $p = .07$. However, no differences were found for the female participants, $t(321) = 0.73$, $p = .46$. In addition, another interaction between the Sex of the Speaker and the Grammatical Gender of the word was found, $F(1, 3074) = 4.21$, $p = .04$, although the multiple comparison did not reach statistical significance for the feminine words, $t(3100) = 1.46$, $p = .14$, neither for the masculine words, $t(3092) = -1.44$, $p = .15$.

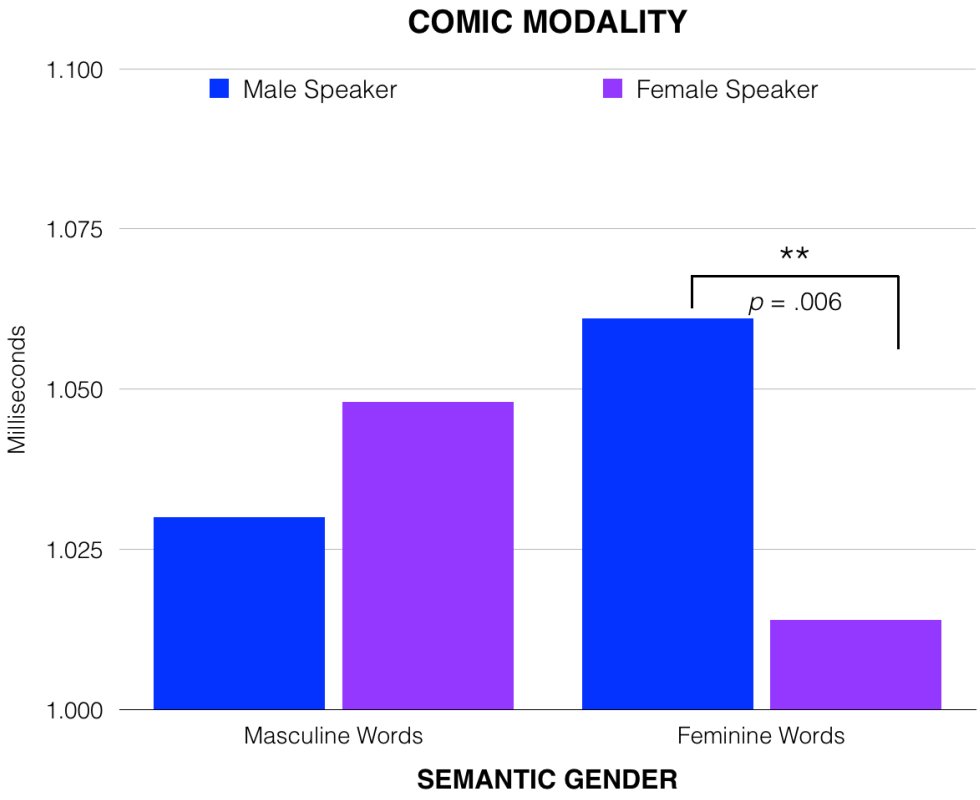

Figure 6. Gender decision experiment: Representation of the interaction between the sex of the speaker and the gender of the word for semantically gendered words the response times analysis in the comic modality.

Response times.

Auditory Modality: The analyses revealed a main effect of the Type of gender, $F(1, 115) = 30.42$, $p < .0001$, with faster processing of the semantically gendered words (mean = 622 ms) compared with the words with arbitrary gender (mean = 685 ms). Further, there was a main effect of the Sex of the Participant, $F(1, 30) = 9.97$, $p = .003$, with the female participants producing faster responses (mean = 608 ms) in comparison with the male participants (mean = 699 ms). There were no main effect of the Sex of the Speaker, $F(1, 1498) = 3.14$, $p = .07$, neither of the Grammatical Gender of the word, $F(1, 115) = 0.03$, $p = .86$. In addition, there was an interaction between the Sex of the Participant and the Grammatical Gender, $F(1, 1492) = 3.72$, $p = .05$, and between the Sex of the Speaker and the Grammatical Gender, $F(1, 1497) = 5.56$, $p = .02$. The two interactions intervened in a three way interaction between the Sex of the Participant, the Sex of the Speaker and the Grammatical Gender, $F(1, 1492) = 3.59$, $p = .05$. The results showed that the male participants were faster processing the words when there was a match between the sex of the speaker and the grammatical gender, such as faster responses were given when the feminine words were presented by the female speaker (mean = 685 ms) compared with when presented by the male speaker (mean = 728 ms), $t(1517) = -3.12$, $p = .009$; the same pattern of responses with the masculine words did not reach statistical significance, $t(1516) = 1.08$, $p = .70$.

Comic Modality: During this experiment there was a main effect of the Type of Gender, $F(1, 115) = 21.2$, $p < .0001$, with the semantically gendered words being processed faster (mean = 1039 ms) than the arbitrary gendered words (mean = 1096 ms). There was also a main effect of the Sex of the Speaker, $F(1, 2963) = 5.6$, $p = .01$; in particular, the female speaker provoked faster responses (mean = 1059 ms) compared with the male speaker (mean = 1076 ms). However, the main effects of the Sex of the Speaker, $F(1, 62) = 0.96$, $p = .32$, and of the Grammatical Gender, $F(1, 115) = 0.01$, $p = .91$ did not reach statistical significance. The analysis revealed an interaction between the Sex of the Participant and the Grammatical Gender of the word, $F(1, 2957) = 6.5$, $p = .01$, although the multiple comparison did not yield any statistically significant differences for the female participants, $t(222) = -1.37$, $p = .17$, neither for the male participants, $t(217) = 1.2$, $p = .22$. In addition, there was a third order interaction between the Sex of the Speaker, the Type of Gender and the Grammatical Gender,

$F(1, 2970) = 7.71$, $p = .005$. Multiple comparisons revealed that in the group of semantically gendered words, the feminine words were processed faster when presented by the female speaker (mean = 1014 ms) compared to the case in which they were presented by the male speaker (mean = 1061 ms), $t(2982) = -3.26$, $p = .006$. Comparisons between the remaining conditions did not reach significance, although they showed the same pattern of congruence.

Discussion.

The present experiment was designed to explore whether the sex role of the participant as well as the identification of the sex of the speaker could play a role in performance on a task for which there is a mandatory activation of the grammatical gender feature. It appears that as well as during the later tasks (word repetition and lexical access) we could observe here the influence of the animacy of the word represented by the type of gender. In particular, the words that represent biologically sexed entities (animates) and which have a congruent relationship between the biological sex and the grammatical gender assignment, are processed more favorably when compared with the arbitrarily gendered words that represent inanimate entities. In this particular case, in addition to the animate-monitoring hypothesis (New et al., 2007), it is important to consider that since the main task was to decide the gender of the word, it should have been easier when the entity represented by the word actually had congruency between its biological and grammatical gender.

Furthermore, as well as during the lexical decision task, we could observe that when there was a congruent relationship between the sex of the participant and the gender of the word, less errors were produced when processing gendered words. During the accuracy analysis of the auditory modality we could clearly see that the female participants processed the feminine words more accurately than the masculine words. Similarly, the male participants processed the masculine words with fewer errors than the feminine words. It appears that the lexical candidates that share the grammatical gender feature with the self sex role representation are highly activated in comparison with the lexical candidates of the opposite gender assignment. This pre-activation or more salience of the congruent candidates allows a better performance of an explicit gender decision task when the gender is in agreement. However, when the participants are presented incongruent candidates the

performance is influenced by the disagreement, because they should inhibit the words that share the grammatical gender with their-selves sex representation and access to the opposite gender words. In addition, it is important to note that the effect of the congruency effect regarding the sex of the participant appears explicitly for the arbitrarily gendered words. According to Andonova et al. (2004) the facilitation effect when processing congruent words may be due to the frequent use of words related to the self sex role, what could be true for the semantically gendered words. However, the use of the selected arbitrary words is supposed to be controlled by all the variables exposed in Table 1. Still, the participants processed more accurately the arbitrarily gendered words that were congruent with their own sex role, which may indicate that people use the grammatical gender distinction to further discriminate categories unrelated to biological sex (Bem, 1983) and that, the concept organization may depend on the sex role, with a stronger activation for the words that match in grammatical gender with the sex role of the addressee.

Before discussing the interaction between the sex of the speaker and the gender of the word, it is important to point out that during the auditory modality, the female participants showed superior processing during the response times analysis. In this case, the task is directly related to high-level linguistic processing and the pattern of responding may be related to recent findings (Wirth et al., 2007) indicating that although men and women are similar in terms of access to initial lexical semantic processing, women engage in a deeper semantic analysis. Further, during the response times analysis we also found that the participants responded faster to the female speakers than to the male speakers during the comic modality. This could be due to the stronger gender cues included in the female drawing compared with the male drawing for which the figure of the female appeared with long hair and earrings, while the male figure was more ambiguous, with an absence of typical male features such as a mustache or beard.

Finally, the results indicate that when there is a match between the sex of the speaker and the gender of the word, there is an advantage in processing leading to a facilitation effect, whilst the detection of an incongruence between the two dimensions produces a decrement in processing, showing a classical congruency effect. During the response times analysis of the

auditory modality we could see that only the male participants were biased by the sex of the speaker when processing feminine words. The same pattern of responses does not appear for the female participants maybe because as they produce a deeper analysis (Wirth et al., 2007), the females overrode the bias. In addition, is important to note that only the feminine words were affected by the sex of the speaker during the auditory modality as well as during the comic modality. Specifically, during the response times analysis in the comic modality, only the semantically feminine words were processed faster when produced by a congruent speaker (female speaker) compared with when produced by an incongruent speaker (male speaker). The effect disappeared for the arbitrarily gendered words (see Figure 5). As we have discussed before, in Spanish the feminine words have a specific mark of gender shown by its desinence which the masculine words lacks (Harris, 1991). In addition, the masculine gender works as the generic gender for the semantically gendered words for all the words representing humans and the majority of animals (Meseguer, 1991). Although some studies have shown that masculine forms lead to a specifically male representation (Gygax, Gabriel, Sarrasin, Oakhill, & Garnham, 2008) in terms of cognitive representations, it appears that, at least in German, the grammatically masculine role names making reference to humans lead to a less gender-specific representation than morphologically marked feminine forms (Irmen & Kurovskaja, 2010). For instance, when hearing the word *amigo* MAS– friend, people are supposed to activate the representation of both male and female friends, meanwhile when hearing the word *amiga* FEM– friend, only the representation of the female friends is activated. In such a way, the word *amiga* FEM– friend is pre-activated when presented by the female speaker (congruent condition) in contrast to when presented by the male speaker (incongruent condition). Nevertheless, when the word *amigo* MAS– friend is presented by the female speaker, the female speaker pre-activates the representation of the "female friend" included in the generic concept (illustrated by the masculine gender) creating a congruent condition, similar to that created by the male speaker (masculine gender — male speaker). The results show that in Spanish the masculine form does work as the generic or default gender instead of like a specific male representation, and that is why no differences appears for the masculine gendered words regarding the sex of the speaker. Overall, it appears that the indexical information about the sex of the speaker obtained during a pure acoustic analysis activates the semantic representation of sex, and thus serves as a semantic prime (Bender et

al., 2011) influencing the selection of linguistic features such as grammatical gender (Vitevitch et al., 2013), going in a top-down manner from high-levels —semantic — to low-levels —lexico-syntactic—, (Brunellière & Soto-Faraco, 2014).

General Discussion

The aim of the present study was to explore whether different cues related to sex such as the sex role of the addressee (the participants performing the tasks, both males and females), the sex of the speaker (male and female) and the type of gender (semantically gendered words and arbitrarily gendered words) influence the processing of Spanish gendered when different levels of linguistic processing are accessed.

First of all, when studying the processing of grammatical gender it seems important to distinguish the type of gender, that is, between semantically gendered words, which represent animate entities and for which there is usually a direct correspondence between the biological sex and the grammatical gender assignment, and the arbitrarily gendered words, which represent inanimate entities and for which the gender assignment is completely random. During the three experiments we observed that the lexical access or selection of words with semantic gender, that is, words that represent animate entities is improved in comparison with the lexical access or selection of words with arbitrary gender. Some experiments in the field of vision research (Altman et al., 2016; Calvillo & Jackson, 2014; New et al., 2007) have demonstrated what they termed the animate-monitoring effect; this effect shows that the animacy produces a salience effect that biases the focus of attention towards animate entities in preference to inanimate objects, due to the importance of the detection of animate objects in ancestral hunter–gatherer environments. The results found in the present experiment extend the animate-monitoring effect to the language processing and production of words that represents animate entities.

Secondly, it is interesting to consider the role of the sex of the participants when processing a gendered language. During the lexical decision task we could see that the participants identified whether the item was a real word more accurately whenever the gender

of the word matched their own sex. The same pattern of response was found during the gender decision task, that is, they determined the gender of the word with more accuracy when there was a match between the gender of the word and their own sex. However, the importance of this finding is that the facilitation effect was obtained for the semantically gendered words as well for the arbitrarily gendered words; in fact, it reflects the existence of a relationship between the categorization of one-self as being part of the male or the female group, and the activation of the gendered words which do not necessarily correspond with biological gender. Overall, it seems that people encode and organize information according to their-selves sex role, such as the words that have a congruent relationship between the sex of the participant and the grammatical gender assignment are strongly activated in comparison with the words with an incongruent relationship and thus are easily to access. More over, the facilitation effect does not exclusively depend on the frequency of use (Andonova el al., 2004) such as it occurs independently on the type of gender.

Finally, the identification of the sex of the speaker modulates the processing of gendered words, similarly in the auditory and in the comic modality, what means that people process the sex cues carried by the face in the same way as that carried by the voice (Belin et al., 2004; Joassin et al., 2011; Schweinberger, Kloth, & Robertson, 2011). With respect to the interaction between the sex of the speaker and the grammatical gender, the findings showed that the identification of the sex of the speaker enhanced the performance on the lexical decision task (an implicit task regarding the grammatical gender) when the gender of the word matched the sex of the speaker. This means that the grammatical gender feature is stored at the lexico-syntactic level and is activated even when it is not explicitly required by the task (Cubelli et al., 2005; de Martino et al., 2011; Paolieri et al., 2011; Paolieri et al., 2010). In addition, the same congruency pattern that leads to a facilitation effect when the two dimension (sex of the speaker and grammatical gender) agree appears during the gender decision task. It seems that the identification of the sex of the speaker created a context that biased the way in which the presented word was processed, priming the selected gendered word and its grammatical feature. In particular, it appears that the mere acoustic analysis activates the semantic information related to the sex clues (a higher-level) influencing the

linguistic processing, specifically the activation of the grammatical gender feature (stored at the lexico-syntactic level) in a top-down manner (Brunellière & Soto-Faraco, 2014).

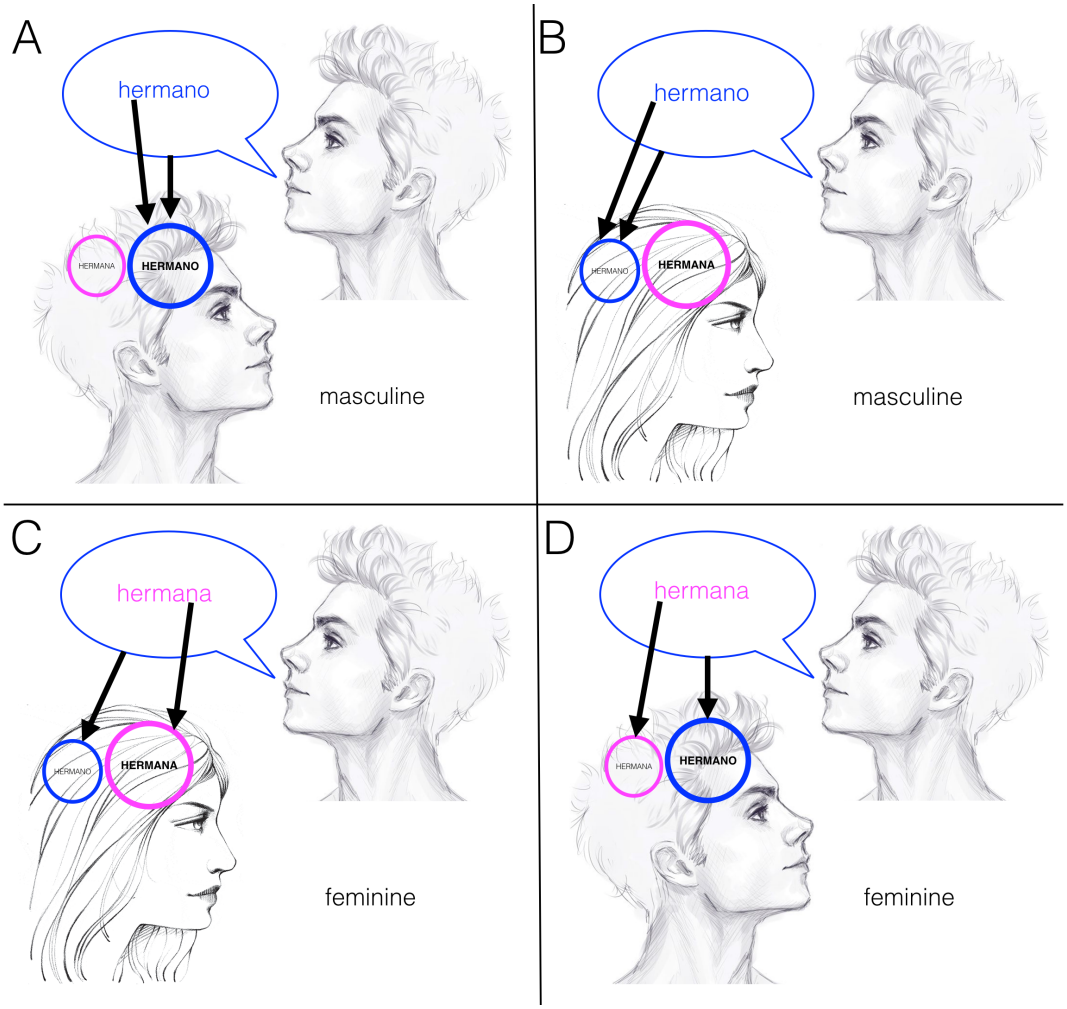

Figure 7. Representation of semantically gendered words processing. The pink color indicates feminine grammatical gender; the blue color indicates masculine grammatical gender, and for the bubble speech indicates male voice. The arrows represent the activation strength due to the grammatical gender of the word, and the priming effect due to the sex of the speaker. Finally, the order indicated the speed of processing: A<B<C<D.

Moreover, the identification of the sex of the speaker gave us the opportunity to observe other linguistic phenomena related to the use of generic gender. Recently, there has been an open debate regarding the issue of whether the masculine gender truly represents the generic gender in some languages such as French or German (Gygax et al., 2008; Irmen & Kurovskaja, 2010). According to the Spanish language rules (Harris, 1991; Meseguer, 1991), the masculine gender in the singular as well as in the plural form for the semantically

gendered words (with the exception of the feminine epicene names) can represent either the specific group of males or the whole/generic group of men and women. In Spanish language, when hearing the word *diputado*— congressmen, people are supposed to activate the representation of congressmen as well as the representation of congresswomen, whilst when hearing the word *diputada*— congresswomen they are supposed to only activate the representation of congresswomen. In relation to our results related to the sex of the speaker, when a female speaker produces a semantically masculine word (the generic gender), the female speaker primes the female representation included within the masculine-generic concept (congruent condition) in the same way that the male speaker primes the male representation included within the masculine concept (congruent condition), which means that the masculine gender actually operates as the generic gender, and not just as the specific male representation (Gygax et al., 2008), and it includes both male and female representations. For a complete summary of the effect see Figure 7.

In conclusion, during the processing of linguistic gendered information, it appears that the different sex clues are integrated. In the present study we observed the importance of the type of gender related to the grade of animacy that it represents. Further, we have demonstrated that the grammatical gender feature is accessed during the lexical decision task and that the addressees organize and encode conceptual information according to the grammatical gender distinction even for the arbitrarily gendered words. Furthermore, the identification of sex of the speaker works as a semantic prime facilitating the lexical access and gender selection when there is a congruent relationship between the sex of the speaker and the grammatical gender. Furthermore, this effect allowed us to see that the masculine gender works as the generic or default gender for the semantically gendered words in Spanish.

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APPENDIX 1

Type of gender	Grammatical Gender	Spanish Word	English translation
Arbitrary	Feminine	Acera	Sidewalk
Arbitrary	Masculine	Acero	Steel
Arbitrary	Feminine	Almendra	Almond
Arbitrary	Masculine	Almendro	Almond tree
Arbitrary	Feminine	Arca	Chest
Arbitrary	Masculine	Arco	Bow
Arbitrary	Feminine	Banca	Bench-ark
Arbitrary	Masculine	Banco	Bench-bank
Arbitrary	Feminine	Banda	Sash
Arbitrary	Masculine	Bando	Side
Arbitrary	Feminine	Bola	Ball
Arbitrary	Masculine	Bolo	Skittle
Arbitrary	Feminine	Bolsa	Bag
Arbitrary	Masculine	Bolso	Purse
Arbitrary	Feminine	Bomba	Bomb
Arbitrary	Masculine	Bombo	Bass drum
Arbitrary	Feminine	Caña	Rod
Arbitrary	Masculine	Caño	Pipe
Arbitrary	Feminine	Castaña	Chesnut
Arbitrary	Masculine	Castaño	Chesnut tree
Arbitrary	Feminine	Copa	Wineglass
Arbitrary	Masculine	Copo	Flake
Arbitrary	Feminine	Cuchilla	Blade
Arbitrary	Masculine	Cuchillo	Knife
Arbitrary	Feminine	Gorra	Cap
Arbitrary	Masculine	Gorro	Hat

Type of gender	Grammatical Gender	Spanish Word	English translation
Arbitrary	Feminine	Grada	Stands
Arbitrary	Masculine	Grado	Degree
Arbitrary	Feminine	Leña	Firewood
Arbitrary	Masculine	Leño	Log
Arbitrary	Feminine	Manta	Blanket
Arbitrary	Masculine	Manto	Cape
Arbitrary	Feminine	Manzana	Apple
Arbitrary	Masculine	Manzano	Apple tree
Arbitrary	Feminine	Maza	Tenderiser
Arbitrary	Masculine	Mazo	Mallet
Arbitrary	Feminine	Naranja	Orange
Arbitrary	Masculine	Naranjo	Orange tree
Arbitrary	Feminine	Oliva	Olive
Arbitrary	Masculine	Olivo	Olive tree
Arbitrary	Feminine	Pala	Shovel
Arbitrary	Masculine	Palo	Stick
Arbitrary	Feminine	Pimienta	Pepper (spice)
Arbitrary	Masculine	Pimiento	Pepper
Arbitrary	Feminine	Plata	Silver
Arbitrary	Masculine	Plato	Plate
Arbitrary	Feminine	Plaza	Square
Arbitrary	Masculine	Plazo	Instalments
Arbitrary	Feminine	Poza	Puddle
Arbitrary	Masculine	Pozo	Well (water)
Arbitrary	Feminine	Puerta	Door
Arbitrary	Masculine	Puerto	Harbour
Arbitrary	Feminine	Punta	Point
Arbitrary	Masculine	Punto	Spot

Type of gender	Grammatical Gender	Spanish Word	English translation
Arbitrary	Feminine	Rama	Branch
Arbitrary	Masculine	Ramo	Bouquet
Arbitrary	Feminine	Tila	Lime blossom
Arbitrary	Masculine	Tilo	Lime blossom tree
Arbitrary	Feminine	Tuba	Tuba
Arbitrary	Masculine	Tubo	Tube
Semantic	Feminine	Abuela	Granmother
Semantic	Masculine	Abuelo	Grandfather
Semantic	Feminine	Amiga	Female friend
Semantic	Masculine	Amigo	Male friend
Semantic	Feminine	Búfala	Female bufalo
Semantic	Masculine	Búfalo	Male bufalo
Semantic	Feminine	Burra	Female donkey
Semantic	Masculine	Burro	Male donkey
Semantic	Feminine	Coneja	Doe
Semantic	Masculine	Conejo	Rabbit
Semantic	Feminine	Cordera	Female lamb
Semantic	Masculine	Cordero	Male lamb
Semantic	Feminine	Cubana	Female Cuban
Semantic	Masculine	Cubano	Male Cuban
Semantic	Feminine	Cuñada	Sister in law
Semantic	Masculine	Cuñado	Brother in law
Semantic	Feminine	Gallega	Female Galician
Semantic	Masculine	Gallego	Male Galician
Semantic	Feminine	Gata	Female cat
Semantic	Masculine	Gato	Male cat
Semantic	Feminine	Hermana	Sister
Semantic	Masculine	Hermano	Brother

Type of gender	Grammatical Gender	Spanish Word	English translation
Semantic	Feminine	Hija	Daugther
Semantic	Masculine	Hijo	Son
Semantic	Feminine	Loba	Female wolf
Semantic	Masculine	Lobo	Male wolf
Semantic	Feminine	Maestra	Female teacher
Semantic	Masculine	Maestro	Male teacher
Semantic	Feminine	Maga	Female magician
Semantic	Masculine	Mago	Male magician
Semantic	Feminine	Médica	Female doctor
Semantic	Masculine	Médico	Male doctor
Semantic	Feminine	Mula	Female mule
Semantic	Masculine	Mulo	Male mule
Semantic	Feminine	Nieta	Granddaugther
Semantic	Masculine	Nieto	Grandson
Semantic	Feminine	Niña	Girl
Semantic	Masculine	Niño	Boy
Semantic	Feminine	Notaria	Female notary
Semantic	Masculine	Notario	Male notary
Semantic	Feminine	Obrera	Female labourer
Semantic	Masculine	Obrero	Male labourer
Semantic	Feminine	Paloma	Female pigeon
Semantic	Masculine	Palomo	Male pigeon
Semantic	Feminine	Perra	Female dog
Semantic	Masculine	Perro	Male dog
Semantic	Feminine	Prima	Female cousin
Semantic	Masculine	Primo	Male cousin
Semantic	Feminine	Rumana	Female Romaninan
Semantic	Masculine	Rumano	Male Romanian

Type of gender	Grammatical Gender	Spanish Word	English translation
Semantic	Feminine	Rusa	Female Russian
Semantic	Masculine	Ruso	Male Russian
Semantic	Feminine	Ternera	Female calf
Semantic	Masculine	Ternero	Male calf
Semantic	Feminine	Tía	Aunt
Semantic	Masculine	Tío	Uncle
Semantic	Feminine	Turca	Female Turk
Semantic	Masculine	Turco	Male Turk
Semantic	Feminine	Vecina	Female neighbour
Semantic	Masculine	Vecino	Male neighbour

Experimental Series II: When The Sex of the Agents Modulate Stereotypical and Arbitrary Gender Processing[2].

The last experimental series showed that the organization of concepts according to grammatical gender depends on the sex-role of the addressee. The gendered words matching the sex role of the addressee are strongly connected among them and its access is easier compared with the gendered words that match with the opposite sex. This effect could be seen for the semantically gendered words as well for the arbitrary words in the gender decision task, where direct attention to the grammatical gender was payed, as well as in the lexical decision task, where the access to the grammatical gender feature was not mandatory. Therefore, the grammatical gender seems to be stored at the lexical level, and partially its activation depends on the sex-role of the addressee. Furthermore, the sex of the speaker acts a semantic clue biasing the activation of the grammatical gender feature. The words that share the grammatical gender with the sex of the speaker are more activated and faster accessed, meanwhile the lower activation of gendered words when the gender and sex dimension disagree makes those words less accessible. In addition, the effects regarding the agents' sex are stronger for the semantically gendered words as compared with the arbitrarily gendered words, because for the first group the gender assignment is directly related to sex.

The present experimental series will further study the interaction between the agents' sex and a specific set of words that are arbitrarily gendered but associated to a social stereotype. The stereotypical gender is an implicit social knowledge which includes cognitive representations associated to male or female roles, and this kind of knowledge is typically incorporated into the conceptual mental representations (Oakhill, Garnham, & Reynolds, 2005). We will select words for which the stereotypical and the grammatical gender agrees and for which the two genders disagree, in order to explore whether other types of semantic knowledge associated to sex (different from the biological sex) modulates the processing of grammatical gender. First of all we will explore what kind of relationship exists between the stereotypical and the grammatical gender. In addition, we will observe whether the influence

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[2] Casado, A., Palma, A., & Paolieri, D. (submitted). When The Sex of the Agents Modulate Stereotypical and Arbitrary Gender Processing

of the agents' sex is stronger regarding the stereotypical gender, which is a purely semantic and higher-level knowledge, compared with the grammatical gender, which belongs to the lexico-syntactic knowledge, a lower-level domain.

Abstract

The stereotypical gender is an implicit form of social knowledge about the cognitive representations associated with male or female roles. The present study investigated the influence of the sex role of the participant and the sex of the speaker during the processing of arbitrarily gendered words with an associated stereotype. Three different task were used, two gender decision tasks —one in the visual and the other in the auditory modality— and a lexical decision task in the auditory modality. The results showed that the grammatical gender information is activated during the processing of isolated words; specifically, when the words have an incongruent relationship between the stereotypical and grammatical gender, the lexical access times were slowed down in comparison to words with a congruent or neuter stereotype. Furthermore, during the gender decision tasks, the sex of the agents modulated the processing of gendered words leading to faster responses when there was a match with the grammatical gender, independently of the stereotypical gender even though the associated sex stereotype belongs to the semantic field. However, the effects due to the role of the agents disappeared when no direct attention to the grammatical gender was payed.

Introduction

The sex concept incorporates the distinction between male and female groups, and, in language, is represented by gender. Gender is an important cognitive category that could be expressed by various means such as grammatical gender (masculine/feminine), biological gender (men/women) and stereotypical gender (semantic associations with the male or female figure) (Irmen, Holt, & Weisbrod, 2010). Grammatical gender is a lexico-syntactic cue that

originally emerged to mark the biological sex distinction in certain languages (Arias, 1990) and the language systems are organized into different categories according to how gender is coded (Corbett, 1991). Spanish is a Romance language which applies the gender distinction to every noun and distinguishes between different kinds of words regarding the grammatical gender feature and its relation with the sex dimension, as follows: *semantically gendered words* —when there is a direct relation between the biological sex and the grammatical gender distinction, such as *abuelo* MAS— grandfather, and *abuela* FEM— grandmother, and *arbitrary gendered words,* when no direct correspondence is found between the gender distinction and the sex dimension, i.e., *plazo* MAS— deadline, *plaza* FEM— square.

