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"Todes" and "Todxs", linguistic innovations or grammatical gender violations?

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ABSTRACT

This study compared the processing of non-binary morphemes in Spanish (e.g., *todxs*, *todes*) with the processing of canonical grammatical gender violations in Spanish pronouns (e.g., *Los maestros… todas…*). Using self-paced reading, the study examined how individual differences in working memory and gender/sex diversity beliefs affected language processing at three regions of interest (ROI): the pronoun, the pronoun +1, and the pronoun +2. Seventy-eight Spanish-English bilinguals completed two self-paced reading tasks, one with non-binary pronouns and another with grammatical gender violations, as well as a working memory task, a language dominance questionnaire, and a gender/sex diversity beliefs questionnaire. Processing costs were operationalized as longer reaction times (RTs) or inaccurate responses. Results showed overall processing costs for non-binary morphemes at all 3 ROIs, but no processing costs were observed in terms of accuracy or response times to the comprehension question. The results suggest that processing non-binary pronouns results in a small processing cost that does not affect overall sentence comprehension. The small observed processing cost was moderated by gender/sex diversity beliefs, with gender normative beliefs increasing RTs at the pronoun and affirmation of diverse gender identities beliefs reducing the RTs at the second spillover region. In contrast, grammatical gender violations only showed a processing cost at the first spillover region and were not moderated by working memory nor gender/sex diversity beliefs. Taken together, the results suggest that non-binary pronouns are processed differently than grammatical gender violations and that the small processing cost they impose can lead to good enough comprehension.

1. Introduction

When people think about gender, several things might come to mind. They might think about the biological aspect and equate its definition to that of biological sex, they might think of gender as a sociocultural phenomenon dependent on how an individual acts in society instead of their biological sex, or they might have a mixture of both definitions. Regardless of what definition someone might have surrounding the term gender, it most likely does not provide a full account on how languages represent gender, because the implications of gender in language go beyond biological and sociocultural notions.

Gender manifests itself differently across languages. This has allowed language researchers to group languages into three groups according to how gender is expressed: natural gender languages, genderless languages, and grammatical gender languages (Corbett, 1991; Stahlberg et al., 2007). On one hand, while natural gender languages like English have gender-neutral nouns (e.g., 'student'), some suffixes that mark gender (e.g., 'actor', 'actress'), and pronouns (e.g., he/she/they) to express social and biological gender, genderless languages like Turkish and Finnish have neither nouns nor personal pronouns that mark gender. Instead, gender is expressed as an attribute (e.g., male secretary) or lexically (e.g., woman). In contrast, grammatical gender languages like French and Spanish arbitrarily mark gender in all nouns (animate and inanimate) as either grammatically masculine (e.g., *el libro* 'the book') or

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grammatically feminine (e.g., *la silla* 'the chair'), with the gender of nouns that refer to people corresponding to their gender (e.g., *maestro*, 'male teacher'; *maestra* 'female teacher'). In languages that mark grammatical gender, marking serves both as a classification system as well as a grammatical feature that interacts with other properties in the sentence such as person and number (Fábregas, 2022). Moreover, when nouns are classified into masculine or feminine grammatical gender, this gender can either be compositional (i.e., corresponding to biological sex or social gender in the case of animate beings) or idiomatic, an arbitrary propriety (like previously mentioned *silla* and *libro*). Therefore, when talking about 'masculine' and 'feminine' terms as it relates to grammatical gender it is important to remember that these terms are not necessarily related to social gender.

While the compositional aspect of grammatical gender in Spanish allows men and women to name themselves, it poses a challenge for those who identify as non-binary (i.e., people who identify as neither a man nor a woman, or both genders). To address this challenge, Spanish speaking LGBTQIA+[2] communities have proposed alternative morphemes to mark gender-neutrality in Spanish (Acosta Matos, 2016; López, 2020; Papadopoulos, 2021; Román Irizarry, 2021; Stetie & Zunino, 2022, 2024). These morphemes serve a double function, first to refer to a non-binary individual and second to serve as gender-neutral alternatives to masculine generics (i.e., the use of masculine forms in generic contexts such as *el hombre* 'mankind' instead of generic words like *la humanidad* 'humankind'). However, due to the recent introduction of non-binary morphemes into Spanish's grammatical gender system alongside the masculine and the feminine forms, many questions remain regarding the acquisition of these non-binary forms.

One essential question that remains unanswered is whether acquiring the non-binary forms in Spanish is similar to how late second language (L2) learners acquire grammatical gender as adults. Although this paper does not directly test the mechanisms by which non-binary forms are acquired in Spanish, it does focus on their processing. We use this processing as a way to assess the extent to which Spanish speakers have been able to integrate a third gender-neutral category into a binary grammatically gendered language. One helpful framework for examining non-binary forms in Spanish is late L2 acquisition of grammatical gender. Even the most proficient L2 learners have difficulty acquiring grammatical gender (e.g., Dussias et al., 2013; Hopp, 2016) in comparison to native speakers who acquire Spanish as their first language (L1). Late L2 acquisition of grammatical gender can be used as a model for examining the processing of non-binary forms, particularly because these non-binary forms are acquired by native Spanish speakers as adults once their masculine/feminine grammatical gender system has already been established. Therefore, for bilingual and monolingual speakers alike, the acquisition of non-binary forms requires learning a new feature of language beyond early childhood. If the challenge that adult learners experience in acquiring non-binary forms is similar to acquiring grammatical gender in an L2 that either marks gender when their L1 does not (e.g., when the L1 is English) or marks gender in a different way than their L1 (e.g., when the L1 is French and the L2 is German) then we might expect to see similar patterns of language processing for sensitivity to non-binary forms and to grammatical gender in an L2 (i.e., processing costs in the form of longer RTs or inaccurate responses). Although the focus of this paper is not to test how L2 learners of Spanish acquire canonical grammatical gender and non-binary forms, comparing the acquisition of non-binary forms in native Spanish speakers to how L2 learners acquire grammatical gender will enable us to situate the study of non-binary forms in the broader literature on grammatical gender acquisition as well as in the emerging literature that focuses on the processing of non-binary forms in different languages.

[2] Stands for lesbian, gay, bisexual, transgender, queer/questioning, intersex, and asexual. The '+' sign denotes other people who are not included in the acronym but feel like they are part of the LGBTQIA+ community.

Although some parallels can be drawn between acquiring non-binary morphemes and grammatical gender, there are also some differences. Adult Spanish speakers must alter pre-existing grammatical structures to create non-binary forms in Spanish, so words like *maestro* ('male teacher') and *maestra* ('female teacher') become *maestre* ('teacher'), an alteration that may involve domain general cognitive resources that have yet to be explored. While native Spanish speakers already know *maestro* and *maestra*, and are just learning to insert the non-binary morpheme as a gender-neutral marker to form *maestre*, a Spanish L2 learner would need to learn all three gender morphemes. Precisely because native Spanish speakers have already acquired the masculine/feminine grammatical gender system, previous studies have shown that they are sensitive to canonical grammatical gender violations (Beatty-Martínez et al., 2021), with the most studied grammatical gender violation being the mismatch between noun and determiner gender agreement (see Beatty-Martínez & Dussias, 2019 for a review). Nevertheless, a question that remains to be answered is how the processing of non-binary morphemes in Spanish, which is situated in a sociocultural context and may potentially draw on cognitive resources, compares to that of grammatical gender violations, which has also been shown to rely on cognitive resources (further described in Section 1.6).

To address these issues, we administered two self-paced reading tasks as a means to tap into early and late processing,[3] a working memory task, and a gender/sex diversity beliefs questionnaire to native Spanish speakers who were also bilingual in English. To facilitate the understanding of our framework, we first provide a brief overview of the gender asymmetries reported for masculine forms and strategies to overcome masculine biases, since this study used non-binary morphemes in plural pronouns. We chose to focus on non-binary morphemes in plural contexts for their dual ability to provide gender-neutral contexts that serve as replacements to masculine generics while also acknowledging non-binary individuals. Besides, other researchers have noted that non-binary morphemes work better as generic alternatives than when they are used to refer to non-binary individuals (Stetie & Zunino, 2024, p. 450). In what follows, we first review how expressing neutrality in grammatical gender languages is different from other languages, the processing of gender-neutral morphological alternatives in grammatical gender languages, referential pronoun processing, the processing of non-binary pronouns in different languages, the processing of grammatical gender violations, and then the effects of social factors on the processing of non-binary morphemes.

To anticipate our findings, the experiments we report will show that processing non-binary pronouns incurred small processing costs that were moderated by gender/sex diversity beliefs. However, these small processing costs were not enough to affect overall comprehension. In contrast, grammatical gender violations were only detected at the first spillover region and were not moderated by gender/sex diversity beliefs. Taken together, the findings suggest that processing non-binary pronouns differs from processing grammatical gender violations.