The relationship between a lexico-syntactic feature as grammatical gender and a semantic feature as sex is controversial, and consequently there have been numerous attempts to explore the nature and implication of this relationship. In 2005, Vigliocco, Vinson, Paganelli, and Dworzynski presented the sex and gender developmental hypothesis, which claims that children first associate the name of the human referents with the different genders (masculine for males, and feminine for females), and they then extend this distinction to animals. In a less constrained version of this hypothesis, the different grammatical gender labels (masculine, feminine) will link together related concepts (i.e., *chica* FEM— girl and *abuela* FEM— grandmother) and those unrelated in terms of biological sex (*chica* FEM— girl and *falda* FEM— skirt). Many studies have explored whether the relationship between grammatical gender and sex information extends to the conceptual representation of arbitrary words (Boroditsky, Schmidt, & Phillips, 2003; Boutonnet, Athanasopoulos, & Thierry, 2012; Flaherty, 2001; Forbes, Poulin-Dubois, Rivero, & Sera, 2008; Konishi, 1993, 1994; Martinez & Shatz, 1996; Sera, Berge, & del Castillo Pintado, 1994). Nonetheless, when exploring the relationship between sex and gender dimensions, some inconsistent findings seem to emerge using different languages, tasks, and different types of words (see also Mickan, Schiefke, & Stefanowitsch, 2014). In German, a language with three-grammatical genders, Bender, Beller, and Klauer (2016a, 2016b) explored implicitly the sex and gender relationship by using a version of the Extrinsic Affective Simon Task (De Houwer, 2003). They explored the gender congruency effect by using semantically gendered words (i.e., *hermano* MAS— brother), and arbitrarily gendered words (i.e., *casa* FEM— house). Within the category of arbitrary gender

assignment, they distinguished between epicene names (words making reference to animals that have a grammatical gender assignment independently of the biological sex, such as *jirafa* FEM— giraffe), allegories (words associated with male and female figures as personifications, such as *libertad* FEM— liberty, associated with the figure of a woman) and purely arbitrarily gendered words (in principle not associated with any specific sex, such as *casa* FEM— house). They found a clear effect of gender congruency for the semantically gendered words (i.e., *hermano* MAS— brother) that is potentiated by the direct relationship between sex and gender dimensions. However, the gender congruency effect was not modulated by the animacy but by the grammatical gender assignment. In the case of the epicene names (i.e., *jirafa* FEM— giraffe), although they make reference to animate entities, they have an arbitrary grammatical gender assignment, and thus the gender congruency effect for this set of words is more similar to that evoked by the purely arbitrary gendered words (i.e., *casa* FEM— house), that is, weaker in comparison with the semantically gendered words. Interestingly, using allegories allowed them to directly explore whether the congruency gender effect was due to grammatical gender or whether it was due to the item-specific semantic associations with biological sex. In the case of the congruent allegories (*libertad* FEM— liberty), they found a clear effect of gender congruency, whilst the effect disappeared in the incongruent allegories, showing that the gender congruency effect depends on the sex-related associations more than on the grammatical gender of the nouns. In addition, these authors proposed that the gender congruency effect is easier to observe in languages with two genders (masculine and feminine), and when using linguistic tasks, particularly those that require explicit processing of grammatical gender.

According to this view, the grammatical gender effect is not due to a link between the grammatical gender feature and the sex dimension, but rather to the relationship between the "semantic gender" and the sex dimension, that is, the sex information associated with the concept. In the case of the purely arbitrary gendered words for which there are no associations with the sex information, the grammatical gender effect appears. When comparing the strength of the effect using the scores obtained on a voice assignment task, they found that the effect for the epicene names depended on the strength or weakness of the semantic association between the word and the sex dimension. Nevertheless, the words that

do not have a direct link with the sex dimension and name inanimate entities, still present a gender congruency effect even when they are weakly associated with male or female figures, which remains unexplained.

We decided to explore the relationship between the sex and gender dimensions of arbitrarily gendered words that make reference to inanimate entities. Specifically, we selected a two-gender language —Spanish, and we used linguistic tasks in order to potentiate the sex-gender interaction (Bender et al., 2016b). The tasks selected vary in the degree to which explicit attention to grammatical gender is required and different levels of linguistic processing are accessed (De Martino, Bracco, & Laudanna, 2011). The first of these tasks is the *gender decision task*, where participants are requested to access grammatical gender in order to reach a deliberate decision. The second task is the *lexical decision task*, which compels participants to access the internal lexicon; more specifically, they are required to decide whether an item is a real word or a pseudoword. Furthermore, we decided to explore arbitrarily gendered words, making reference to concrete concepts as opposed to using allegories, because they make reference to abstract concepts that are more difficult to imagine. We selected concrete words with an associated stereotype, for which the relationship with the sex dimension is conceptually stronger compared with the allegorical words.

Stereotypically gendered words are words with an arbitrary gender assignment, but socially associated with male or females, such as *falda* FEM— skirt, a word associated with females and *corbata* FEM— tie, associated with males. The stereotypical gender is a form of implicit knowledge that includes cognitive representations associated with male or female roles. Social stereotypes are emotionally relevant (Norris, Chen, Zhu, Small, & Cacioppo, 2004), and even they could change depending on the experience of each person or the different social rules that are specific to each cultural group, usually the stereotype remains stable and there exists a cross-cultural and inter-individual similarity (Koening & Eagly, 2014). Moreover, a characteristic of stereotypical gender is that it is immediately incorporated into mental representations and is thus difficult to suppress (Oakhill, Garnham, & Reynolds, 2005). There have been numerous attempts to explore the role of the stereotype using semantically gendered words — specifically role-nouns (i.e., doctor, associated with

males vs. nurse, associated with females) or contextual sentences— and the results have shown that knowledge about stereotypes is available at the very early stages of processing and that the associated gender stereotype interacts with other gender information such as grammatical gender (Cacciari & Padovani, 2007; Carreiras, Garnham, Oakhill, & Cain, 1996; Esaulova, Reali, & von Stockhausen, 2014; Gygax, Gabriel, Sarrasin, Oakhill, & Garnham, 2008; Molinaro, Su, & Carreiras, 2016; Reali, Easulova, & von Stockhausen, 2015; Oakhill et al., 2005) the sex of the speaker (Lattner & Friederici, 2003; van Berkum, van der Brink, Tesink, Kos, & Hagoort, 2008), and the sex of the participant (Osterhout, Bersick, & McLaughlin, 1997).

In the present study, we explored, for the first time to our knowledge, the influence of stereotypical knowledge on the processing of grammatical gender and the interactions with other sex features such as the sex of the participant and the sex of the speaker. The use of arbitrary gendered words that make reference to inanimate entities allows us to directly explore the influence of social knowledge on syntactic knowledge. Moreover, we selected two linguistic tasks that vary in the degree to which explicit attention to grammatical gender is required. We presented the gender decision task in the visual and in the auditory modality, whilst the lexical decision task was only presented in the auditory modality in order to include the sex of the speaker as an independent variable.

Firstly, we predict there to be easy the lexical access when there is congruence between the sex-stereotypical information and gender information, which is accessed after the information about the associated stereotype (Thierry, Cardebat, & Démonet, 2003). In the case of a mismatch between these dimensions, when people accede to the grammatical gender information, they must suppress the previously activated sex-stereotypical gender at the semantic level, which may slow down lexical access. In short, and in accord with the results of Bender et al. (2016a) using allegories, we hypothesize that the words that mismatch in stereotype and gender (incongruent, i.e., *corbata* FEM— tie, associated with males) will be processed slower in comparison with the words that match in stereotype with the assigned grammatical gender (congruent, i.e., *falda* FEM— skirt, associated with females).

Secondly, we predicted that the gender effect may not only be present during a task for which direct attention to the gender feature is required, but also during a task that simply requires lexical access, because we posit that the grammatical gender information is stored at the lexico-syntatic level and is activated both during bare noun production and the processing of isolated words (Cubelli, Lotto, Paolieri, Girelli, & Job, 2005; De Martino et al., 2011; Paolieri, Lotto, Leoncini, Cubelli, & Job, 2011).

In addition, we are interested in exploring the interactions with the sex of both the participant and the speaker. Starting with the sex of the participant, according to Bem (1983), children use information about the sex role to create the self-concept and learn to encode and organize information in terms of an evolving gender schema that is broader than the simpler biological distinction. This implies that sex information is used to distinguish other conceptual representations that essentially have no direct relationship with purely biological sex, such as sex role stereotypes (Kreiner, Sturt, & Garrod, 2008; Ma & Woolley, 2013; Siyanova-Chanturia, Pesciarelli, & Cacciari, 2012) or grammatical gender (Andonova, D'Amico, Devescovi, & Bates, 2004). Consequently, we predicted an influence of the representation of one's own sex on the organization of information related to gender. Regarding the sex role and stereotypical gender, differences have been shown between male and female participants during the processing of anaphors with stereotypical role-nouns measured by electroencephalography (EEG). For instance, Osterhout et al. (1997) demonstrated that female participants elicited a larger positive deflection, as observed in parietal electrodes (P600 components) when processing definitional and stereotypical gender violations in comparison with their male counterparts. Regarding the sex role and the grammatical gender, Andonova et al. (2004) found an interaction between the sex of the participant and grammatical gender processing when the sex of the participant and the grammatical gender agreed in a gender decision task. We hypothesize that lexical access of gendered words will be easier when there is agreement between representation of one's self-sex and the gender dimension, and that lexical access to gendered words that mismatch in this regard will be relatively slower due to the detection of the interference between the two dimensions (sex and gender). In addition, we expect this effect to be stronger for words whose stereotype and grammatical gender relationship is congruent in comparison with the

words for which the relation between the stereotypical and grammatical gender is incongruent. Furthermore, we expect the stereotypical gender information to play a more important role than grammatical gender information (Bender et al., 2016b), because stereotypical knowledge is purely semantic information, and is accessed earlier than the lexico-syntactic properties such as grammatical gender (Thierry et al., 2003). Moreover, according to Molinaro et al. (2016), stereotypical knowledge overrides the processing of syntactic cues. Indeed, we expected to find a greater effect on stereotypical gender compared with grammatical gender, since stereotypical gender, like the perception of one's self-sex, constitutes part of the mental representation of the noun (Cacciari & Padovani, 2007), which is not the case for grammatical gender (a lexical clue).

With respect to the sex of the participant, we expected to find an interaction between the sex of the speaker and gender, given that the situational context in which the information is presented could influence linguistic processing (Brunellière & Soto-Faraco, 2013; Brunellière & Soto-Faraco, 2014; Penolazzi, Hauk, & Pulvermüller, 2007). More specifically, some studies have further explored the role of indexical information such as the social status and sex of the speaker (Lattner & Friederici, 2003; Van Berkum et al., 2008) in the processing of stereotypical information obtained by voice acoustic and voice identity analysis (Belin, Fecteau, & Bedard, 2004). It is well known that the information about the sex of the speaker is processed at the same time as the meaning of the linguistic elements (Belin et al. 2004; Belin, Bestelmeyer, Latinus, & Watson, 2011) and both types of information are integrated at the early stages of processing (Lattner & Friederici, 2003; Van Berkum, et al., 2008). Using semantically and arbitrarily gendered words in isolation, it has been shown that information about the sex of the speaker acts as a prime that pre-activates the words that share the same grammatical gender, facilitating its processing, such in the case of a masculine word spoken by a male speaker, and detecting the incongruence between the sex of the speaker and the grammatical gender when there is a mismatch between them, such as a masculine word spoken by a female speaker (Vitevitch, Sereno, Jongman, & Goldstein, 2013).

To sum up, the main aim of the present study was to explore whether the sex information influences lexical access to words with an arbitrary grammatical gender assignment. In order to explore the effects of different types of sex information and gender during word processing, we selected two specific linguistic tasks (gender decision task and lexical decision task) that vary in the degree to which explicit attention to grammatical gender is required and different levels of linguistic processing are accessed (De Martino et al., 2011).

Table 3. *Characteristics of Words Used in the Study*

	Grammatical Gender		Stereotypical Gender		
	Feminine	Masculine	Feminine	Masculine	
Frequency Log $t(46) = 0.75$; $p = .45$	0.75 (0.51)	0.64 (0.51)	0.57 (0.48)	0.83 (0.52)	Frequency Log $t(46) = -1.78$; $p = .08$
Number of Phonemes $t(46) = -0.81$; $p = .42$	5.96 (1.39)	6.33 (1.78)	6.12 (1.57)	6.17 (1.66)	Number of Phonemes $t(46) = -0.09$; $p = .92$
Phonological Neighbors $t(46) = -0.29$; $p = .76$	14.42 (14.49)	15.79 (17.52)	13.50 (13.48)	16.71 (18.18)	Phonological Neighbors $t(46) = -0.69$; $p = .49$
Imageability $t(18) = 0.27$; $p = .78$	5.98 (0.41)	5.92 (0.49)	6.04 (0.46)	5.90 (0.42)	Imageability $t(18) = 0.69$; $p = .49$
Concreteness $t(22) = 0.37$; $p = .71$	5.66 (0.75)	5.54 (0.77)	5.53 (0.75)	5.66 (0.76)	Concreteness $t(22) = 0.75$; $p = .66$
Stereotype Score $t(43) = -1.58$; $p = .12$	2.31 (0.75)	2.65 (0.67)	2.33 (0.75)	2.64 (0.68)	Stereotype Score $t(43) = -1.45$; $p = .15$
Sound File Duration (ms) $t(94) = -1.16$; $p = .25$	639 (90)	663 (122)	656 (96)	646 (108)	Sound File Duration (ms) $t(94) = 0.49$; $p = .62$
	Sex of the Speaker				
	Female	Male			
Sound File Duration (ms) $t(94) = -0.11$; $p = .91$	650 (103)	652 (101)			

On the whole, with this experimental series we will try to answer three questions related to linguistic processing during oral communication. The first question posed here is whether different types of words are processed differently; we hypothesize that the words that mismatch in stereotype and gender (incongruent, i.e., *corbata* FEM— tie, associated with males) will command slower processing compared with the words that match in stereotype with the assigned grammatical gender (congruent, i.e., *falda* FEM— skirt, associated with females) and the words not having an associated stereotype (neuter, i.e., *casa* FEM —house). In addition, we expect to see this effect in the gender decision task for which direct attention must be paid to the gender feature, as well as in the lexical decision task. The second question explores whether different kinds of people process the words differently; we hypothesize that when there is a match between the sex role of the participant and the gender of the word (stereotypical and grammatical), the lexical access of gendered words will be easier in comparison with the case in which the gender of the word mismatches with the sex role of the participant, due to the detection of interference between the sex and gender dimensions. Further, we expect stereotypical gender to play a stronger role than grammatical gender because the nature of the stereotype is semantic, and this type of information is accessed earlier than that at the lexico-syntatic level, in which the grammatical gender is stored (Cubelli et al., 2005; De Martino et al., 2011; Paolieri et al., 2011). Finally, the third question attempts to address whether the way the information is presented can affect its processing; in particular, we asked whether the identification of the sex of the speaker modulates the way people access words with certain features such as grammatical or stereotypical gender. We anticipated that when there is a match between the sex of the speaker and the gender of the words, there will be easier lexical access in comparison with the case in which there is a mismatch, an effect that should be greater when the relationship between stereotypical and grammatical gender is congruent as opposed to incongruent.

Experiment 4: Gender Decision Task, Visual Modality.

Methods.

Participants. Thirty-two native Spanish speakers from the University of Granada took part in the experiment (16 females and 16 males; mean age= 20.31; SD= 2.99) in exchange for either

course credits or money (5 €). The participants did not have any kind of hearing impairment, uncorrected visual impairments, or language and neurological impairments.

Materials. In order to select stereotypically gendered words, 60 participants (30 men, 30 women) following the same selection criteria as the participants in the study (university students) filled in a pre-test questionnaire in which they were asked to evaluate the stereotype of 124 words in a Likert-type scale from 1 to 7 (How do you perceive these words? 1 = very feminine, 2 = feminine, 3 = slightly feminine, 4 = neutral, 5 = slightly masculine, 6 = masculine, 7 = very masculine). The words that scored highest on the extremes, that is, higher on masculine or higher on feminine stereotypes were selected for the study. Once we had selected the words, for comparison purposes we transformed the stereotypical score of both the feminine and masculine stereotypes into a scale from 1 to 3 (See Table 3 for the characteristics of the words used in the study). In order to avoid morphological influences on lexical access (Padovani, Calandra-Buonaura, Cacciari, Benuzzi, & Nichelli, 2005) we chose 48 transparent arbitrary gendered nouns. We also controlled other variables such as the frequency of use, the number of phonemes, the phonological neighbors, the imageability and concreteness for the grammatical and the stereotypical gender using the scores from the EsPal database (Duchon, Perea, Sebastián-Gallés, Martí, & Carreiras, 2013), see Table 3 for the characteristics of words used in the study. Half of the words belonged to the stereotypical feminine gender (socially associated with the female figure), and the other half the stereotypical masculine gender (socially associated with the male figure); 24 of the selected words were grammatically masculine gendered and 24 were grammatically feminine gendered. In addition, we selected 24 stereotypically neutral words, half of which had masculine grammatical gender, and the other half having feminine grammatical gender (see Appendix 2 for the complete list of the stimuli). For filler trials, we used verbs, which have no gender distinction (Corbett, 1991). In Spanish, regular verbs of the first conjugation, in the first singular person of the present indicative end in –o, and in the third singular person end in –a. In order to avoid ambiguity, we excluded words that can simultaneously be nouns and verbs (e.g., el camino / yo camino - The way / I walk).

Procedure. The stimuli were presented on a laptop computer using E-Prime version 2.0 (Psychology Software Tools, Pittsburgh, PA). The participants saw the words written on the screen. The researcher gave them oral and written instructions in which they had to read each word carefully and then select the grammatical gender by pressing key 1 for masculine words, key 2 for feminine words, and key 3 for words without grammatical gender (verbs). Each trial began with a warning signal, a cross that appeared on the center of the screen for 500 ms, followed by a 250 ms wait interval. Following this, the target word was presented on the screen. The participant had 2000 ms in which to decide how to classify the word by pressing one of three keys. In order to avoid any fatigue effects and to give participants a short rest period, the experiment was divided into three blocks of 32 trials. The presentation of both the trials and the blocks was randomized in each condition. The experimental session lasted approximately 15 min.

Data analysis. The results were measured in terms of both accuracy and response time (where the direct score was used). Two different mix-models for the response time and accuracy were implemented using the software R statistics (R Core Team, 2015) by using the ANOVA function with a “Kenward-Roger" modification for F-tests (Halekoh & Højsgaard, 2014; Kenward & Roger, 1997). The fitted factors selected were Grammatical Gender (masculine vs. feminine), Stereotype Relationship (congruent, incongruent and neuter) and Sex of the Participant (male vs. female), and the random effects were participants and items. When a significant interaction was found, post-hoc *t*-tests with Tukey multiple comparison correction were conducted. When the accuracy of one item was lower than 50% within the total item presentation, we discarded that item from the final analysis. Furthermore, when the response time score was 2.5 SD higher or lower than the total mean, we eliminated it from the analysis.

Results.

Accuracy. No effect of the Grammatical Gender was found, $F(1, 66) = 2.62$; $p = .11$. Nevertheless, there was a significant main effect of the Stereotype relationship, $F(2, 66) = 4.11$; $p = .02$; there was a significant difference between the incongruent (mean = 0.87) and the neuter words (mean = 0.94), $t(77) = -2.78$; $p = .01$. However, there were no significant

differences between the congruent (mean = 0.92) and the neuter words (mean = 0.94), $t(77) = -0.80$; $p = .17$, neither between the congruent (mean = 0.92) and incongruent words (mean = 0.87), $t(77) = 1.98$; $p = .12$. The interaction between the Stereotype and the Grammatical Gender did not reach statistical significance, $F(2, 66) = 0.24$; $p = .78$. The Sex of the Participant did not reach statistical significance either, $F(1, 30) = 0.67$; $p = .42$, neither the interactions between Sex of the Participant and Grammatical Gender, $F(1, 2196) = 2.2$; $p = .13$, or the with the Stereotype, $F(1, 2196) = 0.55$; $p = .57$.

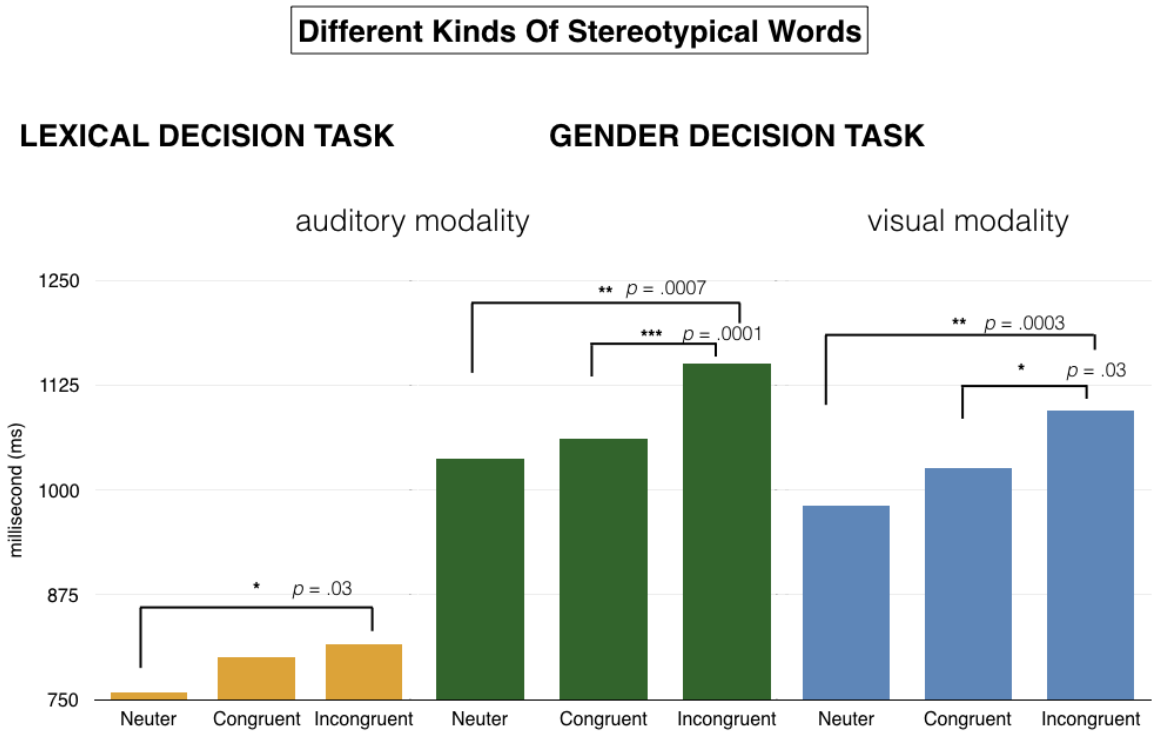

Figure 8. Representation of the different stereotype relationships, neuter, congruent, and incongruent. The results of the lexical decision task are represented in yellow, the results of the gender decision task in the auditory modality are presented in green, and the results of the gender decision task in the visual modality are presented in blue.

Response Times. A main effect of the Grammatical gender was observed, $F(1, 66) = 12$; $p = .0009$; the feminine words (mean = 996 ms) were faster compared with the masculine words (mean = 1074 ms). In addition, there was a main effect of the Stereotype relationship, $F(2, 66) = 8.49$; $p = .0005$. This time, there were statistical differences between the congruent

(mean = 1026 ms) and incongruent words (mean = 1095 ms), $t(77) = -2.49$; $p = .03$; and between the incongruent (mean = 1095 ms) and the neuter words (mean = 982 ms), $t(77) = 4.09$; $p = .0003$. Nevertheless there were not significant differences between the congruent (mean = 1026 ms) and the neuter words (mean = 982 ms), $t(76) = 1.59$; $p = .25$. The interaction between the Stereotype and the Grammatical Gender did not reach statistical significant, $F(2, 66) = 0.27$; $p = .76$ (see Figure 8). The main effect of the Sex of the Participant did not reach statistical significance either, $F(1, 30) = 1.31$; $p = .26$. However, there was an interaction between the Sex of the Participant and the Grammatical Gender of the word, $F(1, 1993) = 7.59$; $p = .005$; the female participants processed the grammatically feminine words faster (mean = 950 ms) as compared with the words with masculine gender (mean = 1060 ms), $t(122) = -4.33$; $p < .0001$. The opposite effect was not significant for the male participants $t(125) = -1.85$; $p = .06$, although the pattern of responses indicated that they also processed the grammatically feminine words (mean = 1041 ms) faster than the words of masculine grammatical gender (mean = 1088 ms), see Figure 9.

Discussion.

During the gender decision task in the visual modality we explored how the stereotypically gendered words with an arbitrary gender assignment are processed, and whether there were any differences regarding the sex of the participants. In the first place, there was a main effect of the grammatical gender; specifically, when the words had a feminine grammatical gender assignment they were processed faster in comparison to when the words had masculine grammatical gender, independently of their associated stereotype. The task the participants had to perform was to decide what was the grammatical gender of the word presented. It is important to note that in Spanish only the feminine marker of gender exists (Harris, 1991), because the masculine works as the generic gender. Indeed, the masculine gender represents the generic gender for the semantically gendered words for all the words representing humans and the majority of animals (Meseguer, 1991). One possibility is that, since the gender decision task requires the participants to decide the grammatical gender, the specific mark of gender that exists on the feminine words facilitated the performance of the task.

In addition, a main effect of stereotype relationship was found (see Figure 8). When there was an incongruent relationship between the stereotype and the grammatical gender assignment there was a slow down in the processing in comparison to when the words had a congruent or neuter relationship. The two types of gender, although belong to different levels —grammatical gender is stored at the lexico-syntactic level meanwhile the stereotype gender is stored at the semantic level — are linked together such as when there is an access to the grammatical gender feature, it influences the activation of words with an associated stereotype. When the two types of gender disagree, there is a detection of the incongruence between the associated sex stereotype and the grammatical gender, which slow down the decision times.

Regarding the sex of the participant, we could see that there was a facilitation effect in which the female participants processed the grammatically feminine words more accurately and rapidly in comparison with the grammatically masculine words, an effect that is independent of the stereotype relationship (similar to the results found by Andonova et al., 2004). It appears that when performing the gender decision task, the participants relied more on the gender information present in the words with feminine grammatical gender, than on the stereotype information. Furthermore, there was a tendency towards the same facilitation effect regarding the feminine grammatical gender for the male participants. It may be the case that both groups of participants — males and females — activate more strongly by default the words that agree in gender with their own sex than the words that disagree, but the task consisted of specifically deciding the grammatical gender of the word. Due to the fact that the feminine words have a processing advantage on account of being the marked gender (Harris, 1991), the effect of the pre-activation of the masculine words by the male participants may have vanished.

In order to check whether the same effects are replicated when the presentation modality changes, we designed a gender decision task with the same stimuli, but presented in the auditory modality. The presentation in the auditory modality allowed us to explore the

role of the sex of the speaker, such as the words will be presented by a male or by a female speaker.

Experiment 5.- Gender Decision Task, Auditory Modality

Methods.

Participants. Thirty-two Spanish speakers from the University of Granada took part in the experiment (16 females and 16 males; mean age = 20.59, SD = 2.92) in exchange for either course credits or money (5 €). The participants did not have any kind of hearing impairment, uncorrected visual impairments, or language and neurological impairments.

Materials. This experiment employed the same words as Experiment 4. In order to create the auditory stimuli, all the words were recorded with a male and a female voice. The speakers were dizygotic twin siblings, with very similar dialectic voices due to their origin and family environment. The words were recorded in mono, 26 bits and 44100 Hz. The mean fundamental frequency (F0) of the male voice was 124,52 Hz, while the female voice F0 mean was 189,58 Hz. The words were recorded with a neutral emotional tone, and were filtered from environmental sounds. The sound recording was time framed in order to control the duration of the word for each word spoken by the two speakers. For filler trials, we used verbs, which have no gender distinction (Corbett, 1991). In Spanish, regular verbs of the first conjugation, in the first singular person of the present indicative end in –o, and in the third singular person end in –a. In order to avoid ambiguity, we excluded words that can simultaneously be nouns and verbs (e.g., *el camino / yo camino* - The way / I walk).

Procedure. The stimuli were presented on a laptop computer using E-Prime version 2.0 (Psychology Software Tools, Pittsburgh, PA). The participant listened to the words via headphones. The researcher gave the participants both oral and written instructions; they were asked to listen carefully to each word and then select the grammatical gender by pressing key 1 for masculine words, key 2 for feminine words and key 3 for words without grammatical gender (verbs). Each trial began with a warning signal, a pure tone of 500 ms in duration, and the stimulus was presented via a recorded file, followed by a 250 ms wait interval. The target word was then presented aurally via headphones. The participant was

given 2000 ms to decide how to classify the word by pressing one of three keys. In order to avoid the fatigue effect and give the participants a short rest period, the experiment was divided into three blocks of 32 trials. The presentation of both the trials and the blocks was randomized in each condition. The experimental session lasted approximately 15 min.

Data analysis. The results were measured in terms of both accuracy (where the direct score was used) and response time; to calculate the participants' response time, to each direct reaction time score the duration of the sound file was subtracted (direct score - duration of the sound file). Two different mix-models for the response time and accuracy were implemented using the software R statistics (R Core Team, 2015) by using the ANOVA function with a "Kenward-Roger" modification for F-tests (Halekoh & Højsgaard, 2014; Kenward & Roger, 1997). The fitted factors selected were Grammatical Gender (masculine vs. feminine), Stereotype Relationship (congruent, incongruent and neuter), Sex of the Participant (male vs. female), and Sex of the Speaker, and the random effects were participants and items. When a significant interaction was found, post-hoc *t*-tests with Tukey multiple comparison correction were conducted. When the accuracy of one item was lower than 50% within the total item presentation, we discarded that item from the final analysis. Furthermore, when the response time score was 2.5 SD higher or lower than the total mean, we eliminated it from the analysis.

Results.

Accuracy. There were not main effects of the Stereotype, $F(2, 66) = 1.43$; $p = .24$, nor of the Grammatical Gender, $F(1, 66) = 0.60$; $p = .44$, neither for the Sex of the Participant, $F(1, 30) = 0.08$; $p = .76$. Otherwise, there was a main effect of the Sex of the Speaker, $F(1, 2184) = 6.49$; $p = .01$. Specifically, the words presented with the female voice were processed with higher accuracy rates (mean = 0.82) than the words presented with the male voice (mean = 0.78). In addition, there was an interaction between the Sex of the Speaker and the Grammatical Gender, $F(1, 2184) = 4.16$; $p = .04$. More interesting, this interaction was modulated by the Stereotype relationship, $F(1, 2184) = 3.43$; $p = .03$; only when the Stereotype relationship was congruent, there was an interaction between the Grammatical Gender and the Sex of the Speaker, such as the grammatically masculine words presented

with female voices (mean = 0.82) were processed more accurately than when presented with male voices (mean = 0.73), $t(2218) = 2.8$; $p = .05$. Nonetheless, when the Stereotype relationship was incongruent the interaction disappeared, $t(2218) = 0.62$; $p = .98$.