1.1. Masculine generic biases and strategies to overcome its use

Across different language families, there is a linguistic gender asymmetry in favor of masculine forms (Hellinger & Bußmann, 2001), particularly masculine generics. For example, in the sentence "If the reader has any questions, he may contact the corresponding author", the pronoun *he* is used in a generic context where the gender is irrelevant or

[3] Not to be confused with early and late processing measures in eye-tracking studies. In self-paced reading studies, the critical region can be taken as an indicator of early processing, and the subsequent regions (spillover regions) are considered to indicate later processing stages. In contrast, in eye tracking early and late processing measures refer to processes that occur within the critical region. See Conklin and Pellicer-Sánchez (2016) for a detailed explanation of eye-tracking measures.

unknown. Although masculine generic forms like the previous example are intended as neutral, psycholinguistic studies have shown that their use can evoke more mental representations of men than of women and gender diverse people (Stetie & Zunino, 2022; see Gygax et al., 2019 for a review).

To combat the use of masculine generics, gender-fair language strategies have been proposed (Sczesny et al., 2016). One of these is neutralization, which refers to the use of gender-neutral nouns and pronouns. In English this can be achieved by using the singular *they* and in Swedish by using the newly introduced gender-neutral pronoun *hen* (Vergoossen et al., 2020). In languages with grammatical gender, like Spanish, the recommended gender-fair language strategy is a combination of feminization and neutralization. Feminization refers to the use of linguistic forms that explicitly mark the inclusion of women. This can take the form of masculine/feminine word pairs or employ innovative gender-inclusive alternatives. In Spanish, the morpheme –o typically marks the masculine gender, while the morpheme –a marks the feminine gender. Some examples of how the feminization gender-fair strategy is used in Spanish are: *maestros y maestras* 'male teachers and female teachers' (heteronymous word pairs), *maestros/as* (use of slash), and *maestr@s* (use of arroba). Regarding neutralization, it is recommended that languages with grammatical gender employ the use of epicenes, that is invariant words that can refer to people from any gender. For example, *la persona* refers to 'the person' although its grammatical gender is female. However, the problem with epicenes is that they can't be used in role names like *maestro* where the gender of the referent must be marked. And so, to mark gender neutrality in a binary grammatical gender language like Spanish, LGBTQIA+ Spanish speakers have proposed several non-binary morphemes, two of the most common being –e (e.g., *maestre*) and –x (e.g., *maestrx*, pronounced as [maestre] or [maestreks]) (Acosta Matos, 2016; López, 2020; Papadopoulos, 2021; Román Irizarry, 2021; Stetie & Zunino, 2022; Stetie & Zunino, 2024; Vidal-Ortiz & Martínez, 2018). While non-binary morphemes in Spanish represent the most recent neutralization strategy, they are not the first linguistic strategies people have opted for. In fact, neutrality began with the creation of feminine nouns that either did not exist in language before or were considered ungrammatical (e.g., *ingeniera* 'female engineer', *abogada* 'female lawyer'). Although the creation of feminine nouns in historically masculine role nouns would be classified today as a feminization strategy, early feminist literature identifies this strategy as a form of neutralization. For a detailed review on the history of the feminization of Spanish and the use of other gender-neutral alternatives before non-binary morphemes see Bengoechea (2008, 2015). Nevertheless, the use of non-binary morphemes in Spanish serves as both a gender-neutral alternative to masculine generics, and second as a way of allowing non-binary identities to be able to name themselves in language.

1.2. How non-binary morphemes differ from gender-neutral pronouns

By using non-binary morphemes to mark neutrality, grammatical gender languages differ from natural gender languages which predominantly rely on gender-neutral pronouns. In natural gender languages, speakers are essentially learning new words that can be used as gender-neutral pronouns like Swedish *hen* or repurposing the generic value of an already existing generic pronoun like the singular *they* in English. In contrast, grammatical gender languages not only require innovative gender-neutral pronouns they also require morphological innovations to achieve gender-neutrality. These morphological innovations vary between languages (e.g., German: Körner et al., 2022; Slovene: Popič & Gorjanc, 2018). For example, French has *écriture inclusive* 'inclusive writing' that uses innovative third-person pronouns such as *iel* to mark agreement with both masculine and feminine forms separated by a *point médian* 'interpunct' (e.g., *Iel est allé·e à l'école.* 'They[singular] went to school.', Knisely, 2020). However, as the name suggests, French inclusive writing mostly works in written modalities since the spoken agreement forms, for now, are pronounced as either masculine or feminine. In contrast, non-binary morphemes in other romance languages like Spanish and Portuguese (Veloso et al., 2023) work both in written and oral modalities (recall in Spanish –x may be pronounced as 'e' or 'eks'). Since the current study focuses on Spanish, we focus on how this language makes use of non-binary morphemes. Spanish's morphological richness allows its speakers the ability to transform pre-existing nouns and pronouns into non-binary forms by using morphemes –x and –e instead of canonical morphemes –o and –a. Although Spanish speaking LGBTQIA+ communities have introduced *elle* as a third-person gender-neutral subject pronoun (see Papadopoulos et al., 2022 for how to mark gender agreement with *elle*), the use of non-binary morphemes allows the neutralization of other types of pronouns in Spanish. In other words, demonstrative pronouns like *esos* and *estos* 'those' would turn into *eses* and *estes*, and indefinite pronouns like *todos* 'all' and *algunos* 'some' would turn into *todes* and *algunes*. All these pronouns fall under the *pronombre* 'pronoun' definition given by the Real Academia Española *(2024)*, which defines pronouns as the class of words that function as noun phrases and are used to refer to people, animals, or things without naming them. This allows for an overarching definition of pronouns that includes the set of personal, demonstrative and indefinite Spanish pronouns tested in this study.

Another feature that sets Spanish apart from other natural gender languages in terms of non-binary pronouns besides its grammatical gender, is the fact that unlike singular *they* (Lee, 2019), Swedish *hen* (Fahl, 2014), or Dutch *hen* and *die* (Taalunie, 2022), which all have been officially recognized as gender-neutral pronouns, Spanish *elle* and non-binary morphemes –x and –e have not (see Proceso, 2021 and Cruz, 2021, for an overview of the Royal Spanish Academy's view on this). This has been done under the premise that non-binary morphemes are factitious resources that are not only foreign to Spanish morphology but also are not generalized across Spanish speakers (RAEinforma. [@RAEinforma], 2021a; RAEinforma. [@RAEinforma], 2021b). While non-binary morphemes in Spanish represent an emerging linguistic change, very little research has been done to address how these forms are processed. In the section below, we first review previous research on processing gender-neutral morphological alternatives in other grammatical gender languages and then focus on Spanish.

1.3. Processing gender-neutral morphological alternatives in grammatical gender languages

Research on gender-neutral morphological alternatives in grammatical gender languages has primarily focused on comparing the processing of these alternatives against masculine generic forms or to one another (e.g., Körner et al., 2022; Pozniak et al., 2024; Tibblin et al., 2023). In French, one morphological alternative is the *point médian*, while one alternative in German is the *. Tibblin et al. (2023) examined how the masculine generic and different gender-fair strategies (i.e., *point médian*, heteronymous word pairs, or gender-neutral collective nouns) shaped mental representations of gender. They found that the masculine generic led to male biases, while the gender-fair strategies eliminated said bias. When comparing the strategies against each other, heteronymous word pairs (what Tibblin et al. call double forms) elicited the most gender balanced representations, while the *point médian* lead to female biased representations and collective nouns resulted in a small male bias. The gender-neutral value of the heteronymous word pairs and the female bias of *point médian* was also found by Pozniak et al. (2024) who examined these forms in detailed contexts (i.e., a paragraph). Körner et al. (2022) found a similar female bias with German * and balanced gender representations with heteronymous word pairs. In summary, research on French and German suggest that gender-neutral morphological alternatives seem to possess a female bias, however whether they could also represent any other non-male gender representations (e.g., a non-binary person) remains an unexplored question in these languages.