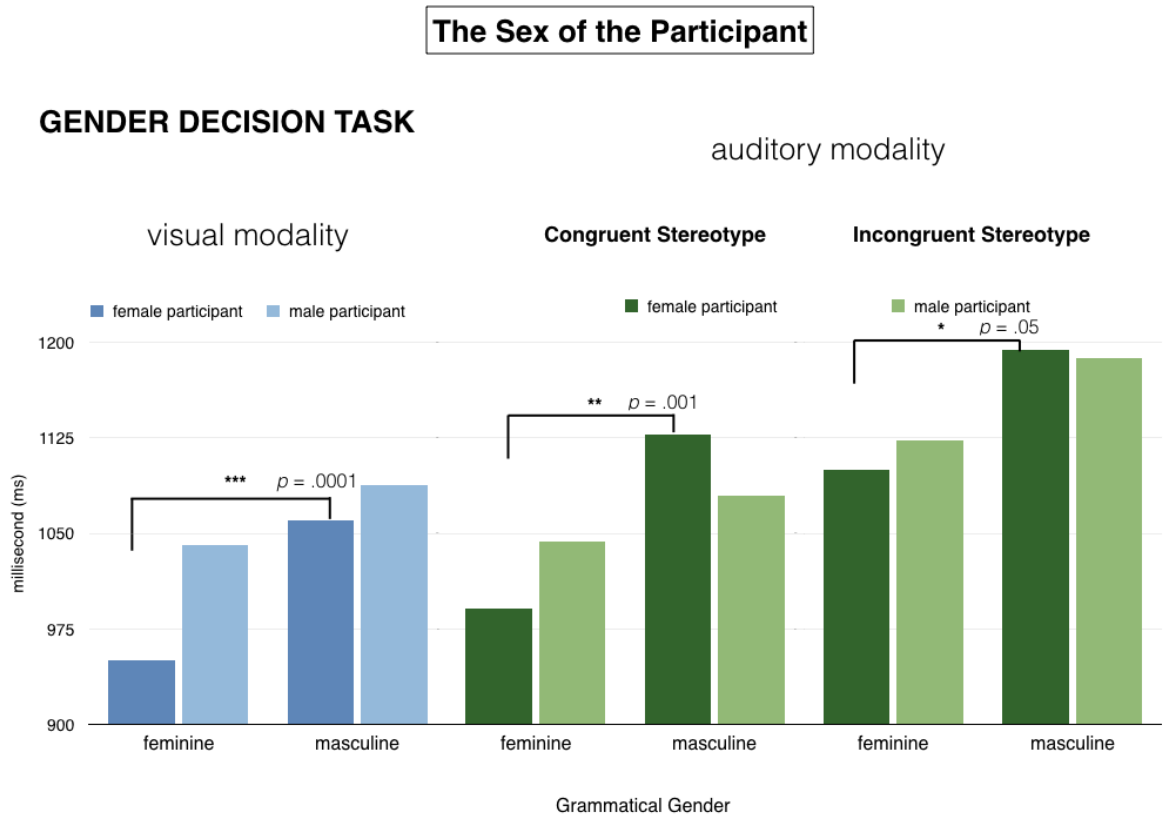

Figure 9. Representation of the participants' sex role interaction with the grammatical gender assignment during the gender decision tasks. In blue appears the data corresponding to the visual modality, and in green the data of the auditory modality.

Response Times. There was a main effect of the Grammatical Gender, $F(1, 65) = 8.53$; $p = .004$; the grammatically feminine words were processed faster (mean = 1054 ms) in comparison with the grammatically masculine words (mean = 1111 ms). In addition, there was also a main effect of the Stereotype Relationship, $F(2, 65) = 12.43$; $p < .0001$ (see Figure 8); the results showed that there were significant differences between the congruent (mean = 1059 ms) and the incongruent stereotype (mean = 1151), $t(78) = -3.79$; $p = .0009$; and also, between the neuter (mean = 1037) and the incongruent stereotype (mean = 1151), $t(77) = 4.71$; $p < .0001$. However, there were not such differences between the congruent (mean =

1059 ms) and the neuter words (mean = 1037), $t(76) = 0.91$; $p = .63$. There was not a main effect of the Sex of the Participant, $F(1, 30) = 0.11$; $p = .74$, neither of the Sex of the Speaker, $F(1, 1796) = 0.03$; $p = .85$. Nevertheless, there was an interaction between the Sex of the Participant and the Grammatical Gender, $F(1, 1735) = 15.65$; $p < .0001$; the female participants processed faster the grammatically feminine words (mean = 1033 ms) compared to the grammatically masculine words (mean = 1121 ms), $t(104) = -4.12$; $p < .0001$. The male participants did not show any statistical differences, $t(102) = -1.2$; $p = .19$ (see Figure 9). There were also an interaction between the Sex of the Speaker and the Grammatical Gender of the word, $F(1, 1797) = 5.66$; $p = .01$. Furthermore, this interaction was modulated by the Stereotype relationship, $F(2, 1796) = 4.5$; $p = .01$. When the words had a congruent Stereotype relationship and were presented by the female speaker, they were processed faster when they had a feminine grammatical gender (mean = 985 ms), compared to when they had a masculine grammatical gender assignment (mean = 1121 ms), $t(104) = -3.71$; $p = .001$. Similarly, when the words had an incongruent Stereotype relationship and were presented by female speaker, were processed faster if their grammatical gender assignment was feminine (mean= 1106) as compared to when it was masculine (mean = 1200 ms), $t(107) = -2.52$; $p = .06$. No differences were found when the words had neutral stereotypical gender, $t(98) = 0.02$; $p = 1$ (see Figure 10).

Discussion.

Similarly as in the gender decision task in the visual modality, we found a main effect of the grammatical gender; during the present task, the grammatically feminine words were processed faster in comparison with the grammatically masculine words. We have explained before that in Spanish, only the feminine words have a specific mark of gender, because the masculine gender works as the generic or default gender (Harris, 1991; Meseguer, 1991). Since the participants had to decide particularly the grammatical gender of the words, the specific mark of gender that exists on the feminine may have facilitated the performance of the task.

In the same way, we also found a main effect of the stereotype relationship, such as a faster processing of words with a congruent stereotype relationship appeared compared with

words with an incongruent stereotype relationship, and also slower processing times of words with an incongruent stereotype relationship compared with neuter words (see Figure 8). It appears that when people activate the grammatical gender feature, it influences the processing of words with an associated semantic stereotype related to the sex dimension; even the two dimensions have a different nature, that is, although gender is lexico-syntactic and sex is semantic, they are linked together —whereas in this case, the grammatical gender assignment is completely arbitrary.

Additionally, the interaction between the participants' sex role and the grammatical gender of the words is also present. We have seen that the female participants processed faster the grammatically feminine words in comparison with the grammatically masculine words, independently of the associated sex stereotype. Interestingly, the interaction appears with the grammatical gender directly instead of the with the stereotypical gender. In spite of the stereotypical gender has a semantic nature and it is accessed before the purely grammatical features such as the grammatical gender (Thierry et al., 2003), maybe due to the requirements of the task, the effect of the sex role of the participant appears to affect more the grammatical gender processing instead of the stereotypical gender processing, although the grammatical gender assignment for this specific set of words is completely arbitrary (See Figure 9).

Lastly, we could see that the sex of the speaker modulated the processing of arbitrarily gender words with an associated stereotype. First of all, we hypothesized that the sex of the speaker would bias the processing of gendered words (Vitevitch et al., 2013) in a stronger way when the stereotype relationship was congruent in comparison with when it was incongruent or neuter. Actually, the fact of having an added semantic knowledge related to sex that is in agreement with the grammatical gender of the word facilitated the gender decision processing; for the case in which the stereotype information disagreed with respect the grammatical gender, there was an incongruence detection that interfered with the pre-activation of words (Lattner & Friederici, 2003; Van Berkum et al., 2008). In particular, during the accuracy analysis we observed that in general, when the words were presented by

the female speaker, less errors were committed compared to when the same words were presented by the male speaker.

Nevertheless, the main effect of the sex of the speaker disappeared during the response time analysis, for which we found a three-way interaction between the sex of the speaker, the gender of the word, and the stereotype relationship. This interaction revealed that when there was a congruent stereotype relationship, the words presented by the female speaker were processed faster when the grammatical gender matched (feminine grammatical gender) than when there was a mismatch (masculine grammatical gender). Interestingly, this effect was replicated when the stereotype relationship was incongruent, that is, the words presented by the female speaker were processed faster when they had feminine grammatical gender compared to when they had masculine grammatical gender, although the effect was weaker. Over all, it seems that the sex of the speaker biased strongly the grammatical gender information (Vitevitch et al., 2013), stored at the lexico-syntactic level instead of the stereotypical gender information (Lattner & Friederici, 2003; Van Berkum et al., 2008), stored at the semantic level (See Figure 10).

In order to explore whether the observed effects during the gender decision task were due to the explicit activation of the grammatical gender feature, or whether the effects are observed at a more automatic level, we designed a lexical decision task, in which the grammatical gender activation is not needed in order to perform the task.

Experiment 6: Lexical Decision Task, Auditory Modality.

Methods.

Participants. Thirty-two native Spanish speakers from the University of Granada took part in the experiment (16 females and 16 males; mean age = 19.48, SD = 2.83) in exchange for either course credits or money (5 €). The participants did not have any kind of hearing impairment, uncorrected visual impairments, or language and neurological impairments. Five male participants were excluded from the final analysis due to the greater number of errors committed.

Materials. This experiment employed the same target words as Experiment 5. As fillers, we used 72 psuedo-words created with the software Wuggy (Keuleers & Brysbaert, 2010) from the target and stereotypically neutral words maintaining the same syllable number and the Spanish syllabicity structure. Two experimental conditions were created in each of which half of the words were presented with the male voice and the other half with the female voice.

Procedure. The participants sat in front of a laptop with headphones. The participants had to listen carefully to each word and press a key depending on whether the stimulus was a word or a pseudo-word. Each trial had the same structure. The participant heard a warning signal, a pure tone of 500 ms in duration, followed by a 250 ms wait interval. Following this, the target word was presented via a recorded file. The participant then had 2000 ms to decide how to classify the word by pressing key 1 for real words, and key 2 for pseudowords. To avoid the fatigue effect and give the participants a short break, the experiment was divided into two blocks of 36 trials. The presentation of the trials and the blocks in each version was randomized. The experimental session lasted approximately 20 minutes.

Data analysis. The results were measured in terms of both accuracy (where the direct score was used) and response time; to calculate the participants' response time, to each direct reaction time score the duration of the sound file was subtracted (direct score - duration of the sound file). Two different mix-models for the response time and accuracy were implemented using the software R statistics (R Core Team, 2015) by using the ANOVA function with a "Kenward-Roger" modification for F-tests (Halekoh & Højsgaard, 2014; Kenward & Roger, 1997). The fitted factors selected were Grammatical Gender (masculine vs. feminine), Stereotype Relationship (congruent, incongruent and neuter), Sex of the Participant (male vs. female), and Sex of the Speaker, and the random effects were participants and items. When a significant interaction was found, post-hoc *t*-tests with Tukey multiple comparison correction were conducted. When the accuracy of one item was lower than 50% within the total item presentation, we discarded that item from the final analysis. Furthermore, when the response time score was 2.5 SD higher or lower than the total mean, we eliminated it from the analysis.

Results.

Accuracy. For the accuracy analysis, there was not a main effect of the Grammatical Gender, $F(1, 65) = 2.21$; $p = .14$, not a main effect of the Stereotype relationship, $F(2, 65) = 1.59$; $p = .21$, neither interaction between the Stereotype and the Grammatical Gender, $F(2, 65) = 0.73$; $p = .48$. The Sex of the Participant was not significant as a main effect, $F(1, 25) = 0.09$; $p = .75$, neither it intervened in the interactions with the Grammatical Gender, $F(1, 860) = 0.02$; $p = .88$, nor with the Stereotype relationship, $F(1, 860) = 0.28$; $p = .75$. There was not main effect regarding the Sex of the Speaker, $F(1, 855) = 0.06$; $p = .80$, neither interactions with the Grammatical Gender, $F(1, 855) = 0.96$; $p = .32$, or with the Stereotype relationship, $F(2, 855) = 1.26$; $p = .28$.

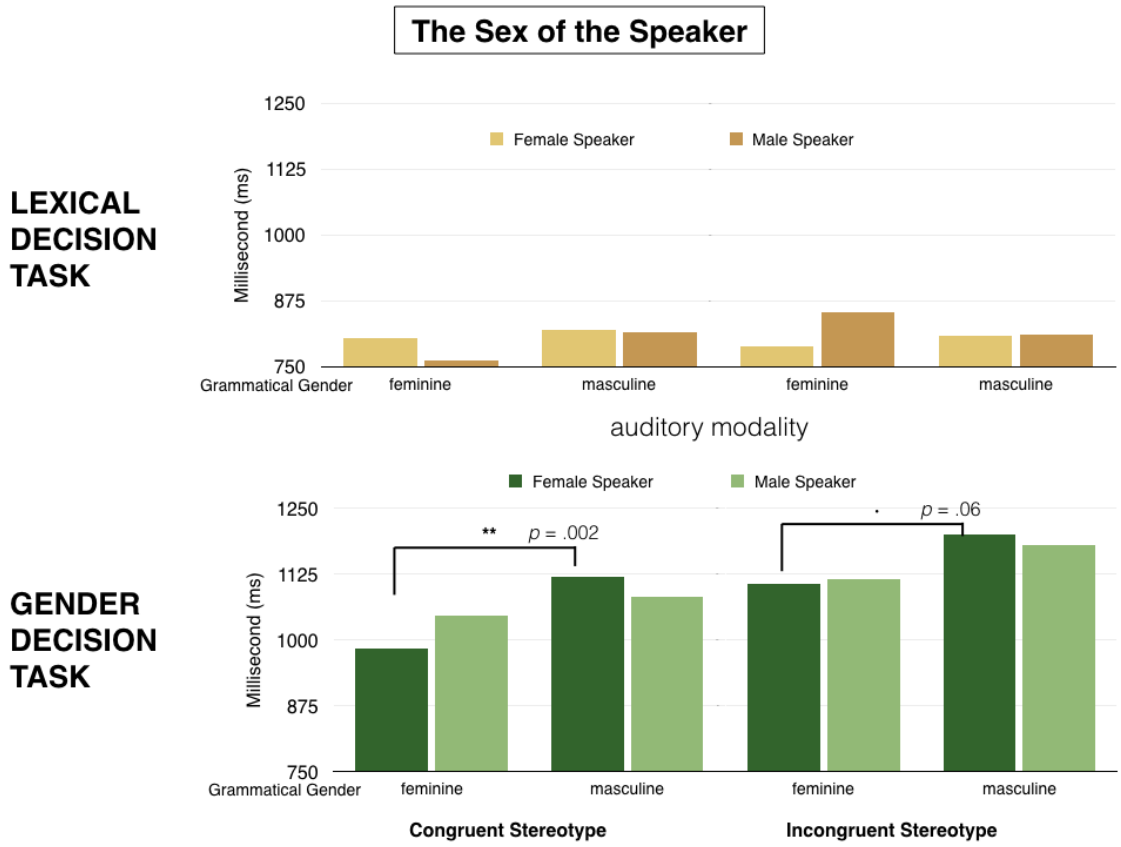

Figure 10. Representation of the interaction between the sex of the speaker and the grammatical gender making the distinction between the congruent vs. incongruent stereotype relationship. The yellow graphs represents the lexical decision task, and the green graphs the gender decision task, in the auditory modality.

Response Times. No effects regarding the Grammatical Gender, $F(1, 65) = 1.63$; $p = .20$ appeared, but a main effect of the Stereotype relationship was found, $F(2, 65) = 3.48$; $p = .03$; there were statistical differences between the incongruent (mean = 816 ms) and the neuter words (mean = 758 ms), $t(76) = 2.54$; $p = .03$. However, there were not significant differences between the congruent (mean = 800 ms) and the neuter words (mean = 758 ms), $t(76) = 1.84$; $p = .16$, neither between the congruent (mean = 800 ms) and the incongruent words (mean = 816 ms), $t(76) = -0.70$; $p = .76$ (see Figure 8). The interaction between the Stereotype and the Grammatical Gender did not reach statistical significance, $F(2, 65) = 0.87$; $p = .42$. The Sex of the Participant was not significant as a main effect, $F(1, 25) = 0.56$; $p = .46$, neither it intervened in the interactions with the Grammatical Gender, $F(1, 834) = 0.00$; $p = .96$, nor with the Stereotype relationship, $F(1, 834) = 0.41$; $p = .66$. The Sex of the Speaker as a main effect was not significant, $F(1, 884) = 0.02$; $p = .86$, neither it intervened in the interactions with the Grammatical Gender, $F(1, 884) = 0.28$; $p = .59$, nor with the Stereotype relationship, $F(1, 884) = 1.53$; $p = .21$.

Discussion.

The results of the response times analysis showed that the main effect of the grammatical gender disappeared, proving that actually, the feminine is the marked gender (Harris, 1991). Specifically, the participants relied on the mark of gender present in the grammatically feminine words in order to perform the gender decision tasks, which derived in a facilitation processing of the feminine gendered words in comparison with the masculine gendered words. This facilitation effect disappeared when the requirements of the task were not directed to the grammatical gender but to perform a lexical decision.

Interestingly, the main effect of stereotype relationship with slower processing of the incongruent words compared with the congruent and neuter words, was present during the lexical decision task, where no direct attention to the gender was required (see Figure 8). That means that the gender information was accessed during the processing of isolated words even when the task did not require direct attention to the lexico-syntactic level (Cubelli et al., 2005; De Martino et al., 2011; Paolieri et al., 2011). Furthermore, it appears that the

stereotypical information of incongruent words slowed down the lexical access in comparison with the words that lack of an added semantic information related to sex.

During the lexical decision task, the interaction between the sex of the participant and the grammatical gender disappeared. Nevertheless, we have to take into account that the participants were not balanced by sex, such as we had to eliminate 5 male participants for the final analysis. At this point, we cannot confirm whether the sex role of the participants played any role during the processing of arbitrary words with an associated sex stereotype.

Nevertheless, we can say that the effects regarding the sex of the speaker disappeared during the lexical decision task, including the main effect we found during the gender decision task (i.e., better processing of the words when presented by the female speaker). It means that the differences due to the sex of the speaker were not due to the quality of the recording either to other physical features of the recorded words. Moreover, the facilitation effect observed during the gender decision task in which the words that matched in grammatical gender the sex of the speaker, disappeared. After all, it seems that the influence of the identification of the sex of the speaker (a contextual clue) on the processing of grammatically gendered words, was driven by the specific requirements of the task rather than a generic influence on linguistic processing.

General Discussion

The aim of the present study was to explore the gender effects during the processing of arbitrarily gendered words that make reference to concrete entities with an associated stereotype. In addition, we were interested in exploring how language processing is affected by other sex-related variables that are present during speech communication. Firstly, we wanted to explore whether the associated sex related information present in the stereotypical words had an impact on lexical access. Secondly we wanted to clarify whether the sex role of the participant influenced how they processed and accessed words with an associated sex stereotype (but arbitrarily gendered). Finally, we questioned whether the role of the communication context, that is, the different kinds of speakers categorized in terms of

biological sex, modulated the way in which the linguistic message was processed, particularly when the presented words had an associated stereotype.

To begin with, we decided to use gendered words with an associated stereotype, for which the grammatical gender assignment is completely arbitrary. In addition, the selected words contained additional semantic information related to sex, which could be congruent, incongruent, or neutral with regard to the grammatical gender assignment. Other authors (Bender et al., 2016a, 2016b) have attempted to explore the nature of the relationship between sex and gender dimensions using semantically gendered words, epicene nouns, and arbitrarily gendered words representing allegories and neuter objects. The use of the present set of words is novel and allowed us to directly explore the interrelation when there is an agreement and a disagreement between the sex and gender dimensions during linguistic tasks. In particular, we designed two gender decision tasks, and used a lexical decision task in which words with a congruent stereotype, with incongruent stereotype, and with neutral stereotype were studied. The main finding regarding the processing of different words suggests that the incongruence relationship between the stereotypical sex information and the grammatical gender assignment creates a bias that hinders lexical access to the incongruent words (i.e., *corbata* FEM— tie, related to males) in comparison with the congruent (i.e., *falda* FEM— skirt, related to females) or neuter words (i.e., *casa* FEM— house). This finding demonstrates that the grammatical gender feature is activated even when no direct attention to the lexico-syntactic features is required. Furthermore, the associated stereotype, even if it is a social convention, is able to create a link between the semantic field (a higher level) and the lexico-syntactic field (a lower level), which is modulated in a top-down manner. See Figures 8 and 11.

Further, we decided to divide the participants into sex groups. We anticipated that the people who categorize themselves into the different sex role groups will have a more similar life experience that will make them process the words accordingly. Moreover, we proposed that information about the own sex role is use to encode and organize information regarding the gender dimension (Bem, 1983). On the basis of these suggestions, we hypothesized that the participants will access the gendered words that match their own sex representation faster

than words that do not match their own sex. During the present study, the effect of sex-gender congruency was found only in the female participants. In their case, they processed words with feminine grammatical gender more rapidly than the words with masculine gender. It is important to note that even though the male participants also showed the same pattern of results regarding the congruency effect, this fell short of statistical significance (see Figure 9). It is possible that the design of the task prevented them from showing the same effect. In particular, as we have already noted, only the grammatically feminine words include a specific mark of gender that is absent in the masculine words (Harris, 1991), particularly in the case of the transparent words that we included in the current design. As the participants' task was to decide the grammatical gender of the word, the fact of having transparent desinences of gender — with a specific gender mark in the case of feminine words — may have created an advantage in processing that might have masked the effect of the sex of the participant for the male group. In short, it is possible that using words with an opaque gender desinence will allow us to see that the male participants also strongly activate by default the words for which grammatical gender matches their own sex representation.

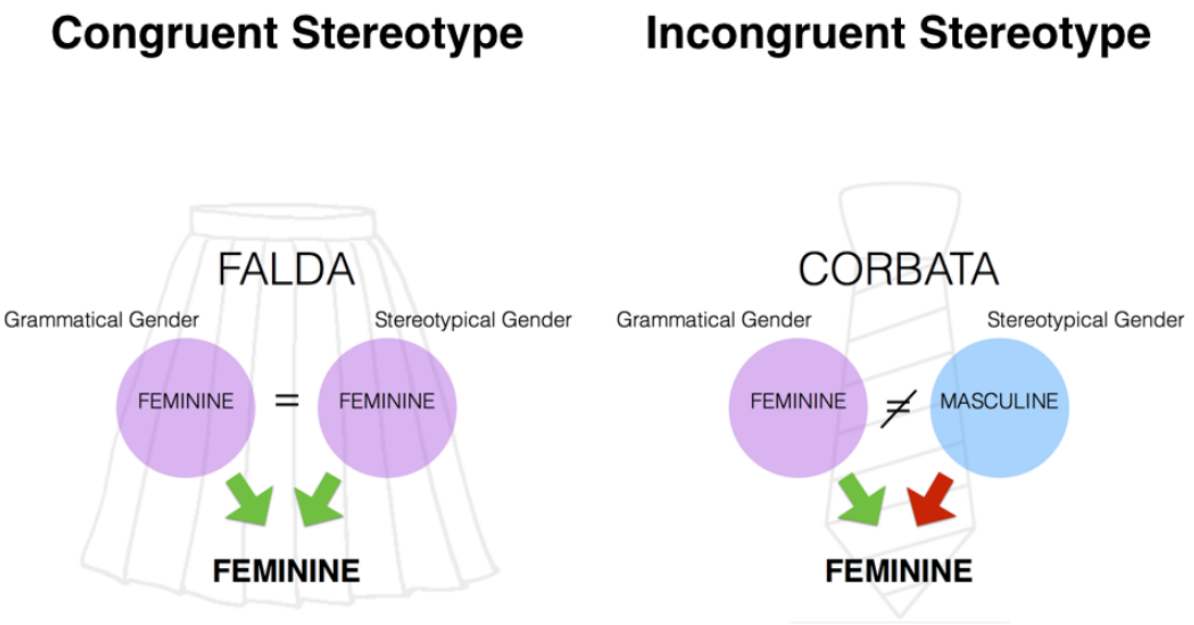

Figure 11. Diagram of the interaction between the grammatical and the stereotypical gender, when congruent (at the left) and when incongruent (at the right).

Finally, we designed the experimental tasks to include speakers of the two sex groups, that is, a male and a female, to explore whether the way the information is presented influences linguistic processing. The results showed that when direct attention was paid to the gender feature (i.e., during the gender decision task), faster responses were given when the sex of the speaker — particularly when the speaker was female— matched the grammatical gender of the word (feminine gender), a finding that is similar to the results obtained by Vitevitch et al. (2013). The effect was potentiated when the words had a congruent stereotype relationship as opposed to an incongruent relationship. Interestingly, the effect was not replicated in the case of the neuter words, possibly because they lack the semantic information related to sex (see Figure 10). Overall, it appears that the neuter words are more readily accessed than those with an associated stereotype, as evidenced by the response times observed in the present study. It is possible that the faster lexical access may have masked the influence of the sex of the speaker, which may be so fast that we were behaviorally unable to detect it. Still, it is important to note that the role of the sex of the speaker appeared to affect the grammatical gender rather than the stereotypical gender, and that the effect disappeared during the lexical decision task. This implies that the contextual effect created by the identification of the sex of the speaker was driven by the requirements of the task, and that the bias occurs at a lexico-syntactic level instead of a purely semantic level, as we predicted on the basis of the findings of Bender et al. (2016b) and Molinaro et al. (2016).

In conclusion, it is important to take into account the existence of complex relationships between the different sex levels present in the context of speech communication. The main finding presented here is that the grammatical gender feature is activated during the processing and lexical access of isolated words, and that this information interacts with the semantic information related to sex in the stereotypically gendered words; the associated stereotype allowed the purely arbitrary gendered words to operate in a similar way to the semantically gendered words, which have a biologically sexed referent (Bender et al., 2016b). However, the effect of the stereotype was weaker than expected, and even though this semantic information is accessed earlier than the lexico-syntactic features (Thierry et al., 2003), the sex role of the participant and the sex of the speaker had a much stronger impact on the processing of grammatical gender than on the stereotypical gender. However, the

participants' sex role identification appears to modulate the processing of words in which there is a match between grammatical gender and their own sex role representation, an effect that is stronger for words in which there is a congruent relationship between grammatical and stereotypical gender. In addition, the sex of the speaker biases more strongly the processing of words with grammatical gender when there is a congruent stereotype relationship in comparison with when there is an incongruent or neutral relationship, but only when direct attention to the gender feature was required. In future studies it could be of interest to include role-names — which are semantically gendered but can have a stereotype of the opposite sex group — to explore whether the stereotype overrides the biological sex information carried by grammatical gender, and compare the effect of the stereotype with that of generic gender.

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APPENDIX 2

Feminine Stereotype - Feminine grammatical gender

braga - *panties*

coleta - *ponytail*

compresa - *sanitary towel*

diadema - *hairband*

faja - *girdle*

falda - *skirt*

horquilla - *hairpin*

melena - *long hair*

moda - *fashion*

muñeca - *doll*

pamela - *pamela hat*

rosa - rose

Masculine Stereotype- Feminine grammatical gender

armadura - *armour*

barba - *beard*

caza - *hunting*

corbata - *tie*

escopeta - *shotgun*

espada - *sword*

gorra - *cap*

pajarita - *bow tie*

pelota - *ball*

perilla - *goatee*

rodillera - *kneepad*

sotana - *cassock*

Neuter Stereotype- Feminine grammatical gender

acera - *sidewalk*

bombilla - *light bulb*

cama - *bed*

carpeta - *folder*

chimenea - *fireplace*

ducha - *shower*

estantería - bookshelf

lámpara - *lamp*

mesa - *table*

puerta - *door*

silla - *chair*

ventana - *window*

Feminine Stereotype- Masculine grammatical gender

bolso - *hand bang*

cepillo - *brush*

coletero - *scrunchie*

cosmético - *cosmetic*

decorado - *theatre set*

fregadero - *sink*

ganchillo - *crochet*

lazo - *bow*

liguero - *suspender belt*

moño - *bun*

plumero - *feather duster*

vestido - *dress*

Masculine Stereotype- Masculine grammatical gender

arado - *plough*

astillero - *shipyard*

barco - *ship*

bolo - *skittle*

boxeo - *boxing*

calzoncillo - *underpants*

escudo - *shield*

puñetazo - *punch*

puro - *cigar*

remo - *oar*

serrucho - *hand saw*

tejado - *roof*

Neuter Stereotype- Masculine grammatical gender

arbusto - *bush*

bolígrafo - *pen*

cuadro - *painting*

despacho - *office*

disco - *disc*

lavabo - *sink*

libro - *book*

mechero - *lighter*

periódico - *newspaper*

plato - *plate*

suelo - *floor*

teléfono - *phone*

Experimental Series III: Experiment 7, The Influence Of Sex Information Into Spoken Words: A Mismatch Negativity (MMN) Study.[3]

The experimental series I and II showed that the grammatical gender knowledge is stored at the lexical level, and its part of the noun mental representation of the semantic as well of the arbitrarily gendered words. The sex-role of the addressee modulates the way concepts related to gender are encoded and organized, given more salience through stronger connexions to those concepts that share the grammatical gender feature with their own sex. Apart from the biological gender, other kinds of sex knowledge also modulate the processing of the grammatical gender; the stereotypical gender is a social knowledge related to male and female roles, and this semantic information works in a similar manner as the semantic gender, where the grammatical gender assignment is directly related to the biological sex. In this specific case, the added sex knowledge included in the stereotypical words preactivated the grammatical gender information, allowing a faster selection of the grammatical gender when the sex and gender information match and a slower access to the grammatical gender when they mismatch. The sex knowledge can be also present during speech communication in the form of the sex of the speaker. One of the main aims of this dissertation is to explore the role of the sex of the speaker during gendered words processing; so far the results have shown that the identification of the sex of the speaker takes part similarly in the visual as well as in the auditory modality, and that when direct attention is payed to the grammatical gender feature, the sex of the speaker works as a context clue modulating the processing of low-level lexico-syntactic information such as the grammatical gender. When the grammatical gender agrees with the sex of the speaker there is a faster processing due to stronger activations of words of the same gender, and this stronger activation leads to an interference bias when the sex of the speaker and the gender disagree. However, this effect is only present behaviorally when the task requires to explicitly process the grammatical gender. Similarly, Boutonnet et al., (2012) reported some effects regarding the grammatical gender shown by the ERP components even the effect did not manifest itself behaviorally. This data lead us thinking that the expected gender effect regarding the sex of the speaker may arise automatically and

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[3] **Published:** Casado, A., & Brunellière, A. (2016). The influence of sex information into spoken words: a mismatch negativity (MMN) study. *Brain Research*, *1650*, 73-83. DOI: 10.1016/j.brainres.2016.08.039

unconsciously during lexical selection, and that the effect may be visible using electrophysiological techniques.