When it comes to Spanish, although numerous literature has been written on the subject of gender-neutral morphological alternatives (see Stetie & Zunino, 2022 for a review on this topic), psycholinguistic studies on the topic present an emerging literature. Out of the studies we could find, one of them compares the processing of non-binary morphemes –x and –e against the masculine –o (Zarwanitzer, 2019), while another compares the mental representations elicited by non-binary morphemes (Stetie & Zunino, 2022). These studies show mixed results. While Zarwanitzer found that processing nouns with non-binary morphemes (e.g., *amigxs*, *amigues,* 'friends') was more costly than nouns with the masculine generic (e.g., *amigos*), Stetie and Zunino did not find this difference. Instead, they found that the use of non-binary morphemes evoked more gender-neutral group representations when they were used in role names that evoked either low male stereotypicality (e.g., *lxs mastrxs*, *les maestres*, 'the teachers') or high male stereotypicality (e.g., *lxs carpinterxs*, *les carpinteres*, 'the carpenters') and that nouns with the masculine generic –o had significantly longer RTs at both the sentence level as well as the question response level. As a follow up to their study, Stetie and Zunino (2024) further explored the relationship between non-binary –e and stereotyped role names, this time including female stereotyped nouns as well. They did this by means of a self-paced reading task and looked at RTs at the noun phrase (Det + N), the three-word spillover region, wrap up region (final word of the sentence), and total sentence time. A semantic bias effect was found only at the first spillover effect for female stereotyped nouns, an effect they attributed to the low occurrence of female stereotyped role names with non-binary –e. Despite this last study not including a comparison against the masculine generic –o, it highlights the importance of taking gender stereotypes into account when assessing the processing of non-binary morpheme –e in Spanish role nouns. In summary, all of the previous studies on the processing of non-binary morphemes have been conducted on River Plate Spanish speakers, a Spanish variety spoken mainly in Argentina and Uruguay. In Stetie and Zunino's first study (Stetie & Zunino, 2022), 75 % of the participants reported using any form of non-binary language from occasionally to frequent, while Zarwanitzer's data did not report usage of non-binary forms by their speakers. Taken together, these findings might suggest non-binary morphemes are only hard to process in noun phrases when speakers are not familiar with them.

What is less known, and to our knowledge yet to be examined, is whether processing non-binary morphemes in Spanish pronouns would follow the same pattern as the one exhibited by noun phrases. This is of great interest to psycholinguists, given that pronouns belong to closed classes that do not easily admit new forms in contrast to open classes like nouns that do (Paterson, 2014). However, non-binary Spanish pronouns might be different in this sense because they are formed by substituting canonical morphemes –o and –a for non-binary morphemes –x and –e in already established Spanish pronouns. Even the third person singular *elle* 'they' (singular) was derived from the feminine third person singular *ella* 'she.' This stands in contrast to Swedish and Dutch which created new gender-neutral subject pronouns, or to English which repurposed the generic use of *they* in unknown contexts to a third person singular. Therefore, the question of whether processing non-binary morphemes in Spanish pronouns exhibits a similar processing pattern as noun phrases with non-binary morphemes, or whether the processing of non-binary pronouns in Spanish is more similar to the processing of non-binary pronouns in other languages is one this study will help answer.

One possible distinction between processing non-binary morphemes in noun phrases versus processing non-binary morphemes in pronouns, could be due to the functionality pronouns serve in referential processing. In the next section, we briefly describe some of the constraints that affect referential pronoun processing.

1.4. Referential pronoun processing

Pronouns are anaphoric expressions that consist of an antecedent, the previous mention of the referent, and an anaphor, the word that 'points' back at the antecedent. The process of linking the anaphor to its antecedent is called anaphora resolution (Mitkov, 2013). This process has been shown to be heavily constrained by what language users encounter before, during, and after the pronoun, with the latter being of particular importance to the disambiguation of multiple referents (Arnold, 2023). It can also be affected by the syntactic position of the antecedent, however since the antecedent in our study always appeared in subject position and only included one referent, we focus on subject type antecedents in pronoun resolution when the referent is not unambiguous (see Mitkov, 2013 for other types of antecedents and anaphoric expressions).

Prior to the pronoun, linguistic context has been shown to be essential for anaphora resolution. It is in this linguistic context where language users start to build a mental model of what the discourse, spoken or written, is about. Psycholinguists have found that when building a mental model, people draw on lexical, grammatical, and world knowledge to do so (see Garnham, 2001 for a review). Once the pronoun is encountered, processing is facilitated when it matches the gender and number of its antecedent (e.g., 'Mary is a student. She wants to pursue a degree in higher education.'). In contrast, when the information does not match the mental model built, like in the case of gender stereotypes, processing costs arise in the form of a mismatch effect (Carreiras et al., 1996; Garnham, 2001). For example, in the sentence 'The nurse prepared the injections. He…', the feminine gender stereotype of the noun does not match the gender of the pronoun *he*. In languages with grammatical gender, like Spanish, not only does the gender stereotype affect the processing of the pronoun, but the grammatical gender information of the noun also affects the pronoun resolution process. And so, in cases where the grammatical gender of the noun does not match the gender stereotype (e.g. *la carpintera* 'the female carpenter'), processing of the pronoun (e.g., *ella* 'she') suffers even if it agrees with the grammatical gender of the noun (Carreiras et al., 1996).

In short, grammatical and world knowledge can both affect the pronoun resolution process. In this study, we take the additional step of examining how recently incorporated non-binary morphemes can affect pronoun resolution in unambiguous referent scenarios with controlled gender-neutral nouns as the antecedents. To understand how non-binary pronouns are processed in other languages, we have the section below.

1.5. Previous research on processing gender-neutral pronouns in different languages

As other researchers have noted, the processing of gender-neutral pronouns is very limited and concentrates mostly on English and Swedish (Decock et al., 2023), with the most pressing question being whether gender-neutral pronouns are more difficult to process than their masculine and feminine counterparts. A more specific question that has been asked in the literature is whether gender-neutral pronouns are hard to process because they are newer or whether because they do not match the lexical (e.g., 'queen') or stereotypical (e.g., 'nurse') gender information of the antecedent. The evidence to date on English and Swedish presents mixed findings.

In English, evidence suggests that the singular *they* is easily understood in gender-neutral contexts, but not when a male or feminine gender is assumed (see Arnold et al., 2021, for a review). One of the oldest studies to document this effect was Foertsch and Gernsbacher (1997). A replication of Foertsch and Gernsbacher's study was done in non-native English speakers (Speyer & Schleef, 2019). Speyer and Schleef (2019) found that singular *they* did not impose additional processing costs for non-native English speakers. They also found that singular *they* was easily processed regardless of the antecedent (i.e., referential versus non-referential), in contrast to Foertsch & Gernsbacher's, 1997 study. In Swedish, Vergoossen et al. (2020) investigated the pronoun resolution of Swedish *hen* when referring to gendered (lexically or stereotypically) or neutral nouns by means of an eye-

tracking study. They found that *hen* only incurred a small processing cost in the spillover region of the pronoun, and that this effect was greater when the antecedent was a neutral noun. Although most of their sample had a positive opinion regarding *hen*, they attributed the small processing cost to the novelty of the pronoun. Despite the subtle differences between the findings in English and Swedish, there is stronger evidence to support the notion that gender-neutral pronouns can facilitate pronoun resolution in gender-neutral contexts.

1.6. Processing grammatical gender in Spanish

Now that we have reviewed the research on non-binary morphemes in Spanish and the research on processing gender-neutral pronouns in other languages, we present a brief overview on processing canonical grammatical gender in Spanish. Spanish speakers are sensitive to the canonical grammatical gender in Spanish. A proper account of how non-binary morphemes are processed cannot be established unless this grammatical gender sensitivity is taken into account.

Grammatical gender sensitivity has been primarily assessed in the form of grammatical gender violations within the noun phrase. The common finding in these studies is that violations between the determiner and the gender of the noun (e.g., *la pollo* instead of *el pollo* 'the chicken') lead to longer RTs in self-paced reading, longer fixation times in eye-tracking studies, and biphasic Left Anterior Negativity (LAN)-P600 effects in event-related potentials (ERP) studies (see Beatty-Martínez & Dussias, 2019 for a review).

The relationship between cognitive resources such as cognitive control and working memory and the processing of complex structures such as grammatical gender violations has also been examined in Spanish monolinguals and L2 speakers. Cognitive control has been hypothesized to operate in two different modes: proactive control, which involves early selection of goal relevant information before the occurrence of a cognitively challenging event, and reactive control, which involves late correction mechanisms that are employed when an unexpected event is detected (Braver, 2012). Working memory is defined as a cognitive system that is responsible for actively maintaining and processing information in the face of distracting information (Conway et al., 2007). Higher working memory has been associated with superior integration of semantic, syntactic, and pragmatic information in comparison to lower working memory (Just & Carpenter, 1992). An ERP study on grammatical gender violations in Spanish monolinguals found that ERP responses to masculine noun violations were reduced as reactive control increased (Beatty-Martínez et al., 2021). Research on L2 speakers found that higher working memory increased sensitivity to violations among L2 Spanish beginner (Sagarra, 2007) and intermediate learners (Sagarra & Herschensohn, 2010). However, Foote (2011) did not find any relationship between working memory and gender agreement distance.