The EEG recording is able to capture the online processing of language and it is much more fine compared with the behavioral recording, whose data is not immediate and may not reflect the complexity of processing as well as more precise techniques such as EEG. Furthermore, with the use of ERP design is possible to time lock the brain response to a given target stimulus and be certain that what we see, the fluctuation in the electric response, is directly related to the person's reaction to the specific target. Given these advantages, we designed a mismatch negativity (MMN) study in order to explore the influence of the sex of the speaker on gendered word processing. The MMN component has been used as a marker of the lexical frequency of the words, besides, it responds to sensory and lexical differences, to semantic and syntactic errors and to the conceptual meaning of words (Hasting, Kotz, & Friederici, 2007; Menning et al., 2005; Pulvermüller, Shtyrov, Hasting, & Carlyon, 2008; Pulvermüller, Shtyrov, & Hauk, 2009; Shtyrov, Kimppa, Pulvermüller, & Kujala, 2011). Therefore, it is the perfect ERP component to explore whether the sex of the speaker bias the activation of memory traces of words that match or mismatch in gender.

Abstract

When exposed to a spoken message, a listener takes into account several sources of linguistic and indexical information. Using the mismatch negativity (MMN) response, we examined whether the indexical information about the sex of the speaker influenced the processing of semantically gendered spoken words. Female participants listened two semantically gendered French words, one masculine and one feminine representing human beings, said either by five male or by five female speakers. The opposite sex voices produced an enhancement of MMN response. In line with interactive connections between indexical and linguistic information processing through activating lexical memory traces, the results showed more pronounced MMN response when the sex of the speaker matched with the gender of the word. Furthermore, there was a later detection of

the incongruence between the sex information about the speaker and the gender of the word, shown by an enhancement of MMN response. Overall, these findings suggest that the listeners integrate the indexical information about the sex of the speakers both at the lexical selection level and at a higher-level processing such as the grammatical access.

Introduction

In daily speech communication, speakers exchange a spoken message with listeners and the sex information can be expressed at three levels, the listener and the speaker, who are biologically sexed, and the sex of the entity represented by the words, categorized by the gender. An intriguing question is to know the interrelation between the three levels of sex information in speech communication (listener, speaker and gender of words). At a very young age, children become aware of their sex and they adapt their behaviors according to the role of males and females depending on their own sex by adopting moral values and attribute of members of the sex that they identify as their own. The gender schema theory (Bem, 1983) proposes that children learn to encode and to organize information in terms of an evolving gender schema beyond the simple biological distinction, and they use this information to create the concept of them-selves directly related to the gender role. The specific gender role assumed is mostly reflected by the sex of the listener, and concepts in memory thus strongly differ between sex groups. Additionally, in speech communication, the message received by the listener activates two routes of information processing (Belin, Fecteau, & Bedard, 2004; Belin, Bestelmeyer, Latinus, & Watson, 2011), the indexical information processing coming from the voice acoustic analysis (i.e. information about the sex of the speaker, height, accent, and emotional state) and the linguistic information processing (lexical, grammatical and semantic information about the words). Regarding indexical information, the most important feature to extract the sex of the speaker thanks to the voice is the fundamental frequency (F0). As proposed by the dual-route model (Sumner, Kim, King, & McGowan, 2013), the information about the speaker's sex could be integrated in the processing of words at sub-lexical and lexical levels. Moreover, the grammatical gender appears as a need to mark in language the biological sex distinction (Arias, 1990).

Corbett (1991) distinguished two language systems according to how the gender is coded. English, for example, belongs to the *semantic gender* system in which the gender code is only applied for those linguistic elements having a biological gender referent (brother/sister). On the contrary, the *formal gender system*, applies the gender distinction to every noun, having or not biological sex referent. Romance languages such as French distinguish between semantically gendered words (when the referent is a biological entity and there is a direct relation between gender and sex distinction, i.e.: *frère*— brother, *sœur*— sister) and arbitrary gendered words (when there is no direct correspondence between the gender distinction and the sex dimension, i.e.: la *voiture*— car, feminine word*, le bateau*— boat, masculine word).

There have been some attempts to explore the inter-relation between the three levels of sex information. For instance, Andonova, D'Amico, Devescovi, and Bates (2004) designed a behavioral study to explore the influence of the listeners' sex over the processing of gendered words. They used a gender decision task in which female and male listeners had to decide the grammatical gender of a series of words spoken by a female speaker. The results showed facilitation over the selection of the word's gender when there was a match between the sex of the listener and the gender of the word and this facilitatory effect was stronger for female as compared to male listeners. Even though the authors selected both arbitrary and semantically gendered words (281 arbitrary and 105 semantically gendered), an analysis exploring the impact of the different kinds of gender (arbitrary vs. semantically) was not performed. To interpret their main findings, the authors suggested the role of the episodic memory at which the lexical frequency of words would be biased by the sex of the listener, that is, people are more used to hear (in the second and third person) and produce words (in the first person) related to their own gender, and they would pay more attention to this specific set of words. The sex of the listener can also affect the way that listeners process voices of the opposite sex. Indeed, a series of experiments explored the interaction between the sex of the listener and the sex of the speaker by using event-related potentials (ERP) and functional magnetic resonance imaging (fMRI). In particular, Li et al. (2014) performed two ERP experiments to explore the processing of opposite-sex voices compared to same-sex voices regarding the sex of the listener. In the first experiment, participants had to indicate the sex of speakers producing a Chinese monosyllabic word (/hie4/, hey). They found that the

ERP amplitude of a positive deflection elicited by the opposite sex voices was stronger than that to the same-sex voices over parieto-occipital recording sites around 750 ms after the voice onset. In their second experiment during which participants had not to pay attention to the sex of the speaker but to a pure tone intercalated among the repeated presentation of the monosyllabic word. In the latter case, no significant ERP differences were found for the opposite sex voices as compared to the same-sex voices. Similarly to the first experiment in the study by Li et al. (2014), Junger et al., (2013) used a task in which participants were asked to indicate the sex of the speakers during the listening of words. By designing a fRMI experiment, they found stronger activation in a fronto-temporal network in response to voices of the opposite sex compared to voices of the same sex.

The information about the sex of the speaker may be accessed almost at the same time as the meaning of the linguistic elements and both kind of information can be integrated at early stages of processing (Lattner & Friederici, 2003; Van Berkum, Van den Brink, Tesink, Kos, & Hagoort, 2008). Furthermore, from the features of voice, such as regional accent, age, social status, and sex, inferences are computed about the linguistic information, leading to modulate the incoming lexical and semantic processing (Brunellière & Soto-Faraco, 2013; Van Berkum et al., 2008). More specifically, in a behavioral study (Vitevitch, Sereno, Jongman, & Goldstein, 2013), it was tested whether the sex of the speaker could influence the grammatical processing. Vitevitch et al. (2013) used a gender decision task during which participants heard masculine and feminine Spanish words. It was required to decide the gender of the word that they had heard. The words were mostly arbitrary gendered (73 arbitrary and 7 semantically gendered) and were said by a male or a female speaker. The results showed that when there was a match between the sex of the speaker and the gender of the word, participants produced faster and more accurate responses than when there was a mismatch between the sex of the speaker and the grammatical gender of the word. It is to be reminded that the majority of the presented words referred to inanimate entities and the gender assignment was not related to sex. They interpreted their results as the acoustic information about the sex of the speaker influencing the processing of high-level information related to the gender feature per se.

It appears thus that the three levels of sex information (listener, speaker and gender of the word) may interact in speech communication. On the one hand, the listener, the person processing the message belongs to either the male or female biological sex group. Their own definition of maleness and femaleness may depend on their own experience (Bem, 1983) and can determine the way people process gender words (Andonova et al., 2014). Besides, the listeners' sex can bias the processing of opposite sex voices (Junger et al., 2013; Li et al., 2014). On the other hand, the information about the sex of the speaker influences the processing of the linguistic information (Van Berkum et al., 2008; Vitevitch et al., 2013), including the grammatical processing of gender. According to the memory traces theory, it is proposed that there are connected assemblies of cortical neurons specified for every word in lexicon in the long-term memory (Pulvermüller et al., 2001; Pulvermüller & Shtyrov, 2006). Such lexical traces are the consequence of the frequent use of words in both perception and production, which links neurons into circuits with strong internal connections through an Hebbian associative learning (Hebb, 1949). Following this theory, the listener may have specific memory traces for the sex concept mostly depending on his own sex group (Bem, 1983), creating a particular and adapted indexical (the sex of the speaker) and linguistic information processing (like, grammatical gender). More exactly, when a person classifies herself into the female group, the memory traces of feminine words would be more strongly connected than the masculine words due to the frequent use of feminine words, leading to a higher activation for feminine words (see, Andonova et al., 2004). Interestingly, three stages are usually described during the spoken-word recognition: initial contact, word selection and word integration (the Cohort model, Marslen-Wilson, 1987). After eliminating the mismatching lexical candidates with the input to obtain the selection of a word, the semantic and syntactic information of the recognized word is mapped onto the contextual information during the word integration. First, during the activation and the selection of lexical candidates, the sex of the speaker could bias the access to the memory traces of words that vary in gender, such that when the information is said by a female speaker the memory traces for the feminine words would be more activated, as compared to the masculine words. In line with some studies showing that inferences driven by the features of voice are computed about the upcoming words (Brunellière & Soto-Faraco, 2013; Van Berkum et al., 2008), we expected a lexical priming effect due to the sex of the voice. Another important aspect to take

into account is the interference effect when the mismatch between the sex of the speaker and the gender of the word (Vitevitch et al., 2013) is detected thereafter at higher levels of semantic and grammatical information during word integration. Indeed, when there is mismatch between the sex of the speaker and the gender of the word, the listeners may detect the incongruence between the sex information carried by the voice and the grammatical information present in the word as the gender.

To explore the interaction of the sex of the speaker and the gender of the word through the memory traces in lexicon, we probed the mismatch negativity (MMN) component (Näätänen, Gaillard, & Mäntysalo, 1978; Näätänen, Paavilainen, Rinne, & Alho, 2007) by measuring electrical brain activity. The MMN is an indicator of experience-dependent memory traces in the brain. This component is evoked when an unusual stimulus ("deviant") is occasionally presented in a sequence of frequently-occurring stimuli ("standard"). Such paradigm composed of deviant and standard stimuli is called *oddball,* during which the participants usually perform a passive listening to the stimuli while their attention is focused on a silent movie. Interestingly, Pulvermüller et al. (2001) demonstrated that when a word is presented as a deviant in an oddball design, the representation of this memory trace is active and the brain activity is enhanced for words compared to when pseudowords are presented as deviant. Moreover, when manipulating the lexical frequency of words, words with higher-lexical frequency produced stronger MMN responses compared to low-frequency words since the active neurons into neuronal circuits are more strongly connected for the higher-frequency words (Shtyrov, Kimppa, Pulvermüller, & Kujala, 2011). Moreover, even if the MMN component appears as an indicator of sensory and lexical differences through experience dependent memory traces, this component is also sensitive to semantic and syntactic errors (Hasting, Kotz, & Friederici, 2007; Menning et al., 2005; Pulvermüller, Shtyrov, Hasting, & Carlyon, 2008) and to the conceptual meaning of words (Pulvermüller, Shtyrov, & Hauk, 2009). Differently to a consequence of the frequency of use of words in both perception and production, in case of semantic and syntactic errors, the amplitude of MMN was enhanced by the semantically and syntactically incorrect forms in comparison with the correct forms, suggesting that the MMN can reflect the processing of higher linguistic levels, as the checking of semantic and syntactic features between words.

In this experiment, we examined the influence of the sex of the speaker on the processing of semantically gendered spoken words by controlling the sex of the listener. Only female participants were selected in order to have a shared definition of maleness and femaleness for one same sex. Importantly, to make sure that the listener extracted the sex of the speaker as a general feature beyond the acoustic features of voices, we used ten different speakers, five males and five females (for similar approaches, Deguchi et al., 2010, Van Berkum et al., 2008; Weston et al., 2015). We selected two semantically gendered words in French making reference to human beings, for which there is a direct connection between the biological sex and the gender given to these words. It is important to note that two grammatical genders, masculine and feminine are expressed in French and when the word represents a human being, the masculine gender is used to describe both the group of males and females (Académie Française, 2002; Baudino, 2001). Since the sex of the speaker was employed as a prime, the sex of the speaker remained the same in each block while the gender of the word changed between the standard and deviant stimuli. In that way, any MMN effect could not be due to the changes in voices but to the changes in the gender of the word. An example of one experimental list is displayed in Table 4.

As all the listeners are females, we could expect stronger connections in memory traces for feminine words due to their frequent use (Shtyrov et al., 2011), which translates in stronger MMN responses to the feminine word compared to the masculine word (Andonova et al, 2004; Bem, 1983). About the interaction between the sex of the speaker and the semantically gendered words, we expected that this interaction could act both at a lexical level and at higher levels, including the processing of the semantic and the syntactic information during word integration. In line with a lexical priming effect due to the sex of speaker (Brunellière & Soto-Faraco, 2013; Van Berkum et al., 2008) during word recognition, the sex of the speaker will bias the access to the memory traces of words that vary in gender, such that when the sex of the speaker information is in accordance with the gender of words, the memory traces would be more activated (e.g. a female speaker for the feminine words) as compared to an incongruent condition (e.g., in the former example, the masculine words). According to the lexical effect of the MMN component through the

activation of memory traces (Pulvermüller et al., 2001; Shtyrov, et al., 2011), we should have greater MMN responses when there is a match between the sex of the speaker and the gender of the word (congruent condition) with respect to when there is a mismatch between the sex of the speaker and the gender of the word (incongruent condition). This pattern of finding would be observed independently of the sex of the speaker. Additionally, at a later timing during the word integration (Marslen-Wilson, 1987), we envisaged a detection of the mismatch between the sex of the speaker (the context information) and the grammatical gender of the word (the syntactic level) during the processing of the incongruent condition (Vitevitch et al., 2013). Similarly to the previous MMN studies showing syntactic MMN effects when the stimuli were composed of a context and a target word (Hasting et al., 2007; Menning et al., 2005; Pulvermüller et al., 2008), we expected greater MMN responses when there is a disagreement between the sex of the speaker and the gender of the word as compared to when there is a match between the sex of the speaker and the gender of the word, and that independently of the sex of the speaker. Furthermore, we explore whether the brain activity of female participants induced by the male voices (opposite-sex voices) would be greater compared to that induced by the female voices (same-sex voices) in a passive auditory oddball paradigm.

Methods.

Participants. Nineteen French native female students from the University of Lille (mean age = 22.1, range = 19-32, SD = 3.1) participated in this study. The participants didn't have any kind of hearing impairment, uncorrected visual impairments, and language nor neurological impairments. All participants were dominant right-handers, as assessed by the Oldfield laterality test (Oldfield, 1971). They participated voluntarily and gave their informed consent in accordance with the approval of the Ethics Committee of the University Lille 3. Three participants were removed after the EEG preprocessing due to a high number of artifacts produced by movements and eye-blinks.

Table 4. *Example of an experimental condition*

	Standard Stimulus	**Deviant Stimulus**
Block1	Male voices- Masculine word	Male voices- Feminine word
Block2	Male voices- Feminine word	Male voices- Masculine word
Block3	Female voices- Masculine word	Female voices- Feminine word
Block4	Female voices- Feminine word	Female voices- Masculine word

Materials. Two semantically gendered French words were selected from the *Lexique* database (New, Pallier, Brysbaert, & Ferrand, 2004), one masculine grammatically gendered, that is, “chanteur” (*singer*) and the other belonging to the feminine grammatical gender, i.e., “chanteuse” (*singer*). The selected words are singular nouns, and contain two syllables. The lexical frequency was equivalent for “chanteur” and “chanteuse”, respectively 9.80 and 7.81 occurrences per million words from French subtitles corpora of films (New et al., 2004), accessible on the *Lexique* website (www.lexique.org). The recognition point of the two selected word is situated immediately after the /t/ phoneme (Marslen-Wilson & Welsh, 1978) such that the gender of selected words could be accessed only after it. In order to facilitate the cross-splicing procedure for controlling potential clues of the first syllable due to coarticulation phenomena, the second syllable began by an occlusive sound, the /t/ phoneme.
To include a great variability in the auditory stimuli, the two words were recorded by five different male speakers and five different female speakers. All speakers were native French speakers. Following this approach, by introducing a high acoustic variability in the auditory stimuli, the expected MMN response to deviant stimuli should be elicited by the sex of the speaker as a general feature, and not to the unique acoustic feature of a given voice (Deguchi et al., 2010, Van Berkum et al., 2008; Weston et al., 2015). The sound recording took part in a sound proof room with an unidirectional microphone. We used the recording of a female French speaker as a model, to help the ten different speakers to control their rhythm and their intensity in word production at the same level. The ten different speakers were exposed to the recording of the critical words, plus the “chantage” word (*blackmail)* said by the model. After the listening, they were asked to read them aloud several times. The recording of auditory stimuli was digitized at a sampling rate of 44,100 Hz with 16-bits. The third word, the “chantage” word (*blackmail)* allowed to perform a cross-splicing procedure by extracting the /ʃɑ̃/ first syllable from the “chantage” word, then by coping it onto the /tœʁ/ and /tøz/ segments to create respectively the masculine word (*chanteu*r) and the feminine word (*chanteuse*). More exactly, once the first syllable /ʃɑ̃/ was selected for each speaker, we added a silence of 81ms (mean duration of the silence between syllables of chan-teur and chan-teuse) and, then the respective segments to create the masculine word (*chanteur*) and the

feminine word (*chanteuse*) for each speaker. An example of the masculine word (*chanteur*) and the feminine word (*chanteuse*) for one speaker is shown in Figure 12.

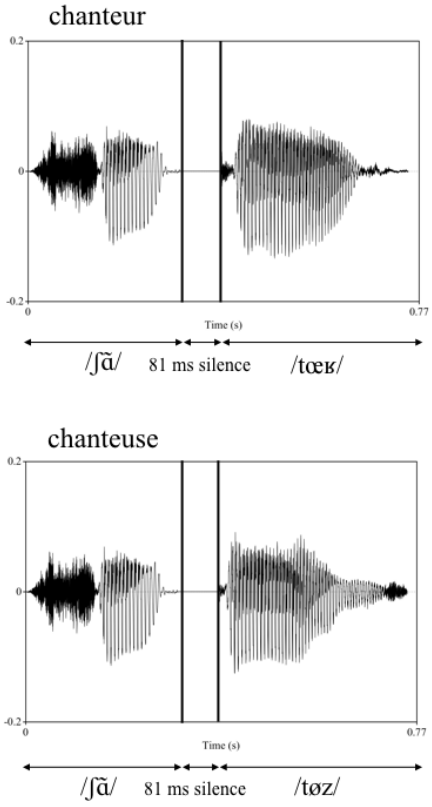

Figure 12. Oscillogram of the two gendered words spoken by the same male speaker (at the top, the masculine word "chanteur" and at the bottom, the feminine word "chanteuse"). Both words shared the same first syllable (/ʃɑ̃/) and the same silence duration, and differed only from the second syllable (/tœʁ/or /tøz/).

The second syllable of each recorded word was normalized in duration across speakers, such that the duration of second syllables did not significantly differ according to either the sex of speakers ($t(9) = 1.5$, $p = .16$); or the gender of words ($t(9) = 1.9$, $p = .08$). By using the software AdobeAudition, the function "volume coincidence" was used to normalize the perceived dB of the first and the second syllable. To measure the volume (mean dB) of each second syllable, we used the mean dB of the vocal instead of the total of the syllable, because the difference in energy between the consonants /r/-/s/ were very reliable. The mean volume (dB) of the second syllables did not differ significantly between the sex of speakers ($t(9) = 0.6$, $p > .2$) and the gender of words ($t(9) = -0.6$, $p > .2$). As expected, the fundamental

frequency significantly differed on the sex of speakers (mean value for female speakers: 219.9; male speakers, 135.4; ($t(9) = 7.2$, $p < 0.0001$) but was equated for the gender of words ($t(9) = -0.5$, $p > .2$).

The experiment consisted of 4 blocks (see, Table 4). Each block contained 600 standard words said by 5 different speakers within one sex of speakers, and 100 deviant words said by the same 5 speakers. The standard stimulus, the more frequent word, appeared the 87% of times and the deviant stimulus, that is, the less frequent word, appeared the 13% of times. In each block, there was a time delay of 1 second between words. The order of stimuli was pseudorandom in each block, such that there were at least two standard stimuli between two deviant stimuli. The approximate duration in each block was 15 minutes. The first two blocks always were presented with speakers of one sex and the last two blocks were presented with speakers of the other sex (see, Table 4). Four experimental lists were created in order to counterbalance the order of presentation of the blocks. Even if the presentation order of one block varied across the experimental lists, the four different conditions (feminine word-female voices; feminine word-male voices; masculine word-female voices; masculine word-male voices) were always included in each experimental list.

Procedures. Participants sat in front of a computer with the EEG cup recording their brain activity. They were presented the auditory words while they watched a silent movie. They were asked not to pay attention to the series of auditory words but to focus on the movie. In order to regulate their fatigue and their vigilance, participants were asked to play a little game with the experimenter that lasted around 5 minutes between each block. At the end of the experiment, they had to fill a form in a Likert type scale from 1 to 7 where they had to estimate some properties about the two critical words of the experiment, such as the imageability, the familiarity, the concreteness and which part of their body is more related to the word. The imageability, the familiarity and the concreteness was equivalent between the "chanteur" word and the "chanteuse" word (respectively, imageability: mean = 5.66, SD = 1.49; mean = 5.47, SD = 1.47; familiarity: mean = 6.36, SD = 0.95; mean = 6.36, SD = 0.95; concreteness: mean = 6.13, SD = 1.03, mean = 6.04, SD = 1.13). Participants gave the same

part of their body related to the “chanteur” word and the “chanteuse” word, corresponding to the mouth. The total duration of the experiment was approximately 2 hours.

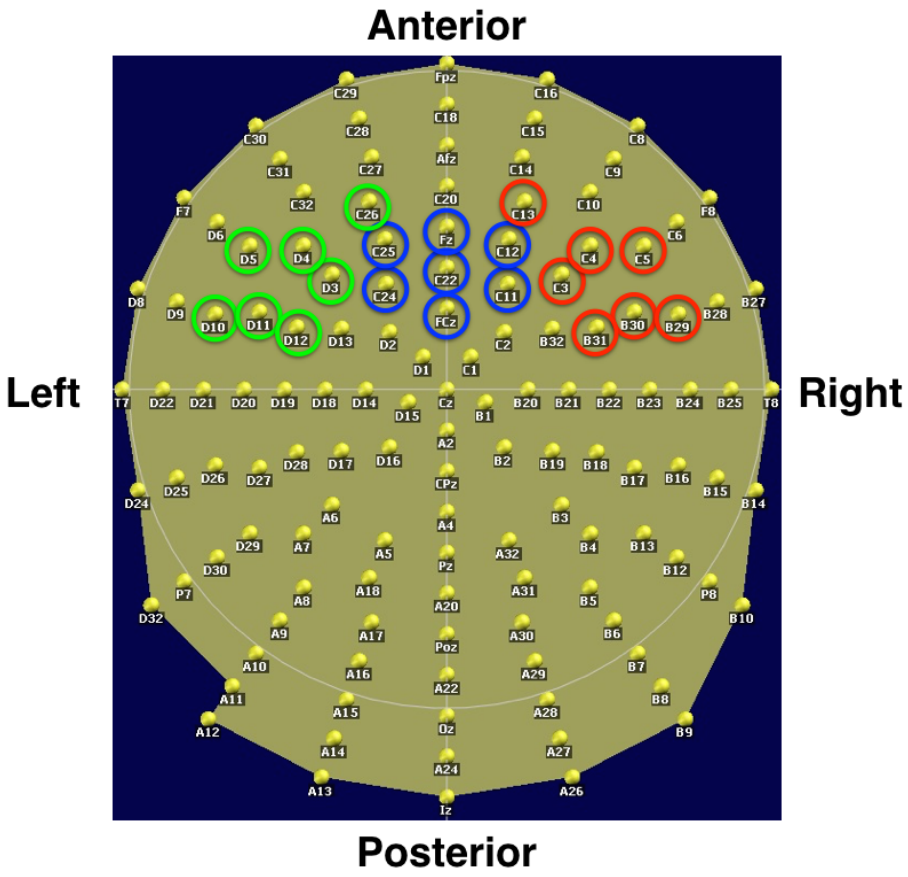

Figure 13. Topographical map of the 88 electrodes across the scalp. The selected frontocentral electrodes were divided in three topographical sites: left side in green, midline in blue, and right side in red

Electrophysiological recording. The electrical signal (sampling rate: 1024 Hz) was recorded during the auditory stimulation with a 128-channel BioSemi ActiveTwo AD-box. Two external electrodes were used to measure the ocular activity (the electrodes were placed at the vertical and horizontal lines of the right eye) and other two external electrodes were used to measure the mastoid activity (at the bone behind both ears). The ocular electrodes were used to remove the artifacts produced by eye-blinks automatically and the mastoid electrodes were later applied as an external off-line reference. First, individual electrodes were adjusted to a stable offset lower than 20 mV during the EEG recording. The offset values were the voltage difference between each electrode and the CMS-DRL reference. Each EEG epoch started 100

ms before the onset of the second syllable and lasted 900 ms thereafter it. Then, we applied a band-pass filter of 1Hz and 30Hz and a notch filter of 50Hz and EEG epoch was corrected by a baseline of 100 ms before the onset of the second syllable. Thereafter, when the EEG activity was greater than 70μV of the absolute maximal amplitude deviation at any electrode, the EEG epoch was rejected. The mean of accepted epochs was equivalent between the four experimental conditions. More exactly, the mean of accepted epochs for the condition feminine word-female voices was 83.9 (SD = 9.7) as deviant and 496.7 (SD = 58.57) as standard; that for the masculine word-male voices condition was 80.3 (SD = 12.39) as deviant and 490 (SD = 67.98) as standard; that for the condition feminine word-male voices was 81.6 (SD = 13.22) as deviant and 476.7 (SD = 80.33) as standard; and finally for the condition masculine word-female voices the mean of accepted stimuli was 82.2 (SD = 10.41) as deviant and 490.3 (SD = 61.91) as standard. The ANOVA comparing the accepted epochs for the four different conditions is not statistically different for the deviant ($F(3, 60) = 0.21$, $p = .88$) neither for the standard stimuli ($F(3, 60) = 0.15$, $p = .92$) showing that the number of remaining trials did not differ across conditions. The EEG accepted epochs were averaged for each participant and each electrode across the four experimental conditions (feminine word-female voices, feminine word-male voices, masculine word-female voices and masculine word-male voices). Finally, the EEG signal was re-referenced offline to the arithmetic mean of the two mastoid recordings.

Data analysis. The MMN difference waves were obtained by subtracting the ERPs elicited by the same sound presented as the deviant and standard stimulus in the four conditions (e.g., masculine word-male voices deviant minus masculine word-male voices standard). This calculation, called "identity MMN" minimizes the possible influence of the physical stimuli properties on the MMN response (Pulvermüller & Shtyrov, 2006; Pulvermüller, Shtyrov, Ilmoniemi, & Marslen-Wilson, 2006). Similarly to previous studies (Brunellière, Dufour, & Nguyen, 2001; Pulvermüller et al., 2001; Shtyrov et al., 2011), we selected all Frontocentral electrodes to measure electrical changes in amplitude of the MMN responses (see, Figure 13). In addition, the selected electrodes were divided according to three topographical sites: Left (C26, D3, D4, D5, D10, D11, D12), Midline (C11, C12, Fz, C22, FCz, C24, C25) and Right (B29, B30, B31, C3, C4, C5, C13) in order to characterize the topography of the MMN response. To determine various time windows along the MMN responses, we focused on 40-

ms-wide time windows placed around the maxima of the peak amplitude of global field power (GFP) (Lehmann & Skrandies, 1980) based on 88 electrodes (not affected by the external artifacts). The measure of global field power (GFP) corresponds to the standard deviation between the EEG signal, and it quantifies the amount of activity at each time point in the field considering the data from all recording electrodes simultaneously resulting in a reference-independent descriptor of the potential field (Skrandies, 1990) (see Figure 14). The MMN response over the frontocentral electrodes was assessed by means of analysis of variance (ANOVA) conducted on the mean amplitude of the difference waves in the four following time windows: 170-210, 240-280, 315-355 and 630-830 ms. A last time window included a larger time range to explore possible late effects (for similar approaches, Brunellière, Dufour, Nguyen, & Frauenfelder, 2009; Korpilahti, Lang, & Aaltonen, 1995; Lattner & Friedericci, 2003; Van Berkum et al., 2008). For each time window, a mix-model with the software R statistics (R Core Team, 2015) was implemented by using the ANOVA function with a “Kenward-Roger" modification for F-tests (Halekoh & Højsgaard, 2014; Kenward & Roger, 1997). Each ANOVA was performed with the fitted factors, Sex of the Speakers (male vs. female), Grammatical Gender of the Word (masculine vs. feminine), and Topography (Left, Midline and Right) and with the random effects, participants and electrodes. When a significant interaction was found, post-hoc *t*-tests with Tukey multiple comparison correction were performed. In order to rule out the possibility that what observed after 0 ms is due to pre-target effects, we performed an ANOVA during -100 to 0 ms time window. The ANOVA revealed a main effect of the gender of the word ($F(1, 1299) = 33.18$, $p < .001$), showing that the amplitude of the MMN response was higher for the feminine (mean of voltage = 0.0002) word compared to that for the masculine word (mean of voltage = 0.003). From this analysis, we also found a significant interaction between the sex of the speaker and the gender of the word ($F(1, 1299) = 5.52$, $p = .019$) for which the post-hoc tests revealed no statistical differences regarding the sex of speaker for the feminine word ($t(1320,79) = -1.12$, $p = 0.3$) but significant differences regarding the sex of the speaker for the masculine word ($t(1320, 79) = 2.21$, $p = 0.02$). The masculine word produced more negative responses when presented with male voices (mean of voltage = -0.007) in comparison to when presented with female voices (mean of voltage = 0.17). More importantly, the pattern of the main effect of the gender of the word and that concerning the

particular interaction between the sex of the speaker and the gender of the word over the baseline period were never observed along critical time windows placed after the onset of second syllable. Consequently, we can rule out the possibility that the effects found over the baseline period might explain those that we observed over the critical time windows placed after the onset of second syllable. Moreover, a tentative hypothesis to explain the effects found over the baseline period may rest on the theoretical framework of predictive models. According to Winkler (2007) and Wacongne, Changeux, and Dehaene (2012), the MMN response results from the mismatch between the predictions produced by the neural representations extracted from the regularities of the acoustic environment and the incoming information. For instance, when participants repeatedly listened to the masculine word in an experimental block, they created a predictive model of this word all along the block even when the information about the gender of the incoming word was not yet available. Consequently, over the baseline period when the first syllable “chan” is processed, the MMN response for the deviant feminine word reflects the prediction of the masculine word presented repeatedly as a standard stimulus. The pre-activation of a word from the prediction and the recognition of a word produced the same effects, such that the prediction of the masculine word produced more negative responses compared to the prediction of the feminine word due to the greater weight of the generic gender. Moreover, the interaction between the sex of the speaker and the gender of the word only appeared when the feminine word was expected (i.e., the MMN response for the masculine word). In this case, the words presented with male voices (opposite sex voices) produced more negative responses compared to the female voices (same sex voices) probably due to the conflict between the expected word (feminine word) and the sex of the speaker. Nonetheless, the effect disappeared when expecting the masculine word because it could activate equally the generic concept with the male and the female representations.

Results.

Visual inspection of the data. The grand-average of MMN responses for the feminine and the masculine words are displayed respectively in Figures 15 and 16 over the selected frontocentral electrodes. For the feminine word, a first negative peak occurring around 200 ms, presented a higher amplitude over midline and left sites for the congruent condition

(feminine word-female voices) in comparison with the incongruent condition (feminine word-male voices). Thereafter, around 330 ms, we observed a greater MMN amplitude for the feminine word said by male voices, suggesting a detection of the incongruence between the sex of speaker and the gender of word particularly over right frontocentral electrodes. As seen in Figure 5, for the masculine word, the amplitude of the first negative response peaking around 200 ms was greater for the congruent condition (masculine word-male voices) in comparison to the incongruent condition (masculine word-female voices). This ERP pattern seemed to last until 280 ms. Then, around 330 ms, it appeared a stronger amplitude of MMN response for the incongruent condition (masculine word-female voices) compared to the congruent condition (masculine word-male voices) more particularly over the right and midline frontocentral electrodes, indicating a detection of the incongruence between the sex of the speakers and the gender of word.

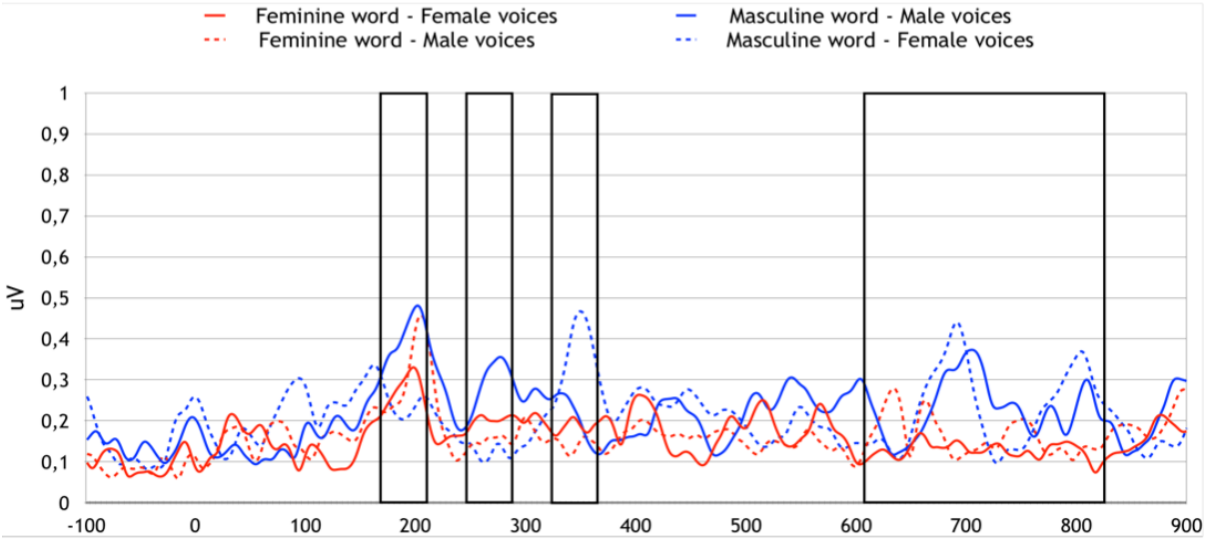

Figure 14. The global field power (GFP) of the MMN response time-locked to the onset of the second syllable in the four conditions of the experiment. The congruent conditions are represented in full lines and the incongruent conditions in dashed lines. The blue lines correspond to the masculine word and the red lines correspond to the feminine word. The black rectangles indicate the various selected time windows (170-210ms; 240-280ms; 315-355ms; 630-830ms).

Analysis of ERP data.

170 to 210 ms window. The ANOVA revealed a main effect of the Gender of the Word, $F(1, 1299) = 5.23$, $p = .02$, showing that the amplitude of the MMN response was higher for the

masculine word compared to that for the feminine word. Interestingly, there was a significant interaction between the Sex of the Speaker and the Gender of the Word, $F(1, 1299) = 25.5$, $p < .0001$. By performing paired *t*-test post hoc comparisons, it appeared that the MMN response to the feminine word was significantly higher for female voices (mean of voltage = -0.8) than male voices (mean of voltage = -0.5), $t(1320.79) = -2.84$, $p = .004$; and that the amplitude of the mismatch response was stronger for the masculine word when the word was said by male speakers (mean of voltage = -1.05) compared to when it was said by female speakers (mean of voltage = -0.6), $t(1320.79) = 4.3$, $p < .0001$. Hence, for both feminine and masculine gendered words, the MMN response was stronger for the congruent conditions between the gender of the word and the sex of the speaker in comparison with the incongruent conditions.

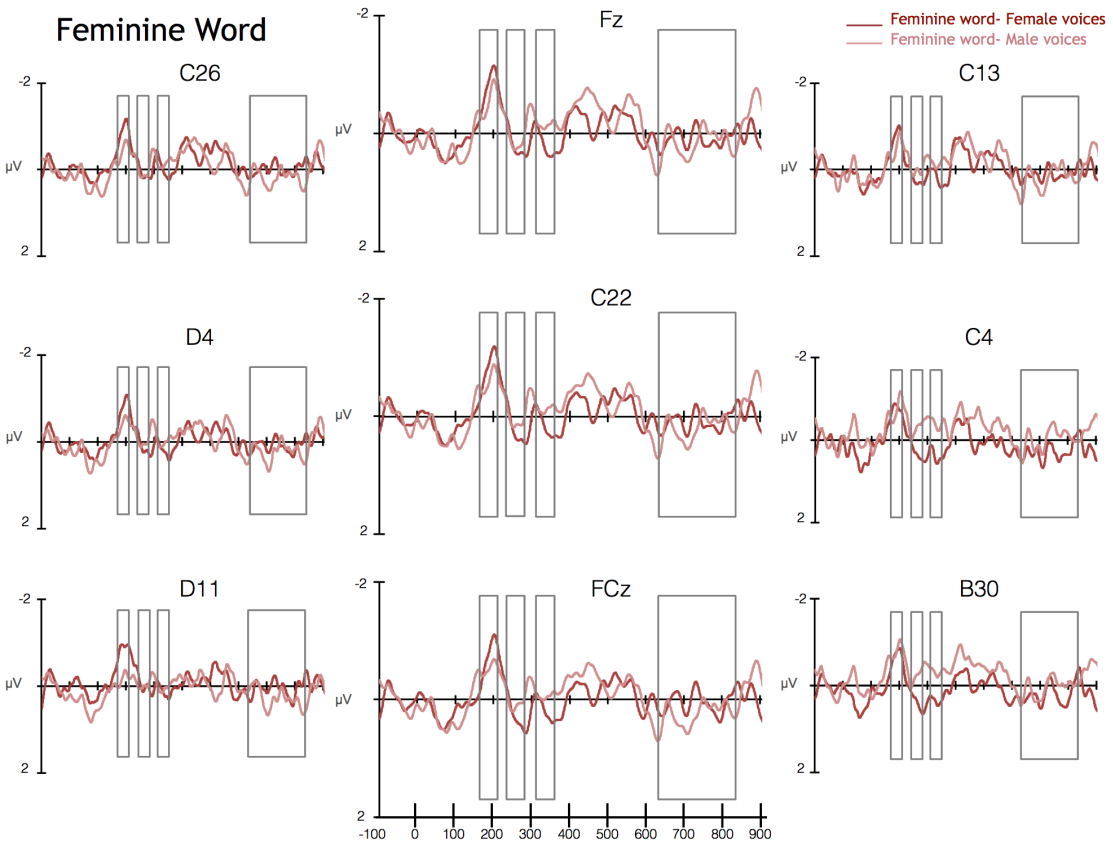

Figure 15. Grand-average waveforms for the MMN response time-locked to the onset of the second syllable for the feminine word. The congruent condition (feminine word-female voices) is represented with the darker lines and the incongruent condition (feminine word-male voices) is represented with the lighter lines. The black rectangles indicate the various time windows of interest (170-210ms; 240-280ms; 315-355ms; 630-830ms).

240 to 280 ms window. During this second time window, there was a main effect of the Sex of the Speaker, $F(1, 1299) = 87.3$, $p < .0001$. More exactly, the amplitude of the MMN response

was higher for male speakers compared to female speakers. There was also a main effect of the Gender of the Word, $F(1, 1299) = 100.3$, $p < .0001$. Similarly to the first time window, the amplitude of the MMN response was higher for the masculine word compared to the feminine word. The interaction between the Sex of the Speaker and the Gender of the Word appeared again during this time window, $F(1, 1299) = 18.3$, $p < .0001$. The post-hoc comparison revealed that the MMN response to the feminine word was stronger in the incongruent condition, that is, when the feminine word was said by male speakers (mean of voltage = -0.06) compared to when it was said by female speakers (mean of voltage = 0.28); $t(1320.79) = 3.58$, $p = .0003$. The masculine word elicited higher amplitude of the MMN response in the congruent condition, that is, when it was spoken by male speakers (mean of voltage = -1.06) in comparison with when it was spoken by female speakers (mean of voltage = -0.11), $t(1320.79) = 9.63$, $p < .0001$, as in the second time window.

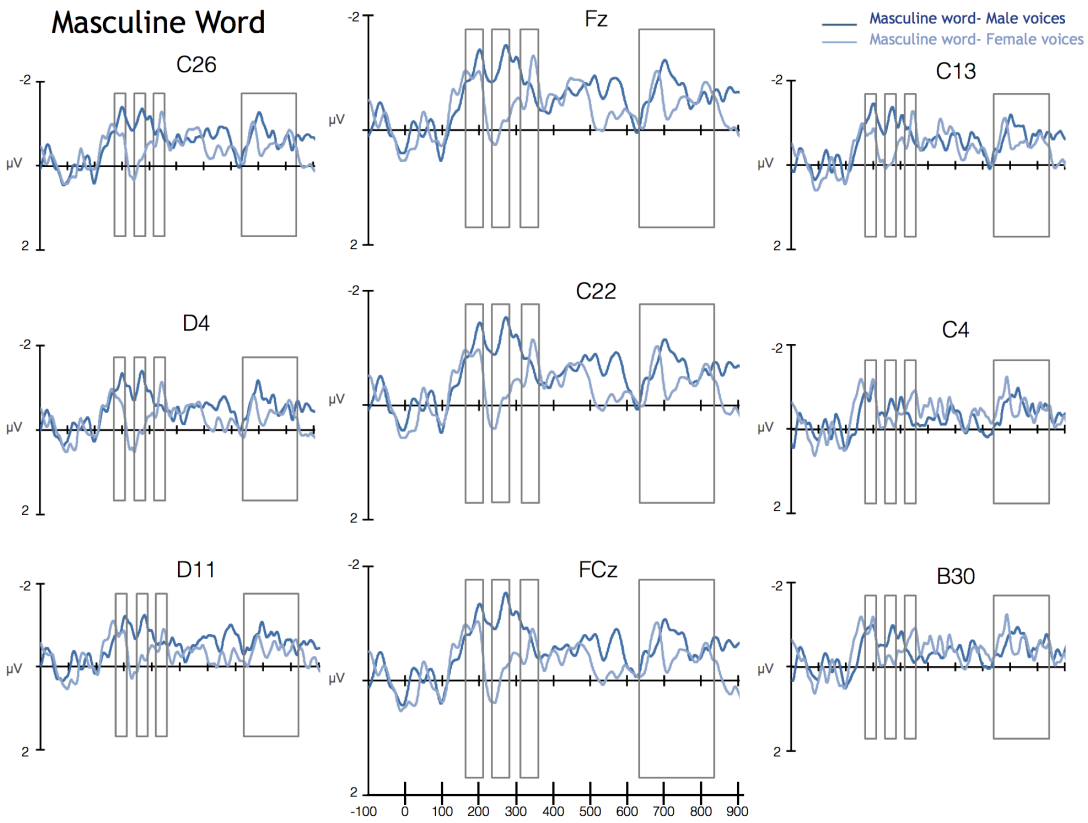

Figure 16. Grand-average waveforms for the MMN response time-locked to the onset of the second syllable for the masculine word. The congruent condition (masculine word-male voices) is represented with the darker lines and the incongruent condition (masculine word-female voices) is represented with the lighter lines. The black rectangles indicate the various time windows of interest (170-210ms; 240-280ms; 315-355ms; 630-830ms).

315 to 355 ms window. Over the third time window, we also found a main effect of the gender of the word, $F(1, 1299) = 121.1$, $p < .0001$. Again, the amplitude of the MMN response was higher for the masculine word compared to the feminine word. The ANOVA also revealed an interaction between the sex of the speaker and the gender of the word, $F(1, 1299) = 26.6$, $p < .0001$. Similarly to the second time window, for the feminine word, the *t*-test between male voices and female voices, $t(1320.79) = 4.96$; $p < .0001$, showed an incongruence effect, such that when the feminine word was presented with male voices the amplitude of the MMN response was higher (mean of voltage = -0.15) than when it was presented with female voices (mean of voltage = 0.27). Also, when the masculine word was presented with female voices, the MMN response was higher (mean of voltage = -0.7) in amplitude compared to when it was presented with male voices (mean of voltage = -0.5), $t(1320.79) = -2.33$; $p = .02$. Like for the feminine word, this latter pattern corresponded to the incongruence effect.

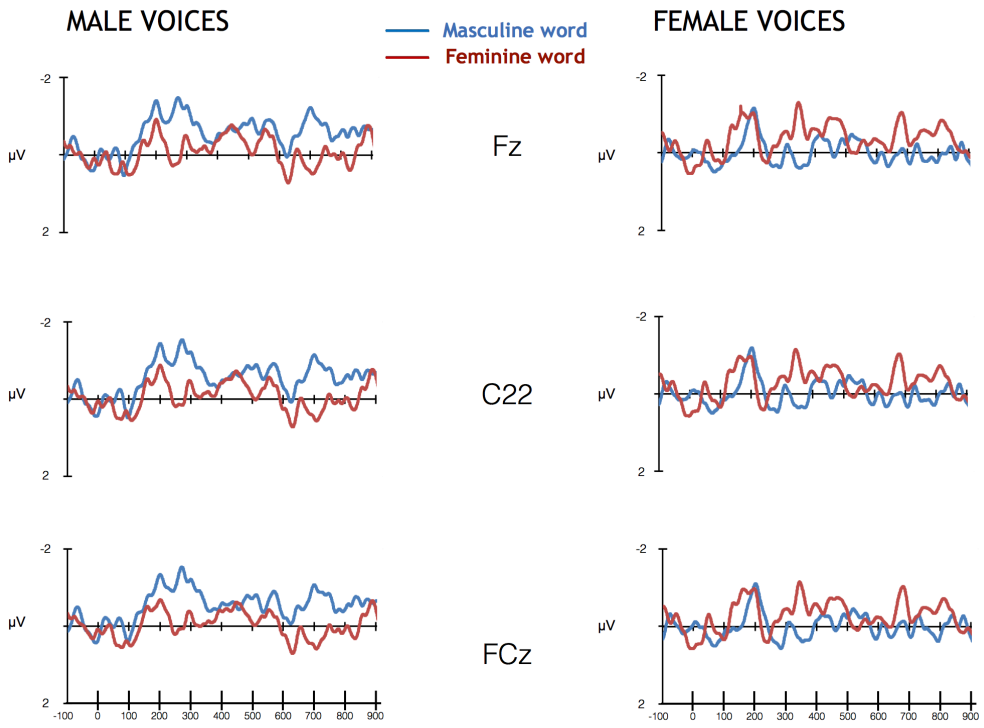

Figure 17. Grand-average waveforms for the MMN response time-locked to the onset of the second syllable for the mean voltage of the two conditions containing the masculine word (masculine word-male voices and masculine word- female voices) represented with a blue line, and the mean of voltage of the two conditions including the feminine word (feminine word- female voices and feminine word-male voices) represented in a red line. The black rectangles indicate the various time windows of interest (170-210ms; 240-280ms; 315-355ms; 630-830ms).

630 to 830 ms time window. During the last time window, there was only a main effect of the gender of the word, $F(1, 1299) = 174.7$, $p < .0001$, indicating that the amplitude of the mismatch negativity response was higher for the masculine word compared to the feminine word. See Figure 17.

Further analyses. Contrary to the first and third time windows, during which the interaction between the sex of the speaker and the gender of the word followed a similar and clear pattern for both the feminine word and the masculine word, over the second time window the effect was totally opposite between *t*he feminine word and the masculine word. We asked whether the unclear pattern of results obtained in the second time window could be explained by the generic gender. In French, the generic gender related to human beings is represented with the masculine form in the plural and singular forms. The masculine form either refers to men (specific use of masculine) or to both sexes. The masculine singular word, for example, "chanteur" refers to both male and female referents (Académie Française, 2002; Baudino, 2001). We performed an ANOVA comparing the MMN amplitude elicited by the feminine word-female voices condition to that elicited by the masculine word-female voices condition during the 240-280 ms time window in order to explore whether the female voices activate the female representation (female singers) included in the masculine word with the same strength as the female voices activate the female representation of the feminine word. The results showed that there were no significant differences between the two conditions, feminine word-female voices and masculine word-female voices, $F(1, 670) = 2.7$, $p = .09$. It seems that the masculine form includes the female group of singers due to the status of the generic gender, leading that the amplitude of MMN was not increased over the second time-window when there was a disagreement between the female voice and the masculine word. Furthermore, concerning the impact of generic gender, the stronger brain activity when hearing the masculine word compared to the feminine word could be explained by the double activation of the male and the female representation for the masculine form with respect to the activation of the female representation for the feminine word only.

Discussion

For the first time, the present study tracked the interaction between different levels of sex information during the processing of spoken words by using the MMN component, an electrophysiological index of experience-dependent memory traces. In particular, we explored whether the sex of the speaker influenced the processing of semantically gendered words in female listeners. The findings showed that the masculine word in comparison with the feminine word produced a stronger MMN amplitude across the whole of time range. Moreover, the detection of the opposite sex voices regarding the sex of the listener (i.e., male voices) produced greater MMN responses between 240 and 280 ms after the onset of the second syllable. Interestingly, the sex of the speaker biased the processing of words with grammatical gender. On the one hand, the MMN amplitude reflected the access level to lexical memory traces of gendered words shaped by the sex of speakers, such that the MMN amplitude was the strongest when there was a match between the sex of the speaker and the gender of the word from 170 ms after the onset of second syllable. On the other hand, after 300 ms, there was a detection of the incongruence when the sex of the speaker did not match with the gender of the word, shown by a greater amplitude of MMN response when there was a disagreement between the sex of the speaker and the gender of the word.

In this study, the sex of the listener was controlled by only selecting female participants. According to Andonova et al. (2004), in their daily life, people are more used to hear (in the second and third person) and produce words (in the first person) related to their own gender. The lexical frequency of gendered words thus would depend on the sex of the listener. Similarly to Shtyrov et al. (2011) showing that the higher-lexical frequency produced stronger MNN responses compared to low-frequency words, we predicted higher MMN responses for the feminine word with respect to the masculine word in this study since the active neurons into neuronal circuits for the feminine words should be strongly connected due to their frequent use by female listeners. However, the pattern of results was in the opposite direction, that is, greater MMN responses when processing the masculine word as compared to those when processing the feminine word. The higher brain responses to the masculine word in comparison with the feminine word can be explained by the status of the generic gender related to the masculine word. As mentioned above, the masculine form in French

refers to the generic gender for words representing human beings (Académie Française, 2002; Baudino, 2001). When hearing the masculine word, the listeners may activate the representation of both male and female singers, while after the listening to the feminine word, only the female representation of singers would be activated. Nonetheless, an alternative hypothesis could come from putative differences in terms of exposure frequency between the two words presented for which the masculine word would have higher exposure frequency than the feminine word. An additional questionnaire[4] about the subjective frequency of the words, including two types of instructions based on the previous studies by Desroches and Thompson (2009) and Ferrand et al. (2008), revealed that the listeners did not report to use more the masculine form of singer than the feminine form (for each instruction, "chanteur" mean = 4.8; SD = 1.4; "chanteuse" mean = 4.8; SD = 1.4). Consequently, differences in terms of exposure frequency between the two words presented may be excluded to explain the stronger MMN brain responses to the masculine word in comparison with the feminine word.

In addition to the role of the sex of the listener when processing gendered words, we explored the role of the sex of the listener when processing sexed voices. Prior studies (Junger et al., 2013; Li et al., 2014) have already shown a greater activation of the brain response when the listeners paid attention to voices of the opposite sex in comparison to voices of the same-sex. In a similar manner, our results showed that the male voices produced an enhancement of the MMN response compared to female voices between 240 and 280 ms after the onset of second syllable, suggesting that the female listeners reacted to the incongruence between the sex of the speaker and the representation of their own sex. Remarkably, this finding was found even though the task did not require a direct attention focused on the identification of sex of the speaker. Indeed, up to now, it had been described

[4]The participants were asked to complete a questionnaire about the subjective frequency of the words and about the stereotypical status regarding the role name "singer" (only 15 participants answered). Two types of instructions were used to examine the use frequency of "chanteur" and "chanteuse": one coming from Desroches and Thompson (2009)'s study (participants we asked to rate the frequency with which they produce and hear the words on a scale) and other coming from Ferrand et al. (2008)'s study (participants were asked to evaluate how many times they encountered the words during the listening and production of utterances). Additionally, we used two types of instructions to explore the stereotype, the Carreiras et al. (1996)'s procedure (participants were asked to indicate the proportion of men and women performing the profession of singer, "chanteur") and the Gabriel et al. (2008)'s procedure (participants were asked to indicate the proportion of males versus females in the role of singers). The mean subjective frequency was equivalent for the words ("chanteur" and "chanteuse") whatever the type of instructions and the ratings of stereotype regarding the role name "singer" indicated that the concept of "singer" was judged as a neutral concept.

that ERP differences between same-sex voices and opposite-sex voices were observed only when participants were instructed to determine the gender of voice (e.g., Li et al., 2014). The main objective of this study was to explore whether the information about the sex of the speaker influenced the processing of gendered words. We hypothesized that the sex of the speaker could bias the access to the memory traces of gendered words, such that when the information is spoken by female speakers, the memory traces for the feminine words would be more activated compared to the masculine words. Following the same hypothesis, when the information is spoken by male speakers, the memory traces for the masculine words would be more activated, compared to the feminine words. Between 170 and 210 ms after the onset of second syllables, we found a MMN response reflecting the access level to the memory traces of gendered words influenced by the sex of speakers. Indeed, the MMN response was enhanced when there was a match between the information about the sex of the speaker and the gender of the word as compared to when there was a mismatch between the sex of the speaker and the gender of the word. Consequently, it appeared that the sex of the speaker played a role of priming context, in which the memory traces of the lexical candidates that matched in gender with the sex of the speaker were more strongly activated than the memory traces of words that disagreed in gender with the sex of speaker. This finding is in line with previous studies demonstrating that the indexical information about the sex of the speaker and the meaning of the linguistic elements is accessed nearly at the same time (Belin et al., 2004, Belin et al., 2011) and is integrated at early stages of processing (Lattner & Friederici, 2003; Van Berkum et al., 2008). Moreover, this study reinforces the previous findings indicating that the contextual information coming from the indexical information can constrain the lexical and the semantic processing (Brunellière & Soto-Faraco, 2013; Van Berkum et al., 2008).

Beyond the influence of the sex of speaker through the memory traces in lexicon, in a later timing, the MMN response was associated with a detection of the mismatch between the indexical information about the sex of the speaker and the grammatical information about gender of the word. More exactly, it was observed that when the feminine word was said by male voices, there was an enhancement of the MMN response compared to when the feminine word was said by female voices from 240 ms after the onset of second syllables.

Contrary to the feminine word, the detection of the incongruence for the masculine word occurred later from 315 ms after the onset of second syllables. This differential latency of the incongruence detection could be caused by the status of generic gender expressed in the masculine form. Since the masculine word includes the representation of female and male groups, this made it more difficult to detect the mismatch between the sex of the speaker and the gender of the word. In line with previous MMN studies manipulating semantic and syntactic errors (Hasting et al., 2007; Menning et al., 2005; Pulvermüller et al., 2008), it was found that the MMN can reflect the processing of higher linguistic levels, as the checking of semantic and syntactic features. However, an alternative explanation for the quicker detection of the incongruence between the sex of the speaker and the gender of words in the case of the feminine words could be accounted by the fact that the female participants would activate by default the memory traces for the feminine words due to their frequent usage (Andonova et al. 2004). Nonetheless, we might exclude this alternative explanation because we did not find any stronger MMN responses to the feminine word compared to the masculine word along the different time windows. Furthermore, the additional post-test questionnaire analyzing the subjective lexical frequency of the feminine word (“chanteuse”) and the masculine word (“chanteur”) did not reveal any difference between them, suggesting that the female participants heard and produced with the same frequency the two words presented.

Moreover, we could hypothesize that the influence of sex of the speaker in the processing of gendered words would be easily observed when the referent is a biological entity and there is a direct relation between gender and sex dimension, such as semantically gendered words. In addition, since the semantically gendered words that we selected may refer to the listener or the speaker, the listeners can have taken more into account the sex dimension in our study, facilitating thus interactions between the sex of the speaker and the gender of the word. Similarly to this hypothesis, Van Berkum et al. (2008) used self-referential pronouns to enhance the speaker-dependent effect during sentence processing. On the contrary, when words are arbitrary gendered, there is no direct correspondence between the gender distinction and the sex dimension. Nevertheless, according to the prior literature using mostly arbitrary gendered words (Vitevitch et al., 2013), we could expect to find the

same findings related to the interaction between the sex of the speaker and the gender of the word, whatever the type of gender (semantic or arbitrary).

In conclusion, to our knowledge, this is the first study showing an interaction between the sex of the speaker and the gender of the word during the processing of spoken word processing using the MMN component. We clearly found an early influence of sex of speaker through activating lexical memory traces of gendered words, then followed by a later interaction between the sex of speaker and the access to the grammatical gender feature at a higher linguistic level. Finally, it is important to take into account the role of the masculine form as the generic gender, which includes larger semantic content due to the activation of the male and the female groups represented in the definition. For future research, it will be interesting to explore the role of the different levels of sex information over the processing of purely arbitrary gendered words and also to explore whether the influence of the generic gender extends to a group of male listeners.

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CHAPTER 3.- GENERAL DISCUSSION AND CONCLUDING REMARKS

This work set out to examine the interaction between the grammatical gender and sex dimension in Romance languages. In a situation of speech communication in which at least two people exchange linguistic messages, the information related to sex is present in different ways. To start with, the communication agents, that is, the speaker and the addressee are biologically sexed and they identify themselves as either males or females. In the case of the speaker, being a member of the male or the female biological sex group will characterize the physical features of their voice, such as in general females have a higher fundamental frequency (F0) compared with males (Casado, 2014), and these specific features will give the listener some clues to identify the sex of their speaker just for their voice automatically. To continue with, the person processing the message perform at least two tasks when listening (Belin, Bestelmeyer, Latinus, & Watson, 2011; Belin, Fecteau, & Bedard, 2004) that are integrated at the early stages of processing (Lattner & Friederici, 2003; Most, Sorber, & Cunningham, 2007; Van Berkum, Van den Brink, Tesink, Kos, & Hagoort, 2008; Vitevitch, Sereno, Jongman, & Goldstein, 2013), one is the identification of the speaker by the physical features of their voice, in which the information about the biological sex of the speaker is available, and the other is to process the linguistic message. Finally, in order to understand the message, the listener has to first select the lexical candidates included in the message, and access to their meaning. In the case of Romance languages, such as Spanish or French, all the nouns have a mandatory grammatical gender assignment, and this lexico-syntactic feature sometimes includes information about sex (the semantically gendered words for which usually there is a direct relation between the biological sex and the gender assignment). Owing the fact that different levels of the sex dimension are present during the speech communication, it is important to explore the possible interactions they could have during the processing of gendered words.

The grammatical gender first appears as a need to distinguish between male and female groups according to biological sex in language (Arias, 1990) and this relation is further extended to concepts whose grammatical gender assignment is purely arbitrary

(Boutonnet, Athanasopoulos, & Thierry, 2012; Cubelli, Paolieri, Lotto, & Job, 2011; Vigliocco, Vinson, Paganelli, & Dworzynski, 2005; Vuksanović, Bjekić,& Radivojević, 2014). With the Experimental Series I we wanted firstly to explore whether the grammatical gender information is an intrinsic feature stored at the lexical level, retrieved automatically even when the task does not specifically require its access (Cubelli et al., 2011), and whether the grammatical gender is part of the noun mental representation (Vigliocco et al., 2005). Secondly, we investigated whether the sex of the addressee and the sex of the speaker influenced the selection of lexical candidates with a grammatical gender distinction. The participants performed three tasks in which different levels of linguistic processing were accessed. The first one was the word repetition task, which requires very little metalinguistic reflection; the second was the lexical decision task, which compels participants to access the internal lexicon, and the final task was the gender decision task, where direct attention is required to access the grammatical gender feature in order to reach a deliberate decision. Regarding the role of grammatical gender during word repetition processing we could see that the semantically gendered words were repeated faster compared with the grammatically gendered words; interestingly, it seems that this advance in processing was due to the animacy represented by the semantically gendered words. In particular, the semantically gendered words make reference to biologically sexed entities such as humans and animals, meanwhile the arbitrary gender words make reference to inanimate objects. In 2007, New, Cosmoses and Tooby developed the animate-monitoring hypothesis in order to explain the early and superior detection of animacy as compared to the detection of inanimate objects during sensory tasks. Similarly, other authors explore the effect obtaining similar results (Altman, Khislavsky, Coverdale, & Gilger, 2016; Calvillo & Jackson, 2014) and they explained the importance of the detection of animate objects in ancestral hunter–gatherer environments regardless of their current utility. Coming back to our results, as well as in the perception domain, during the language processing the animacy intrinsic to the semantically gendered words may have created an attentional bias producing a faster processing in comparison with the words making reference to the inanimate words, thus, the arbitrary gender words. In addition, the same semantic gender superiority effect is replicated during lexical and gender decision tasks; independently of the kind of task, the semantically gendered words were processed faster and with less errors in comparison with the arbitrarily

gendered words. Furthermore, during the gender decision task the faster processing of semantically gendered words may be also caused by a direct link between the biological sex and the grammatical gender assignment.