Although the findings related to working memory and grammatical gender sensitivity were found for L2 Spanish speakers, we believe a parallel can be drawn between this finding and non-binary morphemes, since non-binary morphemes are introduced later in life once the masculine and feminine grammatical gender system has been established. In this study, we test the potential relationship between working memory and the processing of non-binary Spanish pronouns in anaphora resolution. Originally, cognitive control was also included as a variable of interest in our study, but it was removed because participants had difficulty completing the AX-Continuous Performance Task online, which led to poor data quality.

1.7. Social factors and non-binary morphemes

Another variable of interest for the processing of non-binary morphemes in Spanish is gender/sex diversity beliefs. This includes beliefs regarding the ontology of gender/sex while including social constructionist—gender/sex is diverse and socioculturally contingent—and essentialist beliefs—gender/sex as a singular reality—that can be measured through a scale. This scale, called the Gender/Sex Diversity Beliefs scale (GSDB; Schudson & van Anders, 2021) contains five subscales: Affirmation (of diverse gender identities), Gender Normativity (traditional views on gender), Uniformity (how similar people of the same gender are), Surgery (legitimacy of transgender surgeries), and Upbringing (how upbringing influences gender identity). Although gender/sex diversity beliefs have not been examined with respect to the processing of gender-neutral pronouns, Affirmation beliefs have been associated with positive feelings towards gender/sex minorities, while Gender Normativity, Uniformity and Surgery have been found to be associated with negative feelings towards gender/sex minorities (Schudson & van Anders, 2021).

Other factors similar to gender/sex diversity beliefs have been found to affect the acceptability of gender-neutral pronouns in other languages. For example, Renström et al. (2022) found that people who believed in gender as a binary category were less likely to accept the gender-neutral Swedish pronoun *hen*. In another study on the acceptability of Swedish *hen*, Gustafsson Sendén et al. (2015) found that those who had an interest in gender issues were more likely to accept and use Swedish *hen* than those who were not. Given the link that has been found in other languages surrounding gender/sex diversity beliefs and acceptance of gender-neutral pronouns, in this study we ask whether gender/sex diversity beliefs affect the processing of non-binary Spanish pronouns in anaphora resolution.

1.8. The current study

The current study examines a gap concerning the processing of gender-neutral pronouns, non-binary Spanish morphemes, and grammatical gender. For this purpose, we ask three questions: (1) how are non-binary morphemes in Spanish pronouns processed in contrast to canonical morphemes in plural contexts?; (2) what role do working memory and gender/sex diversity beliefs play in the processing of non-binary pronouns?; and (3) does the processing of non-binary pronouns differ or not from the processing of grammatical gender violations at the pronoun level?

For the first question, we hypothesized that processing non-binary morphemes in Spanish pronouns will incur greater processing costs in contrast to canonical morphemes in plural contexts due to the novelty that non-binary morphemes present for the Spanish grammatical gender system. For the second question, we hypothesized that higher working memory and positive gender/sex diversity beliefs would reduce the potential difficulty readers encountered when reading non-binary morphemes in Spanish pronouns. For the third question, we first hypothesized that grammatical gender violations between the noun and pronoun would incur greater processing costs than their congruent counterparts. We also expected that if processing non-binary morphemes is similar to processing grammatical gender violations, then cognitive (i.e., working memory) and social factors (i.e., gender/sex diversity beliefs) would equally affect the reading times on both the non-binary morphemes and the grammatical gender violations. Specifically, we expected working memory to moderate the effect of grammatical gender violations. For gender/sex diversity beliefs we did not expect them to moderate grammatical gender violations because we assumed that canonical grammatical gender and gender/sex diversity beliefs were unrelated.

2. Method

2.1. Ethics and sample size

All study procedures were approved by the University of California, Irvine Institutional Review Board under IRB # 20195424 on August 12, 2022. All our participants gave their consent prior to participation by clicking on "I agree to the terms above and give my consent to

participate in this study" after being prompted to read the inform consent before starting the experiment on the online behavioral research platform, FindingFive (FindingFive Team, 2019).

To estimate the sample size for the study, a simulation-based power analysis (Brysbaert & Stevens, 2018) using the *simr* R package (Green & MacLeod, 2016) was carried out using unpublished data from a study that examined the processing of non-binary Spanish pronouns in college students ($n = 48$) from a metropolitan university in Puerto Rico. This unpublished study used the same materials as the current study, with the exception that the previous study used 6 items per condition while the current used 8 items per condition. The results from the simulation-based power analysis revealed that approximately 108 participants would achieve 80 % statistical power. According to this same power analysis, the sample included in this study ($n = 78$) has an approximate 70 % statistical power.

2.2. Participants

Eighty-two speakers of Spanish who were also bilingual in English participated in this study. To be eligible, participants had to: be 18 years or older, grow up speaking Spanish at home as their first language, be comfortable reading in Spanish, have a stable internet connection, and a computer with an integrated keyboard. They were recruited online via the university's human subjects pool for research and by advertising the study on social media. They were compensated with: 20$ or course credit. Out of the 82 participants, four were excluded for data analysis. The details are explained below in section 2.6.1. Out of the remaining 78, 46 had a bachelor's degree or higher, 29 had completed some college education, while 3 had only completed high school. Their average age was 25.1 years (SD = 5.9). Regarding gender identity,[4] 64 self-identified with the feminine gender, 12 self-identified with the masculine gender, and 2 self-identified as non-binary. Regarding their exposure to non-binary Spanish in four different contexts—home, school, community, peers—, 30 reported being exposed to non-binary Spanish in all 4 contexts, 13 reported being exposed to non-binary Spanish in 3 contexts, 6 reported being exposed to non-binary Spanish in 2 contexts, 7 reported being exposed to non-binary Spanish in 1 context, while 22 reported no exposure to non-binary Spanish. Out of the 78 participants, 22 reported using non-binary Spanish when talking to themselves. Table 1 contains a contingency table by bilingual type and exposure to non-binary Spanish. No significant group differences were found between each category.

Regarding language history, thirty-eight participants acquired Spanish at home as their first language in a society where Spanish is the minority language and English is the societal language, while the other forty acquired Spanish as their first language in a Spanish-speaking country (SC) and learned English as their L2. The former are deemed heritage speakers (HS) of Spanish in the literature, while the latter group are referred to native speakers of Spanish in the literature. In this paper, we acknowledge both groups of speakers as native speakers of Spanish, while accounting for their different language experiences. Despite these differences, the overall sample was Spanish dominant ($M = 23.8$, $SD = 65.0$). Most of the HS reported Mexico ($n = 30$) as their heritage origin, while others reported El Salvador ($n = 2$), Guatemala ($n = 2$), Puerto Rico ($n = 1$), Argentina ($n = 1$), Spain ($n = 1$), and Ecuador ($n = 1$) as their heritage origin. The SC bilinguals were from: Puerto Rico ($n = 15$), Colombia ($n = 6$), Mexico ($n = 6$), Chile ($n = 6$), Peru ($n = 5$), Dominican Republic ($n = 1$), and Spain ($n = 1$). On average, HS were more English dominant ($M = -30.8$, $SD = 31.8$) while SC bilinguals were more Spanish dominant ($M = 73.2$, $SD = 44.8$). Table 1 reports the language history information per group of bilinguals.

Table 1
Language History, Self-rated Proficiency, and Exposure to Non-Binary Spanish.

	Full Sample	Spanish Heritage Speakers	Spanish-speaking Country Bilinguals	*p*-value
Language history				
Age[a] of acquisition Spanish	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	
Age of acquisition English	5.6 (4.7)	4.0 (3.3)	7.1 (5.2)	< 0.001***
Years of study in Spanish	10.1 (6.6)	4.1 (3.5)	15.6 (3.1)	< 0.001***
Years of study in English	14.1 (4.7)	15.4 (3.6)	13.0 (5.2)	< 0.001***
Language use[b] in Spanish	26.5 (12.8)	15.5 (7.4)	36.6 (7.3)	< 0.001***
Language use in English	23.7 (12.5)	34.2 (7.4)	14.1 (7.5)	< 0.001***
Language dominance[c]	23.8 (65.0)	−30.8 (31.8)	73.2 (44.8)	< 0.001***
Self-rated proficiency				
Speaking in Spanish	5.3 (0.9)	4.8 (0.9)	5.8 (0.5)	< 0.001***
Understanding in Spanish	5.8 (0.6)	5.6 (0.7)	5.9 (0.3)	< 0.001***
Reading in Spanish	5.3 (1.0)	4.8 (1.1)	5.8 (0.5)	< 0.001***
Writing in Spanish	4.9 (1.2)	4.4 (1.3)	5.4 (0.9)	< 0.001***
Speaking in English	5.1 (1.2)	5.6 (0.6)	4.5 (1.4)	< 0.001***
Understanding in English	5.4 (1.2)	5.9 (0.4)	4.9 (1.4)	< 0.001***
Reading in English	5.4 (1.0)	5.7 (0.5)	5.2 (1.2)	< 0.001***
Writing in English	5.0 (1.3)	5.6 (0.6)	4.5 (1.5)	< 0.001***
Exposure to non-binary Spanish[d]				
0	22	13	9	0.332
1	7	4	3	0.781
2	6	2	4	0.480
3	13	5	8	0.467
4	30	14	16	0.715
self	20	12	8	0.332
n	78	38	40	

Note. Standard deviations are presented in parentheses. Full sample refers to the sample included in the analysis. For language history and self-rated proficiency, independent Mann-Whitney *U* tests for non-normally distributed data were conducted. For exposure to non-binary Spanish, Fisher's exact test was used.
* $p < .05$. ** $p < .01$. *** $p < .001$.
[a] Measured in years.
[b] Based on the average percentage of time during the week participants use Spanish and English with friends and family as well as at school and/or work. A score of 50 indicates that participants used only one language 100 % of the time, while a score of 25 indicates participants use each language 50 % of the time.
[c] A positive number indicates Spanish dominant, while a negative number indicates English dominant.
[d] Counted for each context (home, school, community, peers) where participants reported being exposed to non-binary Spanish regardless of language modality (oral vs written). 'Self' counted if participants used non-binary Spanish when talking to themselves.