Nonetheless, some may argue that the faster processing of the semantically gendered words do not exactly prove the access to the grammatical gender feature but simply show the animacy importance, and even the biological distinction is marked with grammatical gender, in other languages without a gender system based on sex, similar results should be found. However, other authors (Bender, Beller, & Klauer, 2016) have shown before that the semantically gendered words have a stronger gender effect as compared to the arbitrarily gendered words, due to the direct relationship between the biological sex and the grammatical gender assignment, independently of their animacy; specifically they found that the epicene names, that is, words representing animals without an explicit mark of biological sex (i.e., jirafa FEM— giraffe), are biased by their grammatical gender assignment similarly as the purely arbitrary words (i.e., casa FEM— house), which represent entities that do not have biological sex.

In order to make sure that the semantic information related with sex defining the words influences the grammatical gender processing, we prepared the Experimental Series II. In this case, we selected inanimate stereotypically gendered words, without explicit reference to biological entities but with an associated social knowledge related to males and females. During this experimental series we explored the interactions between the sex of the agents, the given stereotypical gender and the assigned grammatical gender. For the design of the experiments we selected stereotypically masculine and feminine words with counterbalanced arbitrary grammatical gender assignments. The participants' task was to decide the grammatical gender of the word presented, visually (written on the screen) or aurally (presented by a male or a female speaker via headphones). The participants were also presented a lexical decision task in the auditory modality during which they had to decide whether the items presented were real words or pseudowords. Before discussing the effects regarding the stereotype, it is important to note that during the gender decision task in both modalities, the grammatically feminine words were processed faster than the grammatically

masculine words, independently of the associated stereotype. All the selected words, arbitrarily gendered, were controlled by the frequency of use, the length, the duration, the imageability, the concreteness and by the phonological neighbors. It seems that the superiority of the grammatically feminine words was not due by the item selection but to the requirements of the task. In fact, the effect disappeared during the lexical decision task. During the gender decision task the participants had to decide what was the grammatical gender of the words presented. Interestingly, in Spanish the feminine is the marked gender meanwhile the masculine works as the generic or default gender (Harris, 1991). Indeed, the masculine gender represents the generic gender for the semantically gendered words for all the words representing humans and the majority of animals (Meseguer, 1991). In short, it seems that the specific mark of gender that exists on the feminine words facilitated the performance of the task.

In addition, an effect of the stereotype relationship was found during the gender decision tasks in the visual and the auditory modality (Experiment 4 and 5) as well as during the lexical decision task in the auditory modality (Experiment 6). The results showed that when there was an incongruence between the sex- semantic information and the grammatical gender assignment (i.e., *corbata* FEM— tie, related to males), it creates a bias that slowed down the lexical access processing in comparison to when the words had an associated congruent stereotype (i.e., *falda* FEM— skirt, related to females) or either they were stereotypically neuters (i.e., *casa* FEM— house). This finding is another proof that the grammatical gender feature is activated even when no direct attention to the lexico-syntactic features is required (Cubelli, Lotto, Paolieri, Girelli, & Job, 2005; De Martino, Bracco, & Laudanna, 2011; Paolieri, Lotto, Leoncini, Cubelli, & Job, 2011), such as during the lexical decision task. Furthermore, the associated stereotype, even if it is a social convention, is able to create a link between the semantic field (a higher level) and the lexico-syntactic field (a lower level) which is modulated in a top-down manner, similar to the link created in the semantically gendered words between the biological sex distinction and the grammatical gender assignment.

Consequently, the access to the grammatical gender information of words presented in isolation depends on the semantic information related to sex included in the concept definition; the biological (natural) and stereotypical (social) sex information works as a semantic prime, activating strongly the grammatically gendered words that match in gender and sex. Once we observed that the type of gender (arbitrary, semantic or stereotypical) influences the access to the grammatical gender feature, from here on out, we focus on how the gender processing is modulated during communication processes in which the message is processed by a person with an associated sex role and the information about the sex of the speaker is available. See Figure 18.

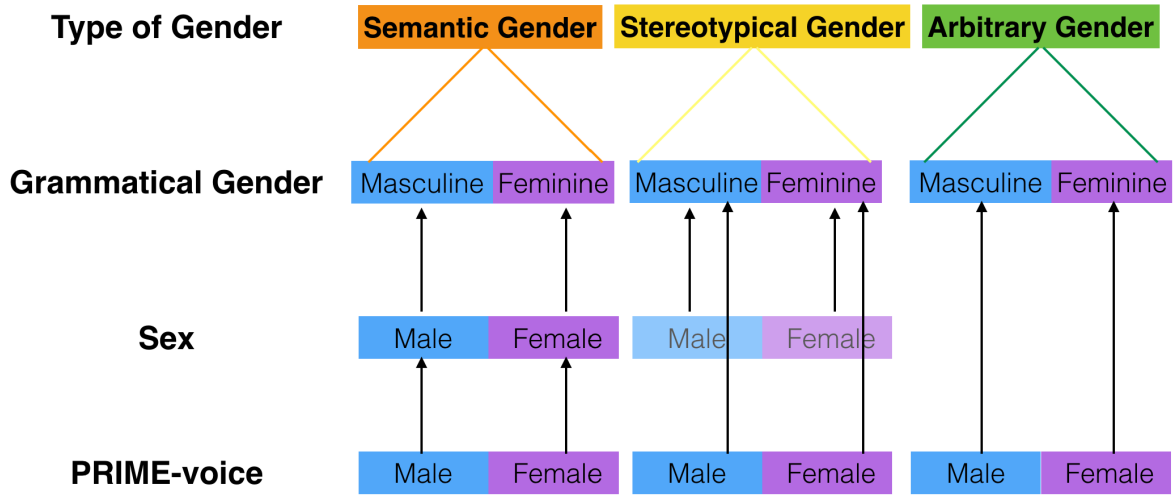

Figure 18. Representation of the different levels of information related to gender and sex, and its interactions.

The role of the sex of the addressee is fundamental to understand the mental organization of the concepts inside the lexicon. As contextualized in Chapter I, the words are represented and systematically organized inside the mental lexicon, that according to Bonin (2004) contains several types of representations including phonological, semantic, morphological and orthographic; these representations are connected among assemblies that link together different words regarding the semantic, the syntactic, the grammatical and the morpho-phonological features; therefore the speed and magnitude of the lexical activation of the words depends on the strength by which the memory traces that characterize each word are connected within each network (Pulvermüller et al., 2001; Pulvermüller, Shtyrov, Kujala, & Näätänen, 2004). The memory traces for each person will be different from other speakers

due to the individuality and uniqueness of the history of every single person (Barsalou, 2008; Wilson, 2002). Some of the questions that arose were first whether the sex role of the addressee modulated the configuration of the memory traces of concepts related to sex, and second whether the sex distinction different for each sex group (males and females) influenced the access to the grammatical gender feature. To start with, the acquisition of sex role knowledge appears during the third year of life (Weinraub et al., 1984), which comes together with gender labeling (classifying people into sex groups) and gender identity (the inclusion of her/himself into a specific sex group), and can be observed in children as young as 2 years old. Bem (1983) proposed that children use the information about the sex role to create the self-concept and later on, people end up encoding and organizing part of their world around the learned sexual distinction between male and female categories. To continue with, on the one hand the mother tongue gender system can influence the gender labeling as well as gender identity; particularly, the children who learn to speak with a formal gender language start to recognize their own and other sexual identities earlier than children for which their mother tongue do not distinguish grammatical gender features (Guiora, Beit-Hallahmi, Fried, & Yoder, 1982). All in all, it seems that the grammatical gender feature included in language models the sex distinction, and it is possible to find a link between the conceptual representation of sex and the lexical representation of gender. On the other hand, the speakers belonging to different sex role groups (males or females) are more used to hear and produce words related to their self-sex role (Andonova, D'Amico, Devescovi, & Bates, 2004), and consequently in formal gender systems, those words usually share the grammatical gender with their own sex representation. Furthermore, the semantic information can prime lexico-syntactic decisions (Schiller, Schuhmann, Neyndorff, & Jansma, 2006). For instance, when we activate a group of words (i.e., *naranjo, manzano, melocotonero* (orange tree, apple tree, peach tree)) that have in common a semantic constrain, for example, all of them are fruit trees, possibly those words share as well other lexico-syntactic features as masculine grammatical gender. The fact of activating the semantic information that link together these words (fruit trees) will prime as well the lexico-syntactic features shared as well among the words inside the category (masculine gender). On the hole, the fact of being exposed more often to words related to your own sex role will create a bias over the processing of words that agree in gender.

In the Experimental Series I, we hypothesized that the words that share the grammatical gender with the sex role of the participant will have stronger connexions as compared to the words that mismatch in gender, and therefore the lexical access to those words will be faster. In fact, during the lexical decision experiment (Experiment 2) and more clearly during the gender decision experiment (Experiment 3) the results showed a facilitation of processing for sex-gender congruent words. This effect was present for the semantically gendered words as well for the arbitrary gendered words, which do not include sex definition but for which the related semantic information primed its activation. After all, people use the grammatical gender distinction to further discriminate categories unrelated to the biological sex (Bem, 1983) and consequently the participants activate more strongly the words that match in grammatical gender with their own sex role. Therefore, these results confirm that people organize and encode concepts regarding their own sex role; furthermore, it appears that the grammatical gender feature is activated with the semantic representation of words related and unrelated to sex. See Figure 19

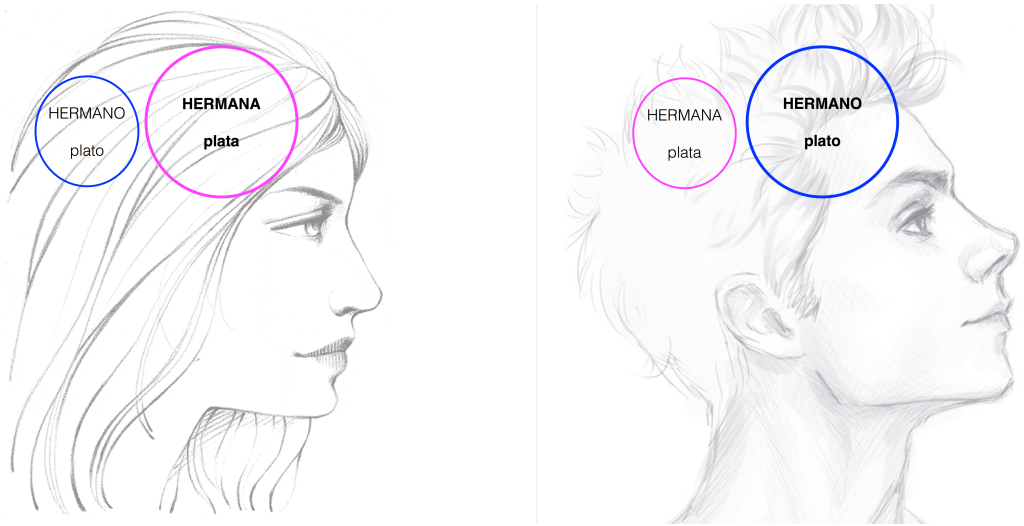

Figure 19. Representation of the lexical candidates inside the mental lexicon of different speakers. The female speaker have the feminine words more activated in comparison with the masculine words. The male speaker have the masculine words more activated compared with the feminine words.

In order to deeply explore the role of the sex of the participant when processing gendered words we designed an ERP study (Experiment 7) for which only female participants were selected. We used the MMN component, that have been shown to be a

marker of the lexical frequency of the words, besides, it responds to sensory and lexical differences, to semantic and syntactic errors and to the conceptual meaning of words. For the present experiment, we selected two semantically gendered words making reference to male singer (*chanteur*) and female singer (*chanteuse*) that were presented by five different male speakers and five different female speakers. Regarding the influence of the sex of the participant when processing gendered words, we hypothesized that the lexical frequency of gendered words thus would depend on the sex role of the addressee such as the words that agree in grammatical gender with the sex representation of the participant will have higher lexical frequencies due to the greater use (Andonova et al., 2004). In fact, Shtyrov, Kimppa, Pulvermüller, and Kujala, (2011) have shown that the higher-lexical frequency of the words produced stronger MNN responses compared to low-frequency words. Therefore, we predicted higher MMN responses for the feminine word with respect to the masculine word in this study since the active neurons into neuronal circuits for the feminine words should be strongly connected due to their frequent use by female addressees. Contrary to our prediction, the pattern of results was in the opposite direction, that is, greater MMN responses appeared when processing the masculine word as compared to those when processing the feminine word. Nonetheless, the higher brain responses to the masculine word in comparison with the feminine word can be explained by the status of the generic gender related to the masculine word (Académie Française, 2002; Baudino, 2001; Meseguer, 1991). In French, the generic gender related to human beings is represented with the masculine form in the plural and singular forms. The masculine form either refers to men (specific use of masculine) or to both sexes. The masculine singular word, for example, “chanteur” refers to both male and female referents. In this case, when the female participants were hearing the masculine word, they activated the representation of both male and female singers, while after the listening to the feminine word, only the female representation of singers would be activated. It is important to note that in the case of the female participants, they are more used to activating the female representation included in the masculine word compared to the male participants, because even though the masculine gender does not match their own gender, the female group is included in the concept. Whilst the male participants are always included in the masculine gender and excluded in the feminine concept, the female participants are always included in the feminine concept and sometimes they are also included in the masculine concept. Given

this fact, the female participants will activate the semantically masculine words similarly as that of the semantically feminine words because their sex group is also represented inside this concept. Overall, during the Experiment 7 we could see that the grammatical gender is processed during the presentation of isolated words, even when no direct attention either to the grammatical gender nor to the word were payed. Furthermore, it appears that is important to account for the masculine grammatical gender as the generic form, and that the female participants conceptualize these words as representing their own sex group. See Figure 20.

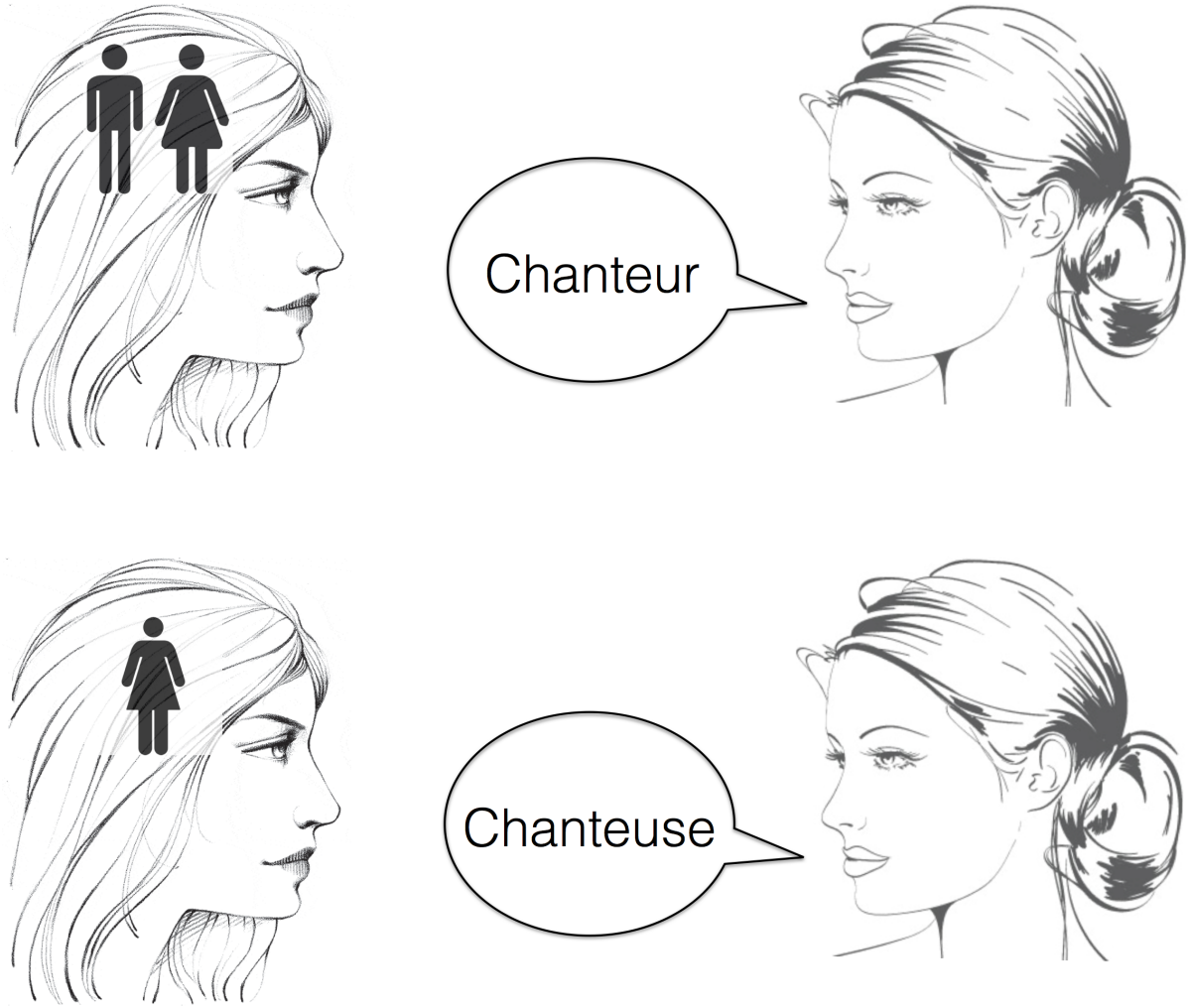

Figure 20. Representation of the masculine word as the generic form. The masculine word (*chanteur*) represents the male and the female singers, and when it is presented by the female speaker, the female voice pre-activates the concept of female singer inside the masculine word (*chanteur*) similarly, as when the female voice pre-activates the concept of female singer inside the feminine word (*chanteuse*).

In addition, with the Experimental Series II we wanted to explore whether the sex of the participant influenced the processing of the stereotypical gender, a semantic and high level information that reflect the social knowledge about male and female roles, or, on the contrary, had more influence over the processing of grammatical gender, a lexico-syntactic feature of a lower-level that is arbitrarily assigned. Owing to the fact that people organize the concepts around the learned sexual distinction between male and female categories (including stereotype information) and it depends on their own sex role group, we expected the stereotypical gender to be a clearly defined category of semantic knowledge directly linked to the own definition of maleness and femaleness. We expected the stereotypical gender to have a more important role as compared to the grammatical gender information (Bender et al. 2016) because the stereotypical knowledge is a pure semantic information, and is accessed earlier than the lexico-syntactic properties such as the grammatical gender (Thierry, Cardebat, & Demonet, 2003). Moreover, according to Molinaro, Su and Carreiras (2016), stereotypical knowledge overrides the processing of syntactic cues. Indeed, we expected to find a greater effect on stereotypical gender compared with grammatical gender, since stereotypical gender, like the perception of one's own sex, constitutes part of the mental representation of the noun (Cacciari & Padovani, 2007), which is not the case for grammatical gender, that is a lexical cue.

Contrary to our prediction, and similar to the results obtained in Experiments 2 and 3, the data from the Experiments 4 and 5 showed that during the visual modality as well as during the auditory modality of the gender decision task, there was a facilitation effect such as the female participants processed faster and more accurate the grammatically feminine words in comparison with the grammatically masculine words, and that independently of the stereotype relationship (similarly as the results found by Andonova et al., 2004). Furthermore, there was a tendency towards the same facilitation effect regarding the feminine grammatical gender for the male participants during the visual modality, what means that when performing the gender decision task, the participants relayed more in the mark of gender present in the words with feminine grammatical gender, than in the stereotype information. It may be the case that both groups, the males and the females, have the words that agree in gender with their own sex more activated by default than the words that disagree

as we have seen during the Experiments 2 and 3, but as the feminine words have an advantage in processing because is the marked gender (Harris, 1991), the effect of the pre-activation of the masculine words by the male participants may have vanished during these gender decision tasks.

Besides the influence of the sex role of the participant on the grammatical gender processing, it is interesting to explore whether it could modulate the identification of the sex of the speaker. During Experiment 7 we found an interesting effect, the information presented with voices of the opposite sex produced an attentional bias, being the words presented with opposite-sex speakers processed faster than the words presented with the same-sex speakers. According with these results, some studies showed a greater activation at brain level when voices or faces of the opposite sex were presented in comparison to the processing of voices belonging to the addressees' sex group (Junger et al., 2013; Li et al., 2014; Proverbio, Riva, Martin, & Zani, 2010; Sokhi, Hunter, Wilkinson, & Woodruff, 2005). In fact, the results form Experiment 7 for which only female participants took part of the study, showed that the male voices produced an enhancement of the MMN response compared to female voices, suggesting that the female listeners reacted to the incongruence between the sex of the speaker and the representation of their own sex. Contrary to previous studies (e.g., Li et al., 2014), this finding was found even though the task did not require a direct attention focused on the identification of sex of the speaker. All in all, the identification of sex of the speaker is an important feature for the addressee, and it could influence the processing of spoken information.

It is important to note that the present thesis try to adapt what happens in a situation of normal communication into a laboratory test in order to see the language processing inside its complex reality taking into account diverse variables and trying not to simplify the issue. We tried to remain conscious that the human behavior is full of interactions and that every little response changes depending on the context created by the participant as well as the given context. In the same way as in the first part of this dissertation we paid attention to the personal experience when processing linguistic messages, for now on we will focus on how the participant processing is influenced by the way the linguistic message is given. It is well

known that when exposed to speech, the listeners decode the meaning of the message at the same time as they analyze the physical features of the speaker with the voice acoustic analysis and the voice identity analysis (Belin et al., 2004, 2011). The voice works as *an auditory face* and even we do not see the speaker, we can build a mental image of the person giving the message. That is, during the communication process, we are influenced automatically by the speaker because it creates a context for which we organize the information in. As we could see in Experiment 7, people react having an enhancement of responses when the words are presented with opposite-sex voices as compared to when the same words were presented with voices of the same sex. Therefore, the identification of some speaker's features is important when processing linguistic messages. In particular, during the present research we were interested in the processing of the sex dimension; until now we have already explored the role of the sex information inside the concept marked by the gender, and the role of the sex of the addressee when encoding and processing information. Finally, we explored the role of the sex of the speaker when processing gendered words, as this feature have been shown to create interference effects when it mismatched with the linguistic information (Lattner & Friedericci, 2003; Van Berkum et al., 2008; Vitevitch et al., 2013).

First of all we wanted to explore whether the identification of the sex of the speaker was similar in the visual and in the auditory conditions; actually, during Experimental Series I similar results were obtained during the comic and the auditory modalities, which means that people process sex information carried by the face in the same way as that carried by the voice (Belin et al., 2004; Joassin et al., 2011; Schweinberger, Kloth, & Robertson, 2011). In the second place, we wanted to see whether the information about the sex of the speaker created a bias when processing gender words. During the Experimental Series I, the findings of the word repetition (Experiment 1) did not support the predicted effects, such that the grammatical gender was not primed by the sex of the speakers' information behaviorally. Nevertheless, we could observe the expected priming effect during the lexical decision task (Experiment 2) and during the gender decision tasks (Experiment 3), that appeared for the semantically gendered words, where the information about the sex of the speaker could activate the information about the sex of the entity (both are pieces of semantic information),

but also for the arbitrary gendered words. Actually, this results shows that the grammatical gender information is accessed even during the lexical decision task, implicit regarding the grammatical gender, and that is modulated by the contextual information formed by the identification of the speaker's sex. Interestingly, only the feminine words were affected by the sex of the speaker during the auditory modality as well as during the comic modality during the gender decision task. Specifically, during comic modality, only the semantically feminine words were processed faster when produced by a congruent speaker (female speaker) compared with when produced by an incongruent speaker (male speaker), what disappeared when processing the arbitrarily gendered words. As we have discussed before, the masculine gender works as the generic gender for the semantically gendered words for all the words representing humans and the majority of animals (Meseguer, 1991). Although some studies have shown that masculine forms lead to a specifically male representation (Gygax, Gabriel, Sarrasin, Oakhill, & Garnham, 2008) in terms of cognitive representations, it appears that, at least in German, the grammatically masculine role names making reference to humans lead to a less gender-specific representation than morphologically marked feminine forms (Irmen & Kurovskaja, 2010). For instance, when hearing the word *amigo* MAS— friend, people are supposed to activate the representation of both male and female friends, meanwhile when hearing the word *amiga* FEM— friend, only the representation of the female friends is activated. In such a way, the word *amiga* FEM— friend is pre-activated when presented by the female speaker (congruent condition) in contrast to when presented by the male speaker (incongruent condition). Nevertheless, when the word *amigo* MAS -friend is presented by the female speaker, the female speaker pre-activates the representation of the "female friend" included in the generic concept (illustrated by the masculine gender) creating a congruent condition, similar to that created by the male speaker (masculine gender - male speaker), see Figure 20. The results show that in Spanish the masculine form does work as the generic or default gender instead of like a specific male representation, and that is why no differences appears for the masculine gendered words regarding the sex of the speaker. Overall, it appears that the indexical information about the sex of the speaker obtained during a pure acoustic analysis activates the semantic representation of sex, and thus serves as a semantic prime (Bender et al., 2011) influencing the selection of linguistic features such as grammatical gender (Vitevitch et al., 2013), going in a top-down manner from high-levels —

semantic — to low-levels —lexico-syntactic—, (Brunellière & Soto-Faraco, 2014). To sum up, the findings of Experimental Series I show that behaviorally we could observe the influence of the identification of the sex of the speaker when direct attention to the grammatical gender feature was required, and also when the access to the grammatical gender is not mandatory as in the lexical decision task. Besides, this information helped us to understand the role of the generic gender represented by the semantically masculine gendered words in Spanish.

In addition, with the Experiments 5 and 6 included in the Experimental Series II we wanted to explore whether the sex of the speaker primed the lexical access to the words with an associated stereotype. We predicted that when there is a match between the sex of the speaker and the gender of the words, there will be an easier lexical access in comparison to when there is a mismatch, and that this effect should be greater when the relationship between the stereotypical and the grammatical gender is congruent, than when the relation is incongruent. The fact of having an added semantic knowledge related to sex, and that this semantic information is in agreement with the grammatical gender of the word will facilitate the lexical activation; in the case of which the stereotype is incongruent, the added semantic information related to sex and the grammatical gender will produce an incongruence detection that will interfere with the pre-activation of words (Lattner & Friederici, 2003; Van Berkum et al., 2008). Actually, the results showed that when there was a congruent stereotype relationship, the words presented by the female speaker were processed faster when the grammatical gender matched (feminine grammatical gender) than when mismatched (masculine grammatical gender). Interestingly, this effect was replicated when the stereotype relationship was incongruent, showing that the participants gave more importance to the grammatical gender, a lexico-syntactic feature (Vitevitch et al., 2013) instead to at the stereotypical gender, stored at the semantic level (Lattner & Friederici, 2003; Van Berkum et al., 2008) and accessed earlier (Thierry et al., 2003), see Figure 18. However, the facilitation effect disappeared during the lexical decision task (Experiment 6); it appears that the influence of higher level information such as the identification of the sex of the speaker that is a contextual clue, on lower levels such as the grammatical gender processing, did not get to influence the processing of arbitrarily gendered words with an associated stereotype. Maybe

the associated stereotype slowed down the lexical access times and masked the effects, that could be observed during the lexical decision task with arbitrary neuter words (Experiment 2). To sum up, when there is a congruency between the sex of the speaker and the grammatical gender, there is a facilitation of the processing that leads to a faster processing when paying direct attention to the grammatical gender. However, when there is an incongruent relationship, there is an interference bias that slow down the processing of the gender feature.

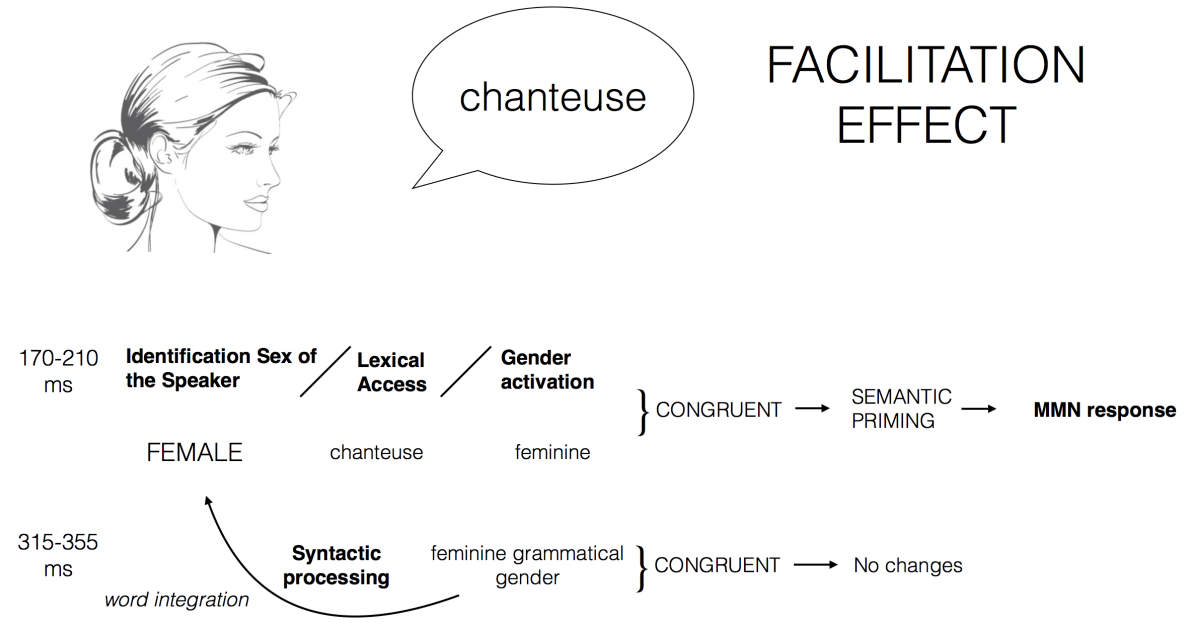

Figure 20. Model of the facilitation effect due to the sex of the speaker identification. At 170-210 ms time window after the word onset, the identification of the sex of the speaker and the lexical access (with the consequent immediate activation of the abstract gender node) takes part. When the sex of the speaker coincides with the gender, there is a priming effect that leads to a mismatch negativity response due to the stronger memory activation of the words of the same gender as the sex of the speaker. At a 315-355 ms time window, the syntactic processing is activated and the word integration takes part, recovering the contextual information related to the sex of the speaker. When the sex of the speaker correspond with the grammatical gender of the word no changes are detected.