[4] Following Conrod (2021)'s suggestion on how to ask the gender question to non-binary and trans participants, we decided to let our participants self-identify because the goals of our study do not include any between participant comparison based on their assigned sex at birth. Participants were asked the following in Spanish "For statistical purposes, which gender identity would you like to identify yourself with?" They could then choose which gender they identified with. The options in Spanish were: *masculino* 'masculine' [gender], *femenino* 'feminine' [gender], and *no-binario* 'non-binary'. We opted for these choices in Spanish instead of terms like *mujer* 'woman' and *hombre* 'man' because gender identity in Spanish is usually presented as *¿con qué género se identifica?* 'which gender do you identify as?'

2.3. Questionnaires and cognitive task

2.3.1. Bilingual language profile

The Bilingual Language Profile (BLP; Birdsong et al., 2012) is a language questionnaire that conceptualizes language dominance as a multidimensional construct, which includes dimensions of language history, language use, language proficiency, and language attitudes, that places bilinguals along a continuum of language dominance (Birdsong, 2016; Olson, 2023). It contains 19 questions in each of a bilingual's two languages. In this study, a positive number indicates Spanish dominant, while a negative number indicates English dominant, and a score near zero indicates not dominant in any language (i.e., more balanced bilinguals).

2.3.2. Gender/sex diversity beliefs scale

The Gender/Sex Diversity Beliefs is a validated scale (see Schudson & van Anders, 2021 Appendix for full scale), previously described in section 1.7, that was chosen because unlike other scales, it does not use language that reinforces stigmatizing gender views on participants (Billard, 2018). The questionnaire uses a 7-point Likert scale and contains five subscales: Affirmation (of diverse gender identities), Gender Normativity (traditional views on gender), Uniformity (how similar people of the same gender are), Surgery (legitimacy of transgender surgeries), and Upbringing (how upbringing influences gender identity). In our study, we excluded the Uniformity subscale, because the authors found it was the only factor that did not correlate with trans prejudice (Schudson and van Anders, 2021). For the Affirmation and Upbringing subscales, scores closer to 7 indicate positive gender/sex diversity beliefs, while for the Gender Normativity and Surgery subscales a score closer to 7 indicates negative gender/sex diversity beliefs.

2.3.3. Questions to measure exposure to non-binary Spanish

To measure participants' exposure to the use of non-binary Spanish forms in plural contexts (e.g., *les amigues* 'the friends') in contrast to the masculine generic (e.g., *los amigos*), we created a series of questions that collect information on the percentage of time in an average week that participants use non-binary Spanish versus the masculine generic in different contexts (home, school/work, community, peers, and themselves) and in different modalities (speaking, reading, writing, and hearing). These questions were modeled after the language use subcomponent of the BLP (Birdsong et al., 2012) and can be found in Appendix A. The exposure to non-binary Spanish was calculated as follows. Participants were given a score of 1 for each context they reported a degree of exposure to non-binary Spanish regardless of the language modality reported.

2.3.4. Operation span task

The Operation Span (OSPAN) Task (Turner & Engle, 1989) requires solving a series of simple math equations (e.g., (18 / 3) – 4 = 2) while also remembering a set of unrelated words (e.g., *grado*, *tío*, 'grade', 'uncle'). Participants were shown one math equation–word string at a time. First, they would see the math equation at the center of the screen and respond "yes" if it was correctly solved or "no" if it was incorrectly solved. Afterwards, a word would appear at the center of the screen. The math equation–word strings were presented in 2–5 sets. Following each set, participants recalled the words they saw. In total, 60 math-equations and 60 words were shown. The total span score was the number of correct words recalled in any order after each correctly solved equation (Klein & Fiss, 1999). The closer the score was to 60, the higher the working memory.

2.4. Self-paced reading tasks

2.4.1. Non-binary Spanish self-paced reading task

For the non-binary Spanish self-paced reading task, experimental sentences were created using a two-clause sentence structure. A clause that introduced a number determiner was followed by a plural gender-neutral noun in Spanish as the subject of the sentence to establish a gender-neutral context. A second clause followed a semicolon that included a pronoun in one of the four conditions under study: canonical morphemes, masculine –o, feminine –a, and non-binary morphemes –x and –e. The gender-neutral nouns were selected by choosing nouns that are not marked for gender in Spanish (e.g., *estudiantes* 'students'), instead their gender is established by the determiner (e.g., *los estudiantes* 'the male students', *las estudiantes* 'the female students'). These nouns were deemed gender-neutral if they obtained a neutral rating of at least 51 % (see Appendix B). The gender-neutral values were obtained from an unpublished study in which Spanish speakers from Puerto Rico (n = 62) used an 11-point Likert scale to rate gender-neutral nouns according to the stereotype they represented in society. The words 'masculine' and 'feminine' appeared on both ends of the scale, alternating positions for each noun to ensure that one gender did not always appear in the same position. The pronouns chosen included all fell under the Royal Spanish Academy's definition of pronoun and included a set of third person pronouns, as well as demonstrative and indefinite pronouns. Table 2 contains an example of the four versions of an experimental item.

2.4.2. Grammatical gender violation self-paced reading task

For the grammatical gender violation self-paced reading task, we constructed sentences with the first clause introducing the subject, and the second clause after the semicolon introducing the pronoun. However, the difference in this task was that both the determiner and the noun were marked for gender. An auxiliary verb and a masculine or feminine past participle were added after the noun to avoid the gender stereotype mismatch effect reported in previous studies (Kennison & Trofe, 2003). This resulted in four conditions: masculine congruent, masculine incongruent, feminine congruent, and feminine incongruent. Table 3 contains an example of an experimental sentence in these four conditions.

2.5. Procedure

The self-paced reading tasks employed a non-cumulative word-by-word paradigm with 8 experimental sentences for each condition, for a total of 32 experimental sentences, which is in line with the recommendation given for self-paced reading studies testing four conditions (Jegerski & VanPatten, 2013; Keating & Jegerski, 2015). The critical region was the pronoun, and always appeared in word position 8, this was our measure of early processing. The two regions after the pronouns, regions 9 and 10, were our spillover regions which reflect later phases of comprehension and serve as indicators of persistent or delayed processing difficulty (Jegerski & VanPatten, 2013). To ensure that

Table 2
Example of the Experimental Sentences Used in the Non-Binary Spanish Self-paced Reading Task.

Condition		Experimental Sentence
Binary	–o	Ochenta estudiantes protestaron contra los recortes institucionales; muchos estaban en su primer año de universidad.
	–a	Ochenta estudiantes protestaron contra los recortes institucionales; muchas estaban en su primer año de universidad.
Non-Binary	–x	Ochenta estudiantes protestaron contra los recortes institucionales; muchxs estaban en su primer año de universidad.
	–e	Ochenta estudiantes protestaron contra los recortes institucionales; muches estaban en su primer año de universidad.
	Question	¿protestaron contra la iglesia? [No]

Note. The sentence translation is: Eighty students protested against institutional budget cuts; many of them were in their first year of college. The question translation is: 'Were they protesting against the church?' [No].

Table 3
Example of the Experimental Sentences Used in the Grammatical Gender Violation Self-paced Reading Task.

Gender	Congruency	
	Congruent	Incongruent
Masculine	Los maestros fueron invitados al nuevo taller; todos lo tomaban por primera vez.	Los maestros fueron invitados al nuevo taller; todas lo tomaban por primera vez.
Feminine	Las maestras fueron invitadas al nuevo taller; todas lo tomaban por primera vez.	Las maestras fueron invitadas al nuevo taller; todos lo tomaban por primera vez.
Question	¿Tomaban el taller por segunda vez? [No]	

Note. The sentence translation is: The teachers were invited to the workshop; all of them took it for the first time. The question translation is: 'Was it their second time taking the workshop?' [No].

participants only read one version of each experimental sentence, experimental sentences were counterbalanced and pseudorandomized into four lists. This was done separately for each self-paced reading task. There were also 32 distractor sentences. For the non-binary self-paced reading task, distractors sentences with similar word length were randomly created and did not include any pronouns. In contrast, for the grammatical gender violation self-paced reading task, sentences included congruent/incongruent clitic pronoun violations from a previous study (Rossi et al., 2014). These latter distractor sentences were also counterbalanced for the second self-paced reading task, while the distractor sentences of the non-binary self-paced reading task were the same across all four lists.

All tasks were conducted in Spanish using the online behavioral research platform FindingFive (FindingFive Team, 2019). To ensure the quality of the online data collection, each participant was monitored on Zoom. After giving informed consent, participants completed the Bilingual Language Profile and the Gender/Sex Diversity Beliefs questionnaires. Then, they were randomly assigned to either complete first the non-binary Spanish self-paced reading task or the grammatical gender violation self-paced reading task. After reading each sentence, they answered a yes/no comprehension question. The instructions participants were given can be found in Appendix C. The order of the two tasks was counterbalanced across participants to avoid ordering effects. Between each self-paced reading task, participants were given the option to take a 5–10-min break to rest. Following the sentence processing tasks, participants answered questions related to their exposure to non-binary Spanish as well as two open-ended questions related to non-binary Spanish. The first question asked participants whether they used any reading strategies when encountering pronouns with non-binary morphemes, while the second question asked whether they agreed with the Royal Spanish Academy's view on non-binary Spanish. The specific questions can be found in Appendix E.

2.6. Data analysis

2.6.1. Data trimming

Reaction times (RTs) were extracted from three regions of interest in the sentence (ROIs): the pronoun, the word after the pronoun, and two words after the pronoun, with the purpose of looking at early and late measures of on-line processing. We also extracted the RT of the comprehension question along with its accuracy with the purpose of looking at later stages of comprehension. Processing costs were operationalized as longer RTs and inaccurate responses. Only correct trials were included in the analysis. To control for outliers, RTs < 200 ms were excluded (Keating & Jegerski, 2015). This resulted in excluding 8.6 % of the data from the non-binary self-paced reading task, and 11.2 % of the data from the grammatical gender violation self-paced reading task at ROI 1. For the second ROI, only trials with RTs > 200 ms and trials in which the first region of interest was correct and not an absolute outlier were included. This resulted in dropping an additional 10 observations from the non-binary self-paced reading task, and an additional 8 from the grammatical gender violation self-paced reading task at ROI 2. For the third ROI, we only included trials with RTs > 200 ms and trials that were not absolute outliers in the first two ROIs. This resulted in dropping 10 additional trials from the non-binary self-paced reading task, and 16 additional trials from the grammatical gender violation self-paced reading task. Furthermore, RTs $\pm$ 2.5 SDs above the mean of each condition were replaced with their respective cutoff values (Keating & Jegerski, 2015). This affected the following percentages of data from the non-binary self-paced reading task: ROI 1 1.4 %, ROI 2 2.5 %, ROI 3 1.7 %; and the following percentages of data from the grammatical gender violation self-paced reading task: ROI 1 1.8 %, ROI 2 1.3 %, ROI 3 1.5 %. Finally, participants with an accuracy of 0 % on the OSPAN and an age of acquisition for Spanish >0 were excluded from the analysis. This resulted in dropping four participants (all SC bilinguals). The final sample included 78 participants. Descriptive statistics for the RTs by ROI and self-paced reading task are shown in Table 4.

2.6.2. Correlations

To determine which of the gender/sex diversity beliefs would be used in the statistical models, correlations between each ROI and gender/sex diversity beliefs were made for each condition of each self-paced reading task.

2.6.3. Statistical modeling

All analyses were conducted in R (Version 4.3.3; R Core Team, 2024) using the *lme4* package for mixed-effects modeling (Bates et al., 2015) as well as the *tidyverse* package (Wickham et al., 2019) for data trimming and transformations. RTs were $\log_{10}$ transformed to correct for non-normal distribution (Winter, 2019). Sum contrasts were applied to the linguistic variables of each self-paced reading task using the *car* package (Fox and Weisberg, 2018; Schad et al., 2020). For this purpose, morphemes –x and –e were collapsed into a "non-binary" category with +1 as the value, while morphemes –o and –a were collapsed into a "binary" category with −1 as the value. For the grammatical gender violation task, the variables "gender" and "congruency" were also sum coded with masculine as +1 and feminine as −1, and congruent as +1 and incongruent as −1. All continuous predictors were centered and standardized prior to analysis.

To assess whether there were any differences in accuracy across the linguistic variables, two generalized linear mixed-effects logistic regression models with random intercepts by subject and item (models a and b below) were built with binomial as the type of probability distribution used.

a) glmer(accuracy ~ morpheme + (1|Subject) + (1|Item))
b) glmer(accuracy ~ gender + congruency + (1|Subject) + (1|Item))

Table 4
Average Reading Times (in milliseconds) by Self-paced Reading Task and Region of Interest.

Condition	Region of Interest		
	Pronoun	Pronoun +1	Pronoun +2
Non-Binary Spanish Self-paced Reading task			
–o	561.4 (271.2)	549.0 (296.9)	496.6 (222.2)
–a	591.7 (320.1)	653.3 (457.7)	533.9 (237.4)
–x	734.7 (531.4)	677.2 (448.8)	549.0 (287.7)
–e	655.0 (540.5)	776.1 (512.3)	579.1 (341.7)
Grammatical Gender Violation Self-paced Reading task			
Masculine Congruent	557.0 (274.2)	557.4 (386.6)	520.0 (305.3)
Masculine Incongruent	560.7 (279.4)	616.4 (431.1)	526.4 (258.2)
Feminine Congruent	556.9 (250.5)	562.3 (370.7)	503.1 (237.9)
Feminine Incongruent	570.1 (393.3)	581.0 (400.9)	539.0 (364.4)

Note. Standard deviations are presented in parentheses.

To answer the research questions, baseline linear mixed-effects models (LMM) with random intercepts by subject and item were created using maximum likelihood for each self-paced reading task. These consisted of the dependent variable (RTs of each ROI) and linguistic variables (i.e., the sum coded variables), as well as language dominance as a control variable given the different linguistic experiences of our participants. Formula 1 below displays the baseline model built for the non-binary Spanish self-paced reading task. This model was compared against two alternative models which included either an interaction between working memory and the morpheme condition (formula 2) or an interaction between morpheme and gender/sex diversity beliefs (formula 3).

(1) lmer(log10rt ~ morpheme + lang_dom + (1|Subject) + (1|Item))
(2) lmer(log10rt ~ morpheme*WM + lang_dom + (1|Subject) + (1|Item))
(3) lmer(log10rt ~ morpheme*GSDB + lang_dom + (1|Subject) + (1|Item))

For the grammatical gender violation self-paced reading task, the baseline model is presented in formula 4, and includes gender and congruency as fixed effects and language dominance as a control variable. This model was compared against two alternative models that included either an interaction between working memory and congruency (formula 5) or an interaction between congruency and gender/sex diversity beliefs (formula 6).

(4) lmer(log10rt ~ gender + congruency + lang_dom + (1|Subject) + (1|Item)
(5) lmer(log10rt ~ gender + congruency*WM + lang_dom + (1|Subject) + (1|Item)

(6) lmer(log10rt ~ gender + congruency*GSDB + lang_dom + (1|Subject) + (1|Item)

The best fitting model was selected using a likelihood-ratio test through the ANOVA function in the lmerTest R-package (Kuznetsova et al., 2017). In cases where this test was not informative (i.e., same number of model parameters), we chose the best fitting model based on the following criteria: higher log likelihood, lower Akaike Information Criterion (AIC) and Bayesian Information Criteria (BIC) and, smaller deviance from a perfect model. In cases where the best fitting model included a non-significant interaction, the interaction term was removed to include only the main effects of the variables tested, thus preserving the parsimony principle in regression.

3. Results

3.1. Individual differences descriptive statistics

Regarding individual differences in working memory and gender/sex diversity beliefs, the overall sample had high working memory (M = 45.7, SD = 8.7) and overall positive gender/sex diversity beliefs. When comparing both groups of bilinguals, the SC bilinguals had overall higher working memory and overall, more positive gender/sex diversity beliefs. These differences are shown in Table 5.