Similarly, Boutonnet et al., (2012) reported some effects regarding the grammatical gender shown by the ERP components even the effect did not manifest itself behaviorally. This data lead us think that the expected gender effect regarding the sex of the speaker may arise automatically and unconsciously during lexical selection, and that the effect may be visible using electrophysiological techniques. In order to explore the influence of the sex of the speaker on gendered word processing we designed a mismatch negativity (MMN) experiment for the Experimental Series III. Regarding the interaction between the sex of the speaker and the semantically gendered French words selected, we expected that this interaction could act both at a lexical level and at higher levels, including the processing of the semantic and the lexico-syntactic information during word integration. In line with a lexical priming effect due to the sex of speaker during word recognition (Brunellière & Soto-Faraco, 2013; Van Berkum et al., 2008), the sex of the speaker should bias the access to the memory traces of words that vary in gender, and regarding the MMN component (Pulvermüller et al., 2001; Shtyrov, et al., 2011), we should observe greater MMN responses when there is a match with respect to when there is a mismatch between the sex of the speaker and the gender of the word, independently of the sex of the speaker. Additionally, at a later timing, during the word integration (Marslen-Wilson, 1987), we predicted a detection of the mismatch between the sex of the speaker (the context information obtained during the acoustic analysis) and the grammatical gender of the word (the syntactic level) during the processing of the incongruent condition (Vitevitch et al., 2013) resulting in greater MMN responses when there is a disagreement between the sex of the speaker and the gender of the word as compared to when there is a match, and that independently of the sex of the speaker (Hasting, Kotz, & Friederici, 2007; Menning et al., 2005; Pulvermüller, Shtyrov, Hasting, & Carlyon, 2008).

Actually, the results showed that between 170 and 210 ms after the onset of second syllables, a MMN response appeared, and it was enhanced when the information about the sex of the speaker and the gender of the word agreed, what might reflect the access to the memory traces of the gendered words influenced by the sex of speakers. In that case, it seems that the sex of the speaker worked as a priming context, in which the memory traces of the lexical candidates that matched in gender with the sex of the speaker were strongly activated

than the memory traces of words that disagreed. Beyond the influence of the sex of speaker through the memory traces in lexicon, at a later timing, the MMN response was associated with a detection of the incongruence between the indexical information about the sex of the speaker and the grammatical information about gender of the word. More exactly, it was observed that when the feminine word was said by male speakers, there was an enhancement of the MMN response compared to when it was said by female speakers from 240 ms after the onset of second syllables. In contrast to the feminine word, the detection of the incongruence for the masculine word occurred later, from 315 ms after the onset of the second syllables. A possible explanation for this differential latency of the incongruence detection, might be due to the masculine form representing the generic gender (Académie Française, 2002; Baudino, 2001; Meseguer, 1991). Since the masculine word includes the representation of female and male groups, it might be more difficult to detect the mismatch between the sex of the speaker and the gender of the word, similarly as the findings in Experiment 3.

On the whole, during the Experiment 7 we could prove that the lexical selection of gendered candidates were influenced by the sex of the speaker producing the word, even when no direct attention was payed to the grammatical gender. More over, the brain detected the incongruence between the voice and the gender at a later timing, and this interference between the semantic and the syntactic level informed us about the masculine semantically gendered words working as the generic gender, and therefore including the representation of both the male and the female figures inside the concept. Above all, it is relevant to point out the existence of two different stages of influence regarding the sex of the speaker, represented in Figures 20 and 21.

One possibility is that the results we observe behaviorally during the lexical and gender decision tasks is the second stage of processing produced by the integration of the purely syntactic features and the identified sex of the speaker, therefore the difference in response time and accuracy may be due to the incongruence detection between the sex of the speaker and the grammatical gender of the word, instead of a facilitation effect during the congruent conditions.

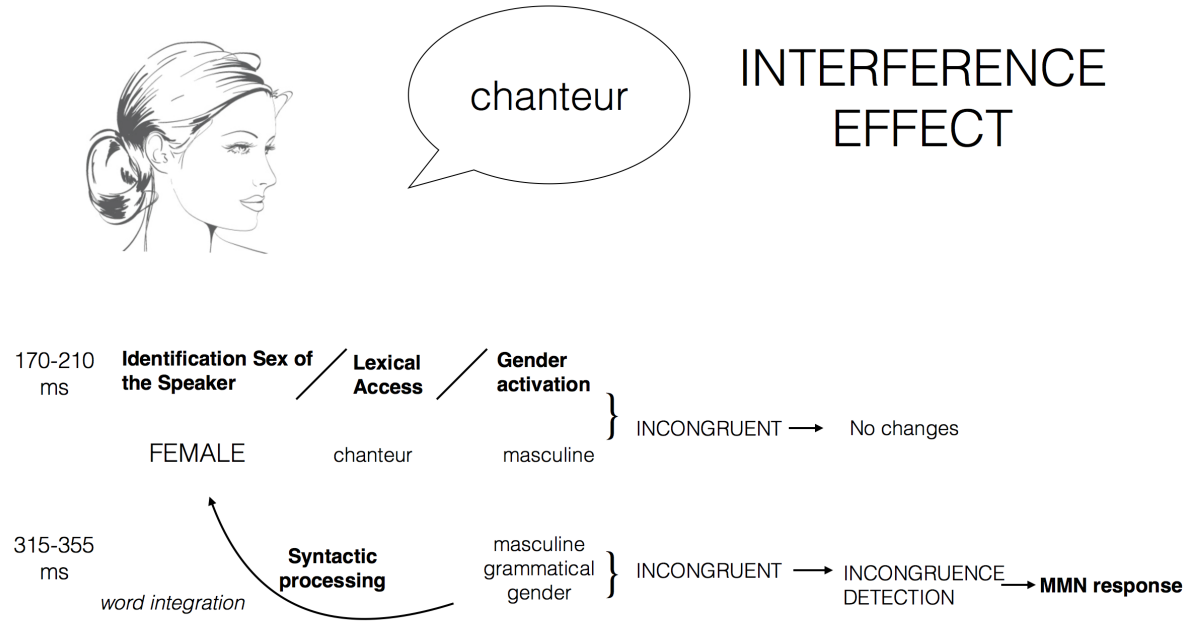

Figure 22. Model of the interference effect due to the sex of the speaker identification. At 170-210 ms time window after the word onset, the identification of the sex of the speaker and the lexical access (with the consequent immediate activation of the abstract gender node) takes part. When the sex of the speaker does not correspond with the activated gender, no changes are detected. At a 315-355 ms time window, the syntactic processing is activated and the word integration takes part, recovering the contextual information related to the sex of the speaker. When the sex of the speaker and the grammatical gender disagree there is a detection of the incongruence of the two dimensions which produces a mismatch negativity response.

On the whole, the Experimental Series I, II and III provides further evidence to suggest that the different levels of sex information present during speech communication interacts. In the first place, the grammatical gender feature is stored at the lexical level and retrieved when processing isolated words outside any linguistic context. Furthermore, the grammatical gender is activated whenever the people process semantic, stereotypical and more importantly, regarding the results from the lexical and the gender decision tasks, arbitrarily gendered words. In the second place, the participants use the gender distinction to encode and

organize conceptual representations depending on their own sex role group; we have seen that words that share the grammatical gender with the representation of own sex role of the participants were strongly activated by default in comparison to words of the opposite gender, independently of the type of gender (however, we have to take into account that the masculine grammatically gendered words represents the generic gender). In the third place, people are influenced by the sex of the speaker such as when the message is produced by speaker of the opposite sex, there is an attentional bias produced by an enhancement of the brain response. And finally, the sex of the speaker influences how people process the grammatically gendered words; firstly, when there is a match between the sex of the speaker and the gender of the word, the lexical candidates that share the gender feature with the sex of the speaker are strongly activated in comparison to the words that mismatch producing a facilitation effect of processing (see Figure 21). After that, at a later timing where there is access to the syntactic features and the word is integrated with its context; whenever there is a mismatch between the sex of the speaker and the gender of the word, there is a detection of the incongruence. The incongruence between the sex of the speaker and the gender of the word produce an enhancement of the MMN response at brain level, and behaviorally is reflected by an interference effect in comparison to when both dimensions coincide (see Figure 22).

In conclusion, the grammatical gender seems to be more than the simpler lexico-syntactic property, and it is used to further discriminate concepts in principle unrelated to sex. Furthermore, the grammatical gender activation is modulated by different levels of sex clues; to start with, depending on the sex role a person have, the encoding and organization of concepts differs, such as the people identified with the female sex role will have by default strongly activated the feminine gendered words in comparison with the masculine words, meanwhile the people that recognize themselves in the male sex role, will have a greater activation of the masculine words compared with the feminine words. To continue with, the sex of the person communicating the linguistic message bias the speech processing. On the one hand, people tend to pay more attention when the information (independently of the kind of linguistic message) is presented by opposite-sex speakers. On the other hand, the sex of the speaker modulate the processing of the linguistic message (both sexes equally) such as people

is prepared to process gendered words matching the sex of the speaker; when this happen, there is an advantage in processing; nevertheless, when there is a mismatch, the detection of the incongruence between the sex of the speaker and the gender of the word produce an interference effect. To end with, the effect observed for the gendered words occurs for those words representing biologically sexed entities, stereotypically masculine and feminine words, as well as for arbitrarily gendered words, what means that the grammatical gender is an important classifier for speakers of formal gender languages.

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CHAPTER 4.- DISCUSIÓN GENERAL Y CONCLUSIONES

Este trabajo pretende examinar la interacción entre el género gramatical y la dimensión de sexo en lenguas romance. En una situación de comunicación oral en la que al menos dos personas intercambian mensajes lingüísticos la información referida al sexo está presente de diferentes maneras. En primer lugar, los agentes de la comunicación, es decir, los emisores y los receptores se clasifican de acuerdo a un género biológico, y se identifican a ellos mismos como mujeres u hombres. En el caso del emisor, el hecho de ser hombre o mujer determinará las propiedades físicas de su voz. En general, las voces de las mujeres tienen una frecuencia fundamental (F0) mayor en comparación con la F0 de las voces de los hombres (Casado, 2014), y estas características físicas, de manera automática dan a los receptores indicios acerca del sexo del hablante a través de su voz. En segundo lugar, la persona que procesa el mensaje hablado realiza al menos dos tareas mientras escucha (Belin, Bestelmeyer, Latinus, & Watson, 2011; Belin, Fecteau, & Bedard, 2004) que son integradas durante estadios tempranos del procesamiento (Lattner & Friederici, 2003; Most, Sorber, & Cunningham, 2007; Van Berkum, Van den Brink, Tesink, Kos, & Hagoort, 2008; Vitevitch, Sereno, Jongman, & Goldstein, 2013). La primera tarea es la identificación del hablante a través de las características físicas de su voz, en la que la información sobre el sexo biológico está presente; la otra tarea consiste en procesar el mensaje lingüístico. En última instancia, para poder comprender el mensaje, el receptor tiene que seleccionar los candidatos léxicos incluidos en el mensaje y acceder a su significado. En el caso de las lenguas romance, como el español o el francés, todos los nombres tienen una asignación de género obligatoria. La característica léxico-sintáctica de género gramatical, que distingue entre palabras masculinas y femeninas, a veces incluye información sobre sexo, como en el caso de las palabras de género semántico, para las que normalmente existe una relación directa entre el sexo biológico y la asignación de género. Debido al hecho de que hay diferentes niveles de la dimensión sexo presentes durante la comunicación oral, es importante explorar las posibles interacciones que puedan existir entre ellos durante el procesamiento de las palabras con género gramatical.

El género gramatical aparece en el lenguaje debido a la necesidad de distinguir entre los grupos de machos y hembras de acuerdo al sexo biológico (Arias, 1990), y esta relación se extiende desde los conceptos con carga semántica relativa al sexo a los conceptos cuya asignación de género es puramente arbitraria (Boutonnet, Athanasopoulos, & Thierry, 2012; Cubelli, Paolieri, Lotto, & Job, 2011; Vigliocco, Vinson, Paganelli, & Dworzynski, 2005; Vuksanović, Bjekić, & Radivojević, 2014). Con la Serie Experimental I pretendíamos en primer lugar, explorar si la información referente al género gramatical es una característica intrínseca guardada a nivel léxico, que se recupera automáticamente aunque la tarea no requiera específicamente que se acceda al género (Cubelli et al., 2011), así como ver si el género gramatical forma parte de la representación mental del nombre (Vigliocco et al., 2005). En segundo lugar, investigamos si el sexo del receptor y el sexo del emisor influenciaban la selección de candidatos léxicos con una distinción de género gramatical. Para ello, los participantes realizaban tres tareas en las cuales se requería acceso a diferentes niveles de procesamiento. La primera era una tarea de repetición de palabras, que requiere muy poco acceso metalingüístico. En la segunda tarea, de decisión léxica, los participantes accedían al léxico interno. La última tarea era de decisión de género, en la cual se necesita acceder al género gramatical para realizar una decisión deliberada. En cuanto al rol del género gramatical durante la tarea de repetición de palabras pudimos ver que las palabras de género semántico eran procesadas antes en comparación con las palabras de género arbitrario; parece que el avance en procesamiento se debía al hecho de que las palabras semánticas hacen referencia a entidades animadas, que tienen un sexo biológico como los animales y las personas, mientras que las palabras de género arbitrario hacen referencia a entidades inanimadas. En 2007, New, Cosmoses y Tooby desarrollaron la hipótesis de monitorización de lo animado, para explicar la pronta y superior detección de las entidades animadas en comparación con los objetos inanimados durante tareas sensoriales. De manera similar, otros autores también han explorado el efecto, obteniendo resultados equiparables (Altman, Khislavsky, Coverdale, & Gilger, 2016; Calvillo & Jackson, 2014); en general, la ventaja del procesamiento de las entidades animadas se explica como un sesgo debido a la importancia del reconocimiento de los objetos animados en los entornos ancestrales de caza. En cuanto a nuestros resultados, de igual manera que en el dominio perceptivo, durante el procesamiento del lenguaje, la propiedad intrínseca de lo animado de las palabras de género

semántico crearía un sesgo atencional produciendo un procesamiento más rápido en comparación con las palabras que hacen referencia a entidades inanimadas, es decir, las palabras arbitrarias. Es más, esta superioridad de procesamiento de las palabras de género semántico se replica durante las tareas de decisión léxica y de decisión de género. Independientemente del tipo de tarea, las palabras semánticas fueron procesadas en menos tiempo y con menos errores que las palabras de género arbitrario. Además, durante la tarea de decisión de género, la conexión directa entre el sexo biológico y la asignación de género gramatical pudo haber facilitado un mejor procesamiento para las palabras de género semántico. No obstante, podría argumentarse que el procesamiento más rápido de las palabras de género semántico no prueba exactamente el acceso a la característica de género gramatical, sino simplemente la importancia de las entidades animadas en los receptores, y aunque la distinción de género está marcada con el género gramatical, en otras lenguas sin un sistema de género basado en sexo, se obtendrían resultados similares. Sin embargo, otros autores (Bender, Beller, & Klauer, 2016) han encontrado que existe un mayor efecto de género sobre las palabras de género semántico en comparación con las palabras de género arbitrario debido a la relación directa entre el sexo biológico y la asignación de género gramatical, independientemente de si son animados o no. De hecho, Bender et al. (2016) encontraron que los nombres epicenos (palabras que representan animales cuya desinencia no expresa el sexo biológico, como en el caso de “jirafa”) tienen un efecto de género similar al que se encuentra en las palabras de género arbitrario, que representan entidades inanimadas sin sexo biológico.

La Serie Experimental II se preparó para investigar cómo la relación entre la información semántica relacionada con el sexo y que define las palabras influye en el procesamiento del género gramatical. Para ello, seleccionamos palabras que hacen referencia a entidades inanimadas, y con una información social asociada a hombres o mujeres, esto es, un género estereotípico. Durante esta serie experimental exploramos las interacciones entre el sexo de los agentes de la comunicación, el género estereotípico y el género gramatical. Para el diseño de los experimentos seleccionamos palabras estereotípicamente masculinas o femeninas, con el género gramatical masculino o femenino contrabalanceado. La primera tarea de los participantes consistía en reconocer el género gramatical de las palabras, que

fueron presentadas de manera visual (escritas en la pantalla) o de manera auditiva (dichas con voz de hombre o con voz de mujer). La otra tarea que tenían que realizar los participantes era decidir si los items presentados eran palabras reales o pseudopalabras.

Antes de discutir los resultados sobre el género estereotípico, es importante resaltar que durante los experimentos de decisión de género en las dos modalidades, encontramos que las palabras de género gramatical femenino eran procesadas de manera más rápida que las palabras masculinas, independientemente del estereotipo asignado. Dado que todas las palabras seleccionadas fueron controladas por su frecuencia de uso, su longitud, duración, capacidad de imaginárselas, por lo concretas que son y por sus vecinos fonológicos, parece que el efecto de superioridad de las palabras femeninas se debe más bien a los requisitos de la tarea. De hecho, este efecto desaparece durante la tarea de decisión léxica. En español el femenino es el género marcado, mientras que el masculino funciona como el género por defecto o el genérico (Harris, 1991). Lo que es más, el masculino representa el genérico para las palabras de género semántico que representan a seres humanos, y la mayoría de animales (Meseguer, 1991). En suma, parece que la marca específica de género que existe en las palabras femeninas crea un sesgo facilitador a la hora de realizar la tarea de decisión de género.

Por otro lado, encontramos un efecto principal de la relación estereotípica durante las tareas de decisión de género (Experimentos 4 y 5), y durante la tarea de decisión léxica (Experimento 6). Los resultados muestran que cuando hay una incongruencia entre la información semántica relacionada con el sexo (el género estereotípico) y el género gramatical (como en el caso de “corbata”), aparece un sesgo que ralentiza el acceso al léxico de estas palabras en comparación con los tiempos de acceso al léxico de las palabras que tienen una relación congruente entre el género estereotípico y el gramatical (como “falda”), o en comparación a las palabras neutras que no tienen un estereotipo asignado (como “casa”). Estos resultados se suman a las pruebas de que el género gramatical se activa incluso cuando no se dirige la atención de manera directa al nivel léxico-sintáctico, como en el caso de la tarea de decisión léxica (Cubelli, Lotto, Paolieri, Girelli, & Job, 2005; De Martino, Bracco, & Laudanna, 2011; Paolieri, Lotto, Leoncini, Cubelli, & Job, 2011). Es más, el estereotipo

asociado, aunque es una convención social, es capaz de conectar el campo semántico, a un nivel superior, con el campo léxico-sintáctico, un nivel inferior que es modulado de arriba hacia abajo (*top-down*), similar a la conexión creada en las palabras de género semántico entre el sexo biológico y la asignación del género gramatical.

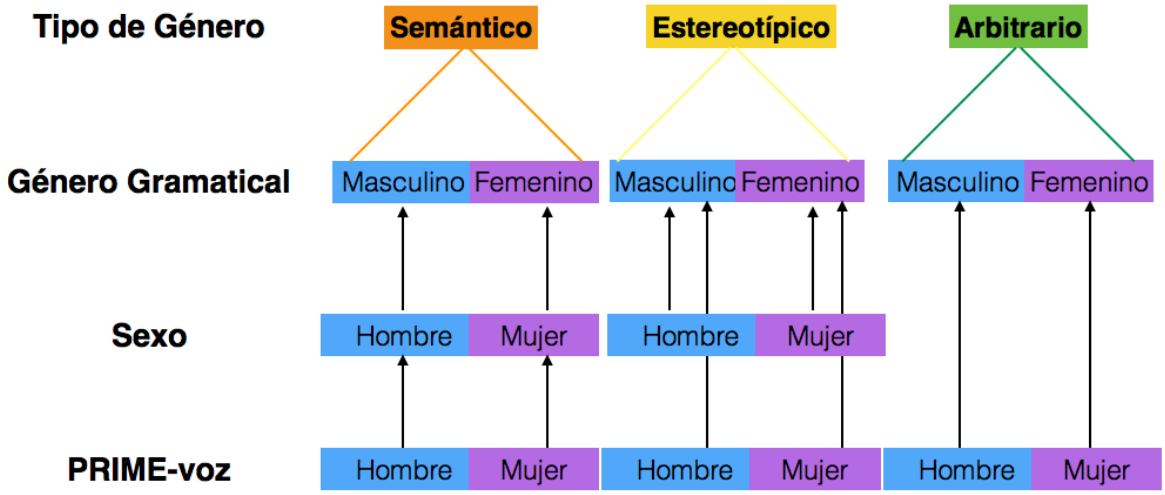

Figura 23. Representación de los diferentes niveles de información de género y sexo, y sus interacciones.

De manera consecuente, el acceso a la información de género gramatical de las palabras presentadas de manera aislada depende de la información semántica relacionada con el sexo, incluida en la definition conceptual. La información biológica (natural) y estereotípica (social) relacionada con el sexo funciona como un *prime* semántico, activando de manera más fuerte las palabras cuyo género gramatical coincide con el sexo. Una vez que hemos observado que el tipo de género (arbitrario, semántico o estereotípico) influye el acceso al género gramatical, a partir de ahora nos centraremos en ver cómo el procesamiento del género es modulado durante los procesos de comunicación en los que el mensaje es procesado por una persona con un rol de sexo asociado, y la información sobre el sexo del hablante está presente.

El rol del sexo del receptor es fundamental para entender la organización mental de los conceptos dentro del lexicon. Como ya hemos contextualizado en el Capítulo I, las palabras se representan y están organizadas sistemáticamente en el lexicon mental; Bonin (2004) propone que el lexicon contiene varios tipos de representaciones, incluyendo la representación fonológica, semántica, morfológica y ortográfica. Estas representaciones estarían conectadas a través de nodos que interconectarían diferentes palabras, de acuerdo a sus características semánticas, sintácticas, gramaticales y morfofonológicas; por lo tanto, la rapidez y la magnitud de la activación léxica de las palabras dependerán de la fuerza con que los diferentes trazos de memoria que caracterizan cada palabra se conectan con cada red (Pulvermüller et al., 2001; Pulvermüller, Shtyrov, Kujala, & Näätänen, 2004). Los trazos de memoria de cada persona serán diferentes de las de otros hablantes, dado que la historia personal de cada persona individual es única (Barsalou, 2008; Wilson, 2002). Esto nos llevó a pensar por un lado si el rol del sexo del receptor modulaba la configuración de los trazos de memoria de los conceptos relacionados con el sexo, y por el otro si la distinción de sexo propia entre hombres y mujeres influía el acceso al género gramatical. En primer lugar, durante el tercer año de vida, los niños adquieren el rol de género, y empiezan a clasificar a las personas en los diferentes grupos de sexo — machos y hembras — (Weinraub et al., 1984). Además, alrededor de los 2 años, aprenden a distinguir su identidad de género, es decir, a incluirse a ellos mismos en el grupo de hombres o de mujeres. Bem (1983) propone que los niños son capaces de usar la información sobre el rol de sexo para crear el concepto de ellos mismos en primer lugar, y que luego usan esa información para codificar y organizar parte de su mundo tomando como referencia la distinción sexual aprendida entre las categorías de macho y hembra. Además, es importante resaltar que el sistema de género de la lengua madre influye a la hora de usar las etiquetas de género y de establecer la identidad de género; de hecho, los niños que aprenden a hablar usando un sistema de género formal, comienzan a reconocer su propio sexo biológico, y el de otras entidades sexuales a edades más tempranas que los niños cuya lengua materna no tiene un sistema de género formal (Guiora, Beit-Hallahmi, Fried, & Yoder, 1982). En definitiva, parece que el género gramatical de cada lengua modula la distinción de sexo, y posiblemente existe una conexión entre la representación conceptual del sexo y la representación léxica del género. Por otro lado,

cuando los hablantes se identifican con un tipo determinado de rol de sexo, estarán más acostumbrados a producir y a procesar palabras relacionadas con su propia definición de género (Andonova, D'Amico, Devescovi, & Bates, 2004); en el caso de que los hablantes tengan un sistema de género formal, aquellas palabras que coincidan en género gramatical con la representación del rol sexual del hablante serán más comunes en su vocabulario. Es más, la información semántica puede preactivar las decisiones de tipo léxico-sintáctico (Schiller, Schuhmann, Neyndorff, & Jansma, 2006). Por ejemplo, cuando activamos un grupo de palabras (p.e. naranjo, manzano, melocotonero) que tienen en común alguna dimensión semántica (todas las palabras representan nombres de árboles frutales), lo más probable es que además tengan en común alguna otra característica léxico-sintáctica (todos los nombres son de género gramatical masculino). El hecho de activar la información semántica que conecta esas palabras (árboles frutales) preactivará también las características léxico-sintácticas que comparten (el género gramatical masculino). En resumen, el hecho de exponerse más a menudo a palabras relacionadas con tu definición de sexo creará un sesgo sobre el procesamiento de las palabras que comparten el género.

En la Serie Experimental I, hipotetizamos que las palabras que comparten el género gramatical con el rol de sexo del participante tendrán conexiones más fuertes, en comparación con las palabras que no comparten el género gramatical con la propia definición de sexo, por lo que el acceso al léxico de las palabras que coinciden será más rápido. De hecho, durante la tarea de decisión léxica (Experimento 2) y más claramente, durante la tarea de decisión de género (Experimento 3) los resultados muestran una facilitación del procesamiento para aquellas palabras cuya relación sexo-género es congruente. Este efecto está presente de igual manera en las palabras de género semántico y en las palabras de género arbitrario, las cuales no incluyen una definición de sexo pero que son preactivadas de igual manera por la información semántica. En definitiva, parece que la gente usa la distinción de género para discriminar otras categorías que no están relacionadas con el sexo biológico (Bem, 1983), y consecuentemente los participantes activan con más fuerza aquellas palabras que coinciden en género gramatical con el propio rol de sexo. Luego estos resultados confirman que la gente organiza y codifica los conceptos de acuerdo con la definición su propio rol de sexo, ver Figura 24. Además, parece que la propiedad de género gramatical se

activa junto a las propiedades semánticas de las palabras relacionadas y no relacionadas con sexo.

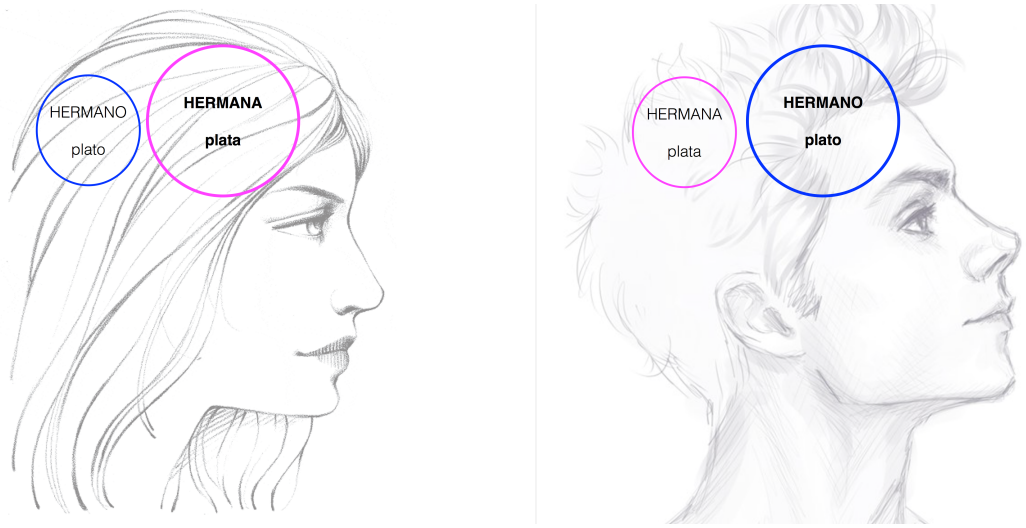

Figura 24. Representación de los candidatos léxicos dentro del lexicon mental de los diferentes hablantes. La mujer tiene las palabras de género femenino más activadas en comparación con las palabras de género masculino. El hombre tiene las palabras masculinas más activadas comparadas con las palabras de género femenino.

Con el fin de explorar más en profundidad el rol del sexo del participante durante el procesamiento de palabras con género gramatical, diseñamos un estudio de potenciales evocados (ERPs) (Experimento 7), en colaboración con la Universidad de Lille 3 en Francia, en el cual sólo seleccionamos participantes mujeres. Usamos el componente evocado conocido como *mismatch negativity* (MMN) que se usa como marca de frecuencia léxica de las palabras; además, responde a las diferencias sensoriales y léxicas, a los errores sintácticos y semánticos, y al significado conceptual de las palabras. Para este experimento seleccionados dos palabras de género semántico, que hacen referencia a "cantante hombre" (*chanteur*) y a "cantante mujer" (*chanteuse*). Las palabras fueron grabadas por diez hablantes diferentes, cinco hombres y cinco mujeres hablantes nativos de francés. Respecto a la influencia del sexo del participante durante el procesamiento de estas palabras, predijimos que la frecuencia léxica de las palabras con género dependería del rol del sexo del receptor, de manera que las palabras que coincidan en género gramatical con el sexo del participante, tendrán una mayor frecuencia léxica debido a un mayor uso de las mismas (Andonova et al., 2004). De hecho, Shtyrov, Kimppa, Pulvermüller, y Kujala, (2011) descubrieron que las

palabras con mayor frecuencia léxica producían unas respuestas MMN de mayor amplitud en comparación con palabras de baja frecuencia. Por lo tanto, nuestra hipótesis predecía mayores respuestas del componente MMN para la palabra femenina (en consonancia con el rol de sexo de los participantes, todas mujeres) en comparación con el componente desatado por la palabra masculina, dado que las circuitos neuronales procesando las palabras femeninas estarán más fuertemente conectados, debido a su mayor uso por las hablantes mujeres. En contra a nuestra hipótesis, los resultados mostraron un patrón de respuesta en la dirección opuesta; se obtuvieron mayores respuestas en el componente MMN cuando se procesaba la palabra masculina en comparación a la palabra femenina. Estas diferencias a favor de la palabra masculina pueden ser explicadas por el estatus del masculino como el genérico (Académie Française, 2002; Baudino, 2001; Meseguer, 1991). En francés (al igual que en español), el género genérico para los humanos se representa con la forma del masculino, en plural y en singular; la forma masculina de la mayoría de las palabras de género semántico se refieren tanto hombres (el uso específico del masculino) como a los dos sexo. La palabra cantante masculino (*chanteur*), a pesar de que tiene un género gramatical masculino en el idioma francés, hace referencia tanto a cantantes hombres como a mujeres. En este caso, cuando las participantes de este estudio (todo mujeres) escucharon la palabra "*chanteur*", activaron la representación de los cantantes hombres y mujeres, mientras que al escuchar la palabra "*chanteuse*" (cantante mujer) sólo activaron la representación de las cantantes mujeres. Es importante resaltar que al tener exclusivamente mujeres como participantes, están más acostumbradas al uso del masculino como la forma genérica, porque a pesar de que el masculino no representa su propio género, el grupo de las mujeres está incluido dentro de esos conceptos. Mientras que los participantes hombres siempre están incluidos en los conceptos masculinos, y siempre excluidos en los conceptos femeninos, las mujeres siempre están incluidas en los conceptos femeninos, y a veces también en los masculinos. Debido a este hecho, las mujeres de este estudio activarán las palabras de género semántico masculino de manera similar a aquellas palabras de género semántico femenino, porque su grupo de sexo también está representado dentro de este concepto. En general, durante el Experimento 7 pudimos ver que el género gramatical se procesa durante la presentación de palabras aisladas, aunque la tarea no requiera directamente prestar atención al género gramatical. Además, parece que es importante tener en cuenta que el masculino

funciona como el genérico, y que las mujeres conceptualizan estas palabras como si representaran a su grupo de sexo, de manera parecida a las palabras de género semántico femenino. Ver Figura 25.