3.2. Accuracy

We were uncertain whether any differences in accuracy between the conditions of each self-paced reading task would arise. No differences were found between the conditions of both self-paced reading tasks accuracy models a and b (see Table 6). Looking at the random effects of both models, the by-item variation was larger than the by subject variation. This could have been due to 42 % of participants getting wrong item 25 and 33 % of participants getting wrong item 24 in the non-binary self-paced reading task, and 42 % of participants getting wrong item 10 from the grammatical gender violation task. Answering items 24 and 25 correctly required participants to pay close attention to the sentence they were reading and go against their world knowledge (item 25), while item 10 contained two possible anaphora bindings, thus causing confusion among some participants. Although these minor issues could have been avoided by piloting the materials, this was not possible in our case due to very limited funding. Nevertheless, to explore the characteristics of the participants who scored inaccurately, we added language dominance to both accuracy models to see if being more Spanish dominant increased the log odds of the accuracy outcome being 1. This was in fact the case and led to a language dominance main effect in both tasks. For the non-binary Spanish self-paced reading task, a one unit increase in language dominance (more Spanish dominant) was associated with a 0.348 log odds increase in the probability of accuracy being 1 (b = 0.348, SE = 0.115, $p < .01$), while for the grammatical

Table 5
OSPAN and GSDB Descriptive Statistics by Bilingual Group.

	Full Sample	Spanish Heritage Speakers	Spanish-speaking Country Bilinguals	Mann-Whitney U test result
Operation Span Task				
OSPAN score	45.7 (8.7)	44.8 (7.1)	46.4 (9.9)	$p < .001$***
Gender/Sex Diversity Beliefs Scale				
Affirmation	5.1 (1.5)	5.0 (1.4)	5.2 (1.5)	$p < .001$***
Gender Normativity [a]	1.7 (1.2)	2.1 (1.5)	1.3 (0.7)	$p < .001$***
Surgery [a]	2.2 (1.4)	2.4 (1.5)	1.9 (1.3)	$p < .001$***
Upbringing	3.5 (1.5)	3.7 (1.5)	3.3 (1.5)	$p < .001$**

Note. Standard deviations are presented in parentheses. The Full sample refers to the sample included in the analysis. Independent Mann-Whitney U tests show differences between the two groups for non-normally distributed data.
* $p < .05$. ** $p < .01$. *** $p < .001$.
[a] Indicates the subscale was reverse scored.

Table 6
Logistic Regression for Accuracy by Self-paced Reading Task.

Non-Binary Spanish SPR	Estimate	*SE*
Fixed effects		
Intercept	3.223***	0.252
Morpheme[NB]	−0.031	0.079
Language dominance	0.348**	0.115
Random effects	Variance	*SD*
Subject	0.44	0.665
Item	1.336	1.156
Grammatical Gender Violation SPR	**Estimate**	***SE***
Fixed effects		
Intercept	2.430***	0.163
Gender[Masculine]	0.052	0.066
Congruency[Congruent]	0.025	0.066
Language dominance	0.295**	0.090
Random effects	Variance	*SD*
Subject	0.249	0.499
Item	0.508	0.713

Note. SPR = self-paced reading. Estimates are in log odds. The morpheme variable was sum coded with non-binary morphemes as +1 and binary morphemes as −1. For gender, +1 represents masculine, while feminine represents −1. For congruency, +1 represents congruent, −1 represents incongruent. All continuous variables were standardized.

gender violation self-paced reading task, a one unit increase in language dominance was associated with a 0.295 log odds increase in the probability of accuracy being 1 ($b = 0.295$, $SE = 0.090$, $p < .01$). Given these findings, individuals who were less Spanish dominant experienced greater difficulty when answering the comprehension questions.

As a follow-up to the accuracy null findings across conditions, we sought to examine the RTs from the comprehension questions. For this purpose, we fitted models 1 and 4 to the RTs of questions that were correctly answered and not absolute outliers at ROI 1. We then followed the same process for removing outliers as outlined in section 2.6.1. The results from these models are displayed in Table 7. They also revealed there were no significant differences between the linguistic conditions of either self-paced reading task. Instead, a language dominance main effect was detected for both tasks (non-binary self-paced reading task, $b = -0.047$, $SE = 0.014$, $p < .01$, grammatical gender violation self-paced reading task, $b = -0.041$, $SE = 0.015$, $p < .01$) showing that individuals who were more Spanish dominant responded to questions faster than those who were less Spanish dominant.

3.3. Processing costs of non-binary pronouns compared to binary pronouns

Hypothesis 1 stated that pronouns with non-binary morphemes would lead to greater processing costs than pronouns with canonical binary morphemes. For this purpose, model 1 was built for each ROI. Results (see Tables 8 & 9) showed a significant main effect for the morpheme variable at all three ROIs (ROI 1: $b = 0.024$, $SE = 0.004$, $p < .001$; ROI 2: $b = 0.038$, $SE = 0.004$, $p < .001$; ROI 3: $b = 0.013$, $SE = 0.003$, $p < .001$). In other words, pronouns with non-binary morphemes resulted in significantly longer RTs when compared to the grand average mean of both binary and non-binary pronouns across all three ROIs (see Fig. 1). A significant main effect of language dominance was also found at all three ROIs, for which a one unit increase in language dominance (more Spanish dominant) led to faster RTs in general (ROI 1: $b = -0.042$, $SE = 0.014$, $p < .01$; ROI 2: $b = -0.064$, $SE = 0.014$, $p < .001$; ROI 3: $b = -0.038$, $SE = 0.011$, $p < .001$).

Table 7
Comprehension Question RT Regression Coefficients by Self-Paced Reading Task.

Non-Binary Spanish SPR	Estimate	*SE*
Fixed effects		
Intercept	3.530***	0.026
Morpheme[NB]	−0.008	0.006
Language dominance	−0.047**	0.014
Random effects	Variance	SD
Subject	0.015	0.122
Item	0.015	0.122
Grammatical Gender Violation SPR	Estimate	*SE*
Fixed effects		
Intercept	3.553***	0.023
Gender[Masculine]	−0.001	0.004
Congruency[Congruent]	−0.005	0.004
Language dominance	−0.041**	0.015
Random effects	Variance	*SD*
Subject	0.016	0.125
Item	0.010	0.100

Note. SPR = self-paced reading. Estimates are in the $\log_{10}$ scale. The morpheme variable was sum coded with non-binary morphemes as +1 and binary morphemes as −1. For gender, +1 represents masculine, while feminine represents −1. For congruency, +1 represents congruent, −1 represents incongruent. All continuous variables were standardized.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 8
Regression Coefficients of the Non-Binary Spanish SPR Task at the Pronoun Region.

Region of Interest	Pronoun	
	Estimate	*SE*
Fixed effects		
Intercept	2.738***	0.015
Morpheme[NB]	0.024***	0.004
Language dominance	−0.042**	0.014
Gender normativity	0.011	0.013
Gender normativity*morpheme[NB]	0.010**	0.004
Random effects	Variance	*SD*
Subject	0.013	0.113
Item	0.001	0.038

Note. SPR = self-paced reading. Estimates are in the $\log_{10}$ scale. The morpheme variable was sum coded with non-binary morphemes as +1 and binary morphemes as −1. All continuous variables were standardized.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 9
Regression Coefficients of the Non-Binary Spanish SPR Task at the Spillover Regions.

Region of Interest	Pronoun +1		Pronoun +2	
	Estimate	*SE*	Estimate	*SE*
Fixed effects				
Intercept	2.749***	0.018	2.686***	0.014
Morpheme[NB]	0.038***	0.004	0.013***	0.003
Language dominance	−0.064***	0.014	−0.038***	0.011
Working memory	−0.030*	0.014	−0.022*	0.010
Random effects	Variance	*SD*	Variance	*SD*
Subject	0.014	0.116	0.008	0.089
Item	0.004	0.065	0.003	0.054

Note. SPR = self-paced reading. Estimates are in the $\log_{10}$ scale. The morpheme variable was sum coded with non-binary morphemes as +1 and binary morphemes as −1. All continuous variables were standardized.
* $p < .05$. ** $p < .01$. *** $p < .001$.

3.4. Individual differences in processing non-binary pronouns

Hypothesis 2 stated that individual differences in working memory and gender/sex diversity beliefs would moderate the processing of non-binary morphemes in Spanish pronouns. To test this hypothesis, models 2 and 3 were built for each ROI and compared against model 1. Adding an interaction between working memory and morpheme type did not improve the overall model fit, except at ROI 3, two words after the pronoun. However, because this interaction was only marginally significant, it was dropped in favor of a more parsimonious model (see Appendix F for model fit indices). This resulted in a statistically significant main effect for working memory at ROIs 2 and 3 (see Table 9, as well as Fig. 2 panels A and B), the spillover regions (ROI 2: $b = -0.030$, $SE = 0.014$, $p < .05$; ROI 3: $b = -0.022$, $SE = 0.010$, $p < .05$). In other words, a one unit increase in working memory was associated with shorter RTs at the spillover regions.