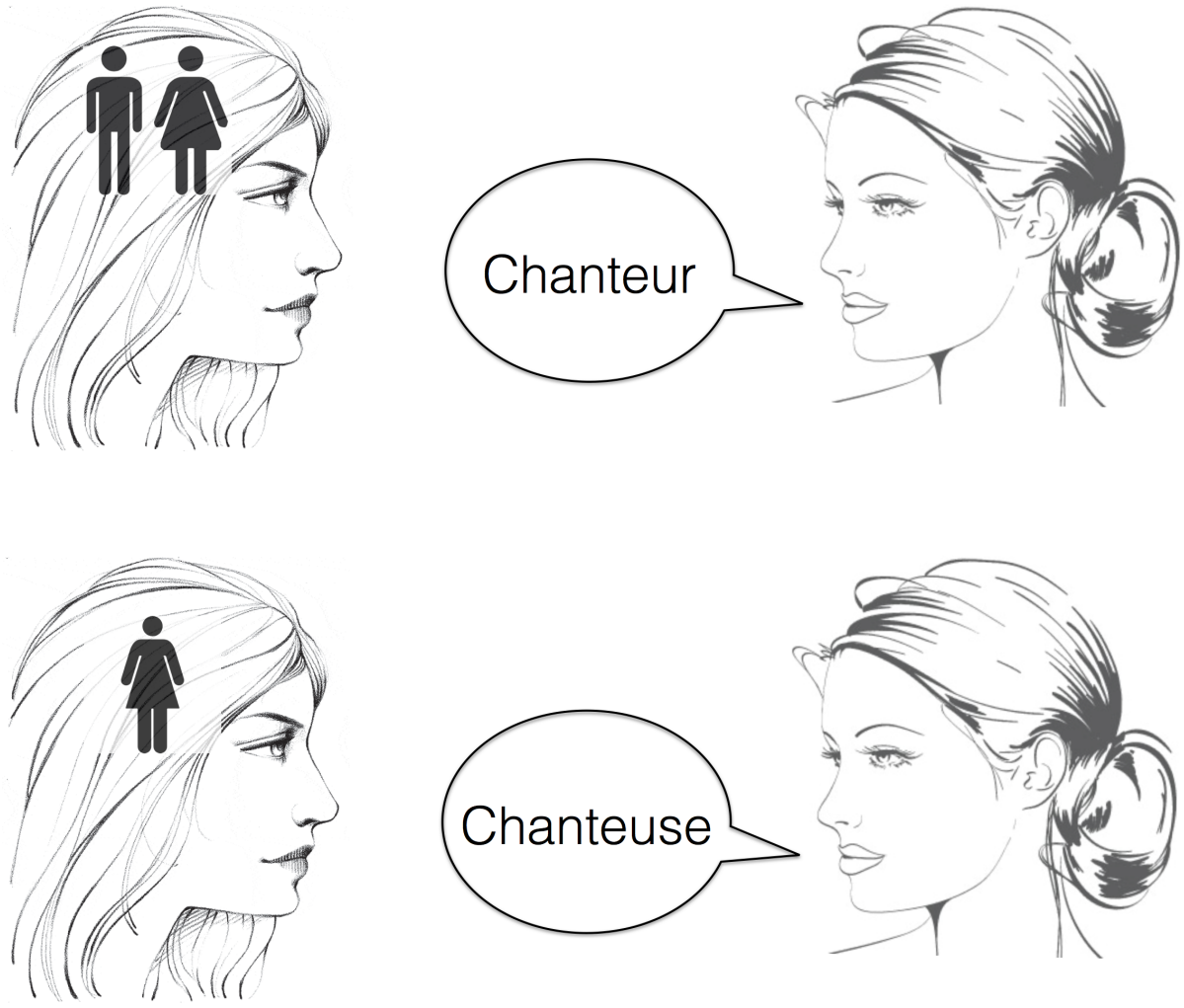

Figure 25. Representación de la palabra masculina como la forma genérica. La palabra masculina (*chanteur*) representa tanto a los cantantes hombres como a los cantantes mujeres, y cuando la presenta una hablante mujer, la voz de mujer preactiva el concepto de cantante mujer incluido en la palabra masculina (*chanteur*), del mismo modo que la voz de mujer preactiva el concepto de mujer cantante incluido en la palabra femenina (*chanteuse*).

Adicionalmente, con la Serie Experimental II queríamos explorar si el sexo del participante interaccionaba con el procesamiento de las palabras con género estereotípico. El estereotipo es una clase de información semántica de alto nivel que refleja un conocimiento social sobre los roles de hombre y de mujer. El diseño de las tareas de esta Serie

Experimental nos permite diferenciar si el estereotipo tiene una conexión más directa con el sexo del participante (dado que es una información de carácter semántico, al mismo nivel que la representación del rol de sexo de los participantes), o bien con el género gramatical (una información de carácter léxico-sintáctico, a un nivel inferior respecto de la semántica, que es asignado de manera arbitraria). Debido al hecho de que la gente organiza los conceptos alrededor de las distinciones sexuales aprendidas entre las categorías de hombre y mujer (incluyendo la información del estereotipo), y que depende del propio rol de sexo, esperábamos que el género estereotípico fuera una categoría claramente definida a nivel semántico, directamente conectada con la propia definición de masculinidad o feminidad. Por eso, nuestra hipótesis predecía que el género estereotípico fuera más importante en comparación con el género gramatical (Bender et al. 2016) a la hora de establecer una relación con el sexo del participante, porque los estereotipos pertenecen a la información semántica, que se accede antes que las propiedades léxico-sintácticas como el género gramatical (Thierry, Cardebat, & Demonet, 2003). Es más, de acuerdo con Molinaro, Su y Carreiras (2016), el conocimiento estereotípico sobrepasa el procesamiento de las claves sintácticas. De hecho, esperamos encontrar un mayor efecto del sexo del participante sobre el género estereotípico que sobre el género gramatical, dado que el género estereotípico, al igual que la percepción del rol de sexo constituye parte de la representación mental a diferencia del género gramatical (Cacciari & Padovani, 2007).

Al contrario de lo esperado, y similar a los resultados obtenidos en los Experimentos 2 y 3, los datos de los Experimentos 4 y 5 mostraron que durante las modalidades visual y auditiva de la tarea de decisión de género, había un efecto de facilitación; las participantes mujeres procesaban antes y con menos errores las palabras de género gramatical femenino en comparación con las palabras de género gramatical masculino, independientemente de la relación estereotípica (similar a los resultados obtenidos por Andonova et al. 2004). Es más, durante la modalidad visual, aparecía una tendencia del mismo efecto de facilitación en el procesamiento de las palabras de género gramatical femenino en el grupo de hombres, lo que significa que los participantes, durante la tarea de decisión de género, daban más importancia a la marca de género presente en las palabras femeninas, y que ésto facilitaba la tarea. Puede ser que ambos grupos tengan activado por defecto las palabras que coinciden en género

gramatical con su propia definición de rol de sexo como hemos visto durante los Experimentos 2 y 3, pero como las palabras femeninas tienen una ventaja de procesamiento al ser el género marcado (Harris, 1991), el efecto de la preactivación de las palabras masculinas por los participantes hombres se desvanecería durante estas tareas de decisión de género con palabras puramente arbitrarias (ver Figura 23).

Aparte de explorar la influencia del rol de sexo de los participantes durante el procesamiento de palabras con género gramatical, es interesante explorar si este procesamiento puede ser influenciado por el sexo del hablante. Durante el Experimento 7, encontramos un efecto interesante: la información presentada por hablantes del sexo opuesto sufre un sesgo atencional, de manera que las palabras que se presentan por hablantes del sexo opuesto se procesan antes que las palabras presentadas por hablantes del mismo sexo. Acorde con estos resultados, algunos estudios han mostrado una mayor activación a nivel cerebral cuando se presentan voces o caras del sexo opuesto en comparación con voces o caras del mismo sexo que los participantes (Junger et al., 2013; Li et al., 2014; Proverbio, Riva, Martin, & Zani, 2010; Sokhi, Hunter, Wilkinson, & Woodruff, 2005). De hecho, los resultados del Experimento 7 en el que únicamente participaron mujeres, vemos que las voces de hombre produjeron un aumento de la respuesta MMN comparado con la respuesta producida por las voces de mujer. Esto sugiere que las oyentes mujeres reaccionaron a la incongruencia entre el sexo del hablante y su propia representación de sexo. Al contrario que en estudios previos (e.g., Li et al., 2014), este resultado se obtuvo a pesar de que la tarea no requería un foco de atención explícito sobre la identificación del sexo del hablante. En definitiva, la identificación del sexo del hablante es importante para el receptor, y puede afectar a cómo se procesa la información hablada.

Ante todo, es importante tener en cuenta que la presente tesis trata de adaptar qué pasa en una situación de comunicación oral a un test de laboratorio, para poder ver el procesamiento del lenguaje formando parte de su realidad compleja, teniendo en cuenta las diferentes variables que pueden afectar a este procesamiento. Hemos intentado permanecer conscientes de que el comportamiento humano está lleno de interacciones, y que todas las pequeñas respuestas cambian dependiendo de cada participante, y del contexto en el que son

presentadas. De manera similar a la primera parte de esta disertación, que incide en la experiencia personal del receptor cuando procesa el mensaje lingüístico, a partir de ahora nos centraremos en explorar cómo los participantes procesan el mensaje dependiendo de cómo éste viene dado. Cuando se exponen al habla, los receptores descodifican el significado del mensaje al mismo tiempo que analizan las características físicas del hablante mediante un análisis acústico, así como por un análisis de identificación de la voz (Belin et al., 2004, 2011). La voz funciona como una *cara auditiva* y aunque no podamos ver al hablante, podemos construir una imagen mental de la persona que produce el mensaje. Durante el proceso de comunicación, estamos influenciados de manera automática por el hablante, porque crea el contexto en el cual nosotros organizamos la información. Como hemos podido ver en el Experimento 7, la gente reacciona de manera diferente, teniendo un efecto de facilitación o un aumento de las respuestas cerebrales cuando la información es presentada por hablantes del sexo opuesto en comparación a cuando la misma información es presentada por hablantes del mismo sexo. Por lo tanto, la identificación de algunas características físicas del hablante es importante cuando se procesan los mensajes lingüísticos. En particular, durante la presente investigación estamos interesados en el procesamiento de la dimensión de sexo. Hasta ahora hemos explorado el rol de la información de sexo dentro del concepto — marcado por el género, y hemos explorado el rol del sexo del receptor cuando codifica y procesa información. A continuación, exploraremos los resultados del rol del sexo del hablante en el procesamiento de palabras con género, dado que el sexo del hablante parece que crea interferencia cuando está en disonancia con la información lingüística (Lattner & Friedericci, 2003; Van Berkum et al., 2008; Vitevitch et al., 2013).

En primer lugar, queríamos explorar si la identificación del sexo del hablante era similar en la modalidad auditiva y en la visual. De hecho, durante la Serie Experimental I encontramos resultados similares durante las modalidades comic y auditiva, lo que significa que la gente procesa la información relacionada con el sexo del hablante de manera similar por la cara que por la voz (Belin et al., 2004; Joassin et al., 2011; Schweinberger, Kloth, & Robertson, 2011). En segundo lugar, queríamos ver si la información sobre el sexo del hablante creaba un sesgo durante el procesamiento de palabras con género. Los resultados de la tarea de repetición (Experimento 1) no apoyan las predicciones, esto es, el género

gramatical no era preactivado por el sexo del hablante de manera conductual. Aún así, pudimos observar el predicho efecto de *priming* durante la tarea de decisión léxica, y durante la tarea de decisión de género (Experimento 3). Específicamente, observamos que el efecto *priming* aparecía para las palabras de género semántico, donde la información sobre el sexo del hablante pudo preactivar la información sobre el sexo de la entidad (ambas son piezas de la información semántica), pero también para las palabras de género arbitrario. De hecho, estos resultados muestran que el género gramatical se accede incluso durante la tarea de decisión léxica, que tiene un procesamiento implícito del género gramatical, y que es influenciado por la información contextual creada por la identificación del sexo del hablante. Además, tenemos que resaltar que durante la tarea de decisión de género, sólo las palabras femeninas se vieron afectadas por el efecto de congruencia con la voz. En particular, durante la modalidad comic vemos que únicamente aparece un efecto de facilitación cuando las palabras femeninas eran presentadas por un hablante congruente en sexo (hablante mujer), y que el efecto desaparecía cuando eran presentadas por un hablante incongruente (hombre), y durante el procesamiento de palabras de género arbitrario. Recordamos que al igual que en francés, en español la forma del masculino funciona como el genérico incluyendo aquellas palabras que hacen referencia a seres humanos, y a la mayoría de animales (Meseguer, 1991). A pesar de que algunos estudios muestran que la forma del masculino provoca representaciones conceptuales específicamente masculinas (Gygax, Gabriel, Sarrasin, Oakhill, & Garnham, 2008), en términos de representaciones cognitivas, parece que al menos en alemán, los nombres de género gramatical masculino que hacen referencia a personas, provocan una representación menos específica que los nombres femeninos que hacen referencia a personas (Irmen & Kurovskaja, 2010). Por ejemplo, cuando escuchamos la palabra “amigo”, se supone que activamos la representación de amigos hombres y de amigas mujeres, mientras que cuando escuchamos la palabra “amiga” únicamente activamos la representación de amigas mujeres. De esta manera, la palabra “amiga” se preactivará si aparece presentada por una hablante mujer (situación congruente) en comparación a cuando aparece presentada por un hablante hombre (situación incongruente). Sin embargo, cuando la palabra “amigo” es presentada por una hablante, el sexo mujer preactivará la representación de amigas mujeres incluida dentro del concepto masculino que es el genérico, creando una condición congruente, de manera similar a la que se crearía cuando la palabra “amigo” es

presentada por un hablante hombre (palabra masculina- hablante hombre). Los resultados muestran que efectivamente, en español, la forma masculina funciona como el género por defecto o el género neutro, y en vez de crear representaciones específicas de hombres, activa la representación de las figuras masculinas y femeninas incluidas en el concepto, por lo que no observamos el sesgo del sexo hablante sobre estas palabras, ver Figura 25. En conclusión, parece que la información indexical a cerca del sexo de hablante funciona como un *prime* semántico (Bender et al., 2011), influyendo la selección de información lingüística de bajo nivel, como el género gramatical (Vitevitch et al., 2013), yendo de arriba a abajo (*top-down*) desde los altos niveles (la semántica) a los bajos niveles (lo léxico-sintáctico) (Brunelliére & Soto-Faraco, 20114). En resumen, los resultados de la Serie Experimental I muestran que a nivel conductual pudimos observar la influencia de la identificación del sexo del hablante cuando se dirigía el foco de atención sobre el género gramatical, además de cuando la tarea no requería de manera obligatoria acceder al género gramatical, como en la tarea de decisión léxica. Además, esta información nos ayuda a entender el rol del masculino como genérico en español.

Además, con los Experimentos 5 y 6 incluidos en la Serie Experimental II queríamos explorar si el sexo del hablante preactivaba el acceso al léxico de las palabras con un estereotipo asociado. Predijimos que cuando hay una coincidencia entre el sexo del hablante y el género de las palabras, habrá un acceso al léxico más sencillo que cuando las dos dimensiones no coinciden; además, este efecto será mayor cuando la relación entre el estereotipo y el género gramatical es congruente, que cuando la relación es incongruente. El hecho de tener una información semántica añadida relacionada con el sexo, y el hecho de que esta información semántica concuerde con el género gramatical facilitará la activación léxica; en el caso en el que la información sobre el estereotipo sea incongruente, esta carga de información semántica producirá una detección de la incongruencia con la información de género gramatical que interferirá con la preactivación de las palabras (Lattner & Friederici, 2003; Van Berkum et al., 2008). De hecho, los resultados muestran que cuando hay una relación congruente entre el género gramatical y el estereotípico (i.e. género gramatical femenino), las palabras presentadas por hablantes de sexo congruente (i.e., voz de mujer) son procesadas antes cuando coincide en género gramatical (femenino) que cuando no coincide

(masculino). Además, los resultados muestran que cuando hay una relación incongruente entre el género gramatical y el estereotípico, el efecto se replica, lo que significa que los participantes dan más importancia al género gramatical, una característica léxico-sintáctica (Vitevitch et al., 2013) en vez de al género estereotípico, situado a nivel semántico (Lattner & Friederici, 2003; Van Berkum et al., 2008) al cual se accede antes (Thierry et al., 2003), ver Figura 24. Sin embargo, el efecto de facilitación desaparece durante la tarea de decisión léxica (Experimento 6); parece que la influencia de los nivel superiores (información léxica, como el sexo del hablante) sobre nivel inferiores (género gramatical) no aparece durante el procesamiento de palabras de género arbitrario con un estereotipo de sexo asociado. Puede ser que el estereotipo asociado ralentizara los tiempos de acceso al léxico y enmascarara los efectos, que se pueden observar durante el procesamiento implícito de palabras neutras de género arbitrario (Experimento 2). En resumen, cuando el género gramatical concuerda con el sexo del hablante hay una facilitación en el procesamiento de las palabras del mismo género, y esta ventaja en el procesamiento se convierte en un sesgo de interferencia cuando el sexo del hablante y el género no coinciden.

De manera similar, Boutonnet et al. (2012) encontraron algunos efectos provocados por el procesamiento del género gramatical que únicamente se manifestaron a nivel cerebral, resultando en componentes de potenciales evocados (ERP), y no a nivel conductual. Estos datos nos llevan a pensar que el efecto que esperábamos encontrar del sexo del hablante influyendo el procesamiento del género gramatical, puede que aparezca de manera automática e inconsciente durante las tareas de decisión léxica, y que este efecto pueda ser visible gracias a las técnicas electrofisiológicas. Para poder explorar esta hipótesis, diseñamos el Experimento 7 usando el componente evocado MMN en la Serie Experimental III. Durante el experimento, pudimos observar si existe algún tipo de interacción entre el sexo del hablante y el procesamiento de palabras francesas con género semántico a nivel cerebral. Esperábamos encontrar un efecto a nivel léxico, y también a niveles más superiores, incluyendo el procesamiento de la semántica y de las claves léxico-sintácticas durante la integración de la palabra. En línea con los resultados de Brunellière y Soto-Faraco, (2013) y de Van Berkum et al. (2008), deberíamos encontrar un efecto de *priming* léxico provocado por la identificación del sexo del hablante durante el reconocimiento de la palabra; la

identificación del sexo del hablante en este caso sesgaría el acceso a los trazos de memoria de aquellas palabras que varían en género, provocando un cambio en la respuesta MMN (Pulvermüller et al., 2001; Shtyrov, et al., 2011), de manera que observaríamos mayores respuestas MMN cuando coinciden el sexo del hablante y el género de la palabra, en comparación cuando las dos dimensiones no coinciden, lo que provocaría respuestas MMN de menor amplitud, independientemente del sexo del hablante. Además, durante un tiempo posterior del procesamiento, específicamente, cuando se lleva a cabo la integración de la palabra (Marslen-Wilson, 1987), predecimos al igual que Vitevitch et al. (2013) una detección de la incongruencia entre el sexo del hablante (contexto en que se presenta la información) y el género gramatical de la palabra (a nivel sintáctico), resultando en mayores respuestas del componente MMN cuando hay una discordancia entre el sexo del hablante y el género gramatical, que cuando ambas dimensiones coinciden, independientemente del sexo del hablante (Hasting, Kotz, & Friederici, 2007; Menning et al., 2005; Pulvermüller, Shtyrov, Hasting, & Carlyon, 2008).

En efecto, los resultados mostraron que en la ventana temporal entre 170 y 210 ms después del inicio de la segunda sílaba, aparecía una respuesta MMN, que aumentaba cuando la información sobre el sexo del hablante y el género de la palabra coincidían; esto reflejaría el acceso a los trazos de memoria de las palabras con género influenciado por el sexo de los hablantes. En este caso, parece que la identificación del sexo del hablante funciona como un *prime* conceptual, que preactivará los trazos de memoria de los candidatos léxicos que coincidan en género gramatical con el sexo del hablante, ya que estarán más activados que los trazos de memoria de las palabras que no coinciden en género. Más allá de la influencia del sexo del hablante durante la activación de los trazos de memoria en el lexicon, en un tiempo más tardío, aparece la respuesta MMN asociada con la detección de la incongruencia entre la información indexical sobre el sexo del hablante, y la información gramatical sobre el género de la palabra. De hecho, lo que se observa es que cuando la palabra femenina se presentaba por hablantes hombres, había un aumento de la respuesta MMN comparado con cuando la misma palabra se presentaba con voces de mujer, alrededor de los 240 ms después del inicio de la segunda sílaba. A diferencia de con la palabra femenina, la detección de la incongruencia en la palabra masculina ocurría un poco después, exactamente alrededor de los

315 ms después del inicio de la segunda sílaba. Una posible explicación a esta diferencia en las latencias de la detección de la incongruencia puede deberse a que el género masculino representa el genérico (Académie Française, 2002; Baudino, 2001; Meseguer, 1991). Dado que el concepto masculino incluye la representación de los grupos de hombres y mujeres, debe ser más difícil detectar la incongruencia entre el sexo del hablante y el género de la palabra, de manera similar a lo que ocurre durante el Experimento 3.

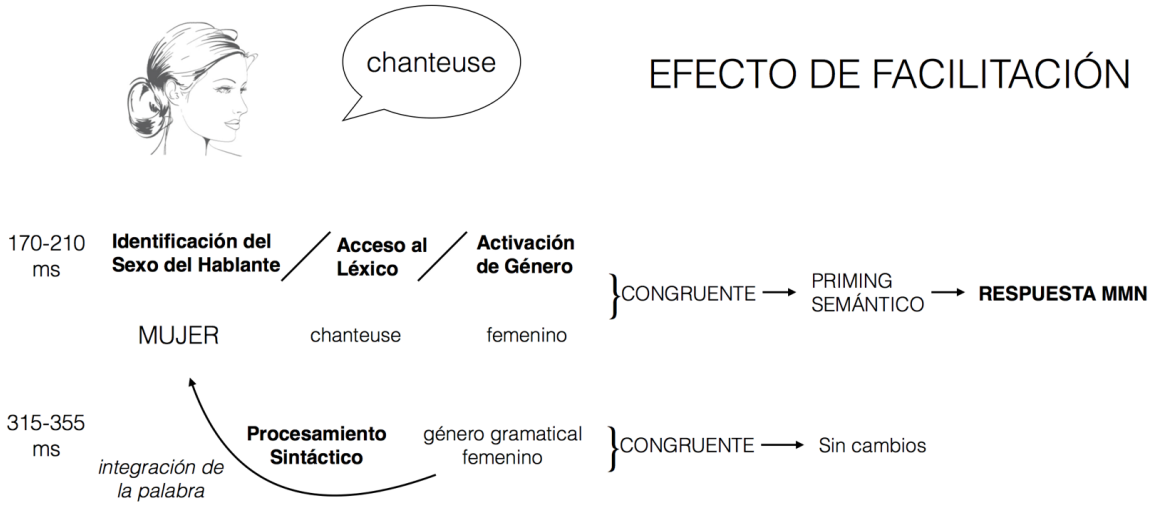

Figura 26. Modelo del efecto de facilitación provocado por la identificación del sexo del hablante. Durante la venta temporal de 170- 210 ms después del inicio de la segunda sílaba, se suceden la identificación del sexo del hablante y el acceso al léxico (con la consecuente activación inmediata del nodo abstracto de género). Cuando el sexo del hablante coincide con el género, hay un efecto priming que provoca una respuesta Mismatch Negativity (MMN) debido a la mayor activación de los trazos de memoria del mismo género que el sexo del hablante. En la ventana temporal de 315-355 ms el procesamiento sintáctico es activado y sucede la integración de la palabra, recuperando la información contextual referente al sexo del hablante. Cuando el sexo del hablante se corresponde con el género de la palabra, no se detectan cambios.

En su conjunto, durante el Experimento 7 pudimos probar que la selección léxica de las palabras con género gramatical se ven influenciadas por la identificación del sexo del hablante que produce la palabra, aunque no se dirija un foco de atención directa al género gramatical. Además, el cerebro detecta la incongruencia entre la voz y el género en un tiempo tardío, y la interferencia entre los niveles semánticos y sintácticos nos muestra que el género masculino para las palabras de género semántico funciona como el genérico, incluyendo ambas representaciones de las figuras masculinas y femeninas dentro del concepto. Sobre

todo, es importante diferenciar la existencia de dos estadios diferentes en los que influye la identificación del sexo del hablante, representado en las Figuras 26 y 27.

Teniendo en cuenta los resultados conductuales durante las tareas de decisión de léxica y de decisión de género, parece que observamos un reflejo del procesamiento a nivel tardío o el segundo nivel de procesamiento producido por la integración de las propiedades puramente sintácticas y la identificación del sexo del hablante. De esta manera, las diferencias que observamos a nivel conductual no serían provocadas por un efecto de facilitación, sino por un efecto de la detección de incongruencia entre el sexo del hablante y el género gramatical de la palabra.

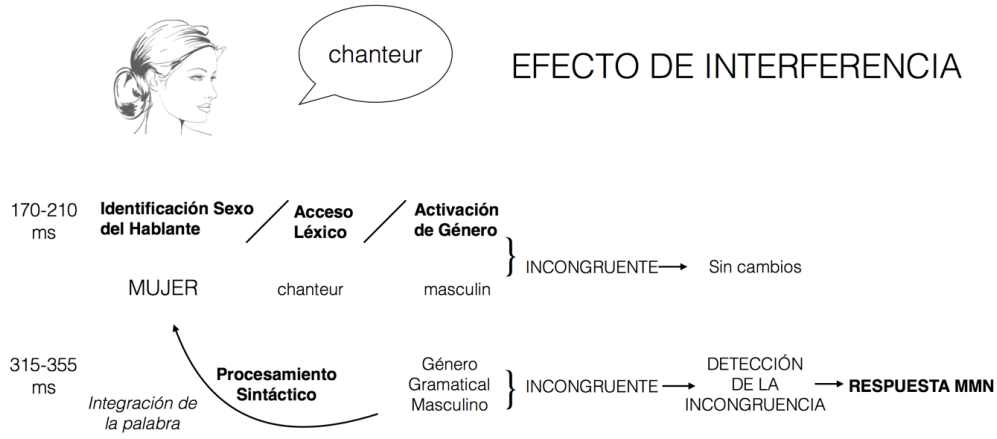

Figura 27. Modelo del efecto de interferencia provocado por la identificación del sexo del hablante. Durante la venta temporal de 170- 210 ms después del inicio de la segunda sílaba, se suceden la identificación del sexo del hablante y el acceso al léxico (con la consecuente activación inmediata del nodo abstracto de género). Cuando el sexo del hablante no coincide con el género no se detectan cambios. En la ventana temporal de 315-355 ms el procesamiento sintáctico es activado y sucede la integración de la palabra, recuperando la información contextual referente al sexo del hablante. Cuando el sexo del hablante no se corresponde con el género de la palabra, hay una detección de la incongruencia entre las dos dimensiones que produce la respuesta de mismatch negativity (MMN)

En general, las Series Experimentales I, II y III nos proporcionan más evidencias que sugieren que los diferentes niveles de la información sobre sexo presente durante la comunicación oral interactúan. En primer lugar, el género gramatical pertenece al nivel léxico, y se recupera durante el procesamiento de palabras aisladas, fuera de un contexto lingüístico. Además, el género gramatical es activado siempre que se procesan palabras de género semántico, de género estereotípico, y también, durante el procesamiento de palabras

de género puramente arbitrario. En segundo lugar, los participantes usan la distinción de género para codificar y organizar las representaciones conceptuales dependiendo de su propio rol de sexo; hemos visto que el rol de sexo de los participantes activaba con más fuerza, y por defecto, las palabras que coinciden en género con su propio rol de sexo en comparación con aquellas palabras que no coinciden en género, independientemente del tipo de género (aunque tenemos que tener en cuenta que el masculino representa el genérico). En tercer lugar, estamos influenciados por el sexo del hablante de manera que cuando el mensaje viene dado por un hablante del sexo opuesto, hay un sesgo atencional producido por un aumento de la respuesta cerebral. Y finalmente, el sexo del hablante influye en cómo la gente procesa las palabras de género gramatical; en primer lugar, cuando hay una coincidencia entre el sexo del hablante y el género de la palabra, los candidatos léxicos que comparten la característica de género gramatical con el sexo del hablante son activados de manera más potente que los candidatos léxicos con un género gramatical opuesto al sexo del hablante, produciendo así un efecto de facilitación (ver Figura 26). Después, en un estadio más tardío de procesamiento se accede a las características sintácticas y la palabra se integra con su contexto; cuando hay un desacuerdo entre el sexo del hablante y el género de la palabra, se detecta la incongruencia. La incongruencia entre el sexo del hablante y el género de la palabra produce un aumento de la respuesta MMN a nivel cerebral, y en el campo conductual vemos que hay un efecto de interferencia que ralentiza los tiempos de reacción en comparación a cuando las dos dimensiones coinciden (ver Figura 27).

En conclusión, el género gramatical parece ser más que una simple propiedad léxico-sintáctica, que se usa para discriminar conceptos que en principio no están relacionados con el sexo. Además, la activación del género gramatical está modulada por los diferentes niveles de la dimensión sexo presente durante el proceso de comunicación oral. Para empezar, dependiendo del rol de sexo que una persona tiene, ésta codificará y organizará los conceptos de manera diferente, es decir, la gente que se identifique con un rol de mujer tendrá activado por defecto las palabras de género gramatical femenino en comparación con las palabras de género gramatical masculino; mientras que las personas que se reconozcan a ellos mismos como hombres, tendrán una mayor activación de las palabras de género masculino en comparación con las palabras de género femenino. Para continuar, el sexo de la persona que

comunica el mensaje lingüístico sesga el procesamiento del habla. Por un lado, la gente tiende a prestar más atención cuando la información (independientemente del contenido) se presenta por hablantes del sexo opuesto. Por el otro lado, el sexo del hablante modula el procesamiento lingüístico del mensaje (los dos sexos por igual), es decir, la gente está preparada para procesar las palabras que coinciden en género gramatical con el sexo del hablante; cuando esto ocurre, hay una ventaja de procesamiento. De todas formas, cuando hay una discordancia, la detección de la incongruencia entre el sexo del hablante y el género de la palabra ocurre para aquellas palabras con género semántico, género estereotípico y género arbitrario, lo que significa que el género gramatical es un clasificador importante para los hablantes de lenguas con un sistema de género formal.

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