To test the part of hypothesis 2 related to gender/sex diversity beliefs, we first conducted correlations between each GSDB subscale and ROI by morpheme to choose which of the subscales would be used for model 3. In general, the correlation coefficients between each gender/sex diversity belief and ROI by morpheme was very low (see Table 10). Nevertheless, we chose the correlations that showed differences in statistical significance between binary and non-binary morphemes for the statistical models. For ROI 1, we chose the gender normativity subscale which had a positive association between reading non-binary pronouns and gender normative beliefs $r(1,138) = 0.14$, $p < .001$, while for ROI 3

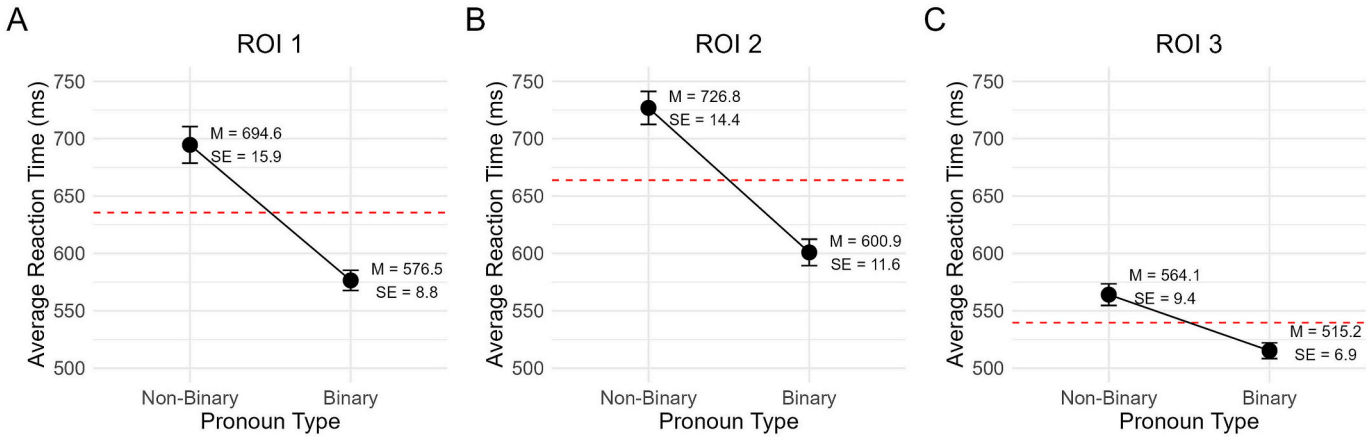

Fig. 1. *Note.* Mean differences between non-binary and binary pronouns by region of interest (ROI). Whiskers represent the standard error of the mean. The red dashed line represents the grand mean. All three panels show non-binary pronouns had longer reading times than binary pronouns across all three ROIs. These differences were statistically significant. Panel A shows mean differences at the pronoun level. Panel B shows mean differences at the word after the pronoun. Panel C shows mean differences two words after the pronoun.

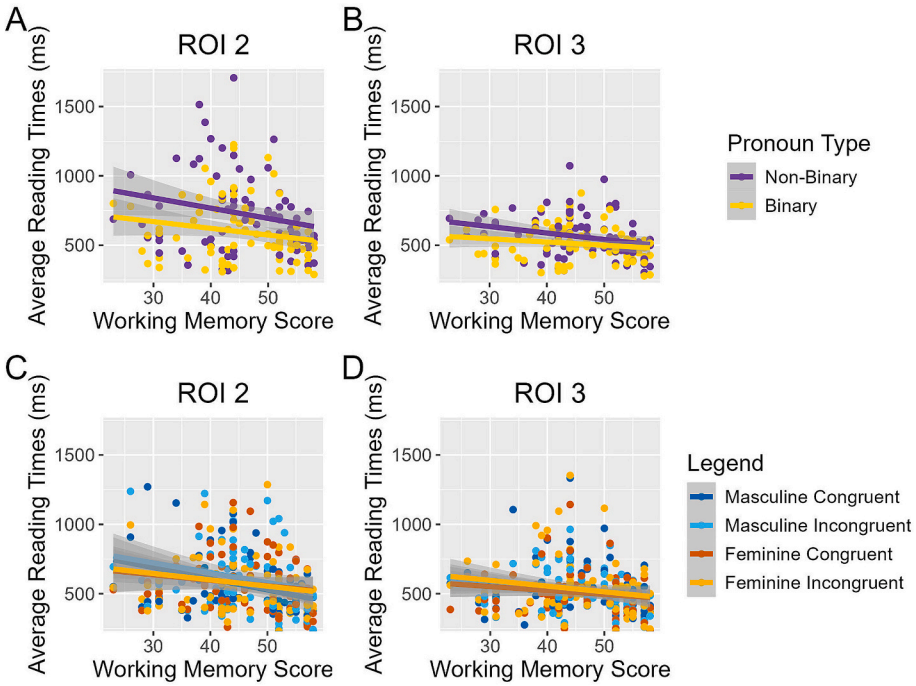

Fig. 2. *Note.* Graphical display of working memory reducing overall reaction times at the spillover regions of both self-paced reading tasks. Panels A and B are from the non-binary Spanish self-paced reading task, while panels C and D correspond to the grammatical gender violation self-paced reading task.

we chose the affirmation subscale which had a negative association between reading times on non-binary pronouns and affirmation of diverse gender identities beliefs $r(1,129) = -0.07, p < .05$. ROI 2 did not show any significant differences between GSDB subscales and RTs by morpheme type, so we did not create model 3 for this ROI.

The results of the alternate models (see Table 8 and Table E1) showed a statistically significant interaction between gender normative beliefs and RTs on non-binary pronouns at ROI 1 ($b = 0.010, SE = 0.004$, $p < .01$), as well as a statistically significant interaction between affirmation beliefs and RTs at ROI 3 for non-binary pronouns ($b = -0.006$, $SE = 0.003$, $p < .05$). In other words, a one unit increase in gender normative beliefs (i.e., more traditional views on gender) led to an additional processing cost of 0.010 log10 RTs when reading non-binary pronouns. In contrast, the findings from ROI 3 indicate that a one unit increase in affirmation beliefs (i.e., the more people affirmed diverse gender identities) reduced the late processing cost of non-binary pronouns at the second spillover region by 0.006 log 10 RTs. These moderating effects are visually displayed in Fig. 3.

When comparing the fit of models with GSDB factors against the other alternative models, gender/sex diversity beliefs only managed to significantly improve model fit at the pronoun level. In other words, although the interaction between morpheme and affirmation beliefs was significant, the alternate model with working memory was a better fit. This model along with all other model fit indices can be found in Appendix F.

3.5. *Comparing the processing of non-binary pronouns with the processing of grammatical gender violations*

Hypothesis 3 included two predictions. First, that grammatical

Table 10
Correlations Between Reaction Times and GSDB Subscale by Morpheme Type.

		Region of Interest		
	GSDB Subscale	Pronoun	Pronoun +1	Pronoun +2
Binary Morphemes	Affirmation	−0.03	−0.09**	0.01
	Gender Normativity	0.04	0.10***	0.06*
	Surgery	0.06*	0.15***	0.12***
	Upbringing	0.09**	0.07*	0.08**
	n	1138	1132	1127
Non-Binary Morphemes	Affirmation	−0.09**	−0.11***	−0.07*
	Gender Normativity	0.14***	0.13***	0.12***
	Surgery	0.11***	0.12***	0.12***
	Upbringing	0.11***	0.10***	0.07*
	n	1138	1134	1129

* $p < .05$. ** $p < .01$. *** $p < .001$.

gender violations between the noun and pronoun would incur greater processing costs than their congruent counterparts, and that working memory, not gender/sex diversity beliefs, would moderate the observed costs. Second, that if processing non-binary morphemes is similar to processing grammatical gender violations, then cognitive (i.e., working memory) and social factors (i.e., gender/sex diversity beliefs) would equally affect the reading times on both the non-binary morphemes and the incongruent trials. To test this hypothesis, we first consider how grammatical gender violations were processed.

3.5.1. *Processing grammatical gender violations*

Model 4 was built for each ROI to determine how grammatical gender violations were processed (see Table 11). A main effect of congruency was detected at ROI 2, the first spillover region, ($b = -0.009$, $SE = 0.003$, $p < .05$). This effect showed that gender congruent pronouns had significantly shorter spillover effects than the grand average mean of both conditions (see Fig. 4). The lack of a congruency effect at the pronoun region is an unexpected result given the grammatical gender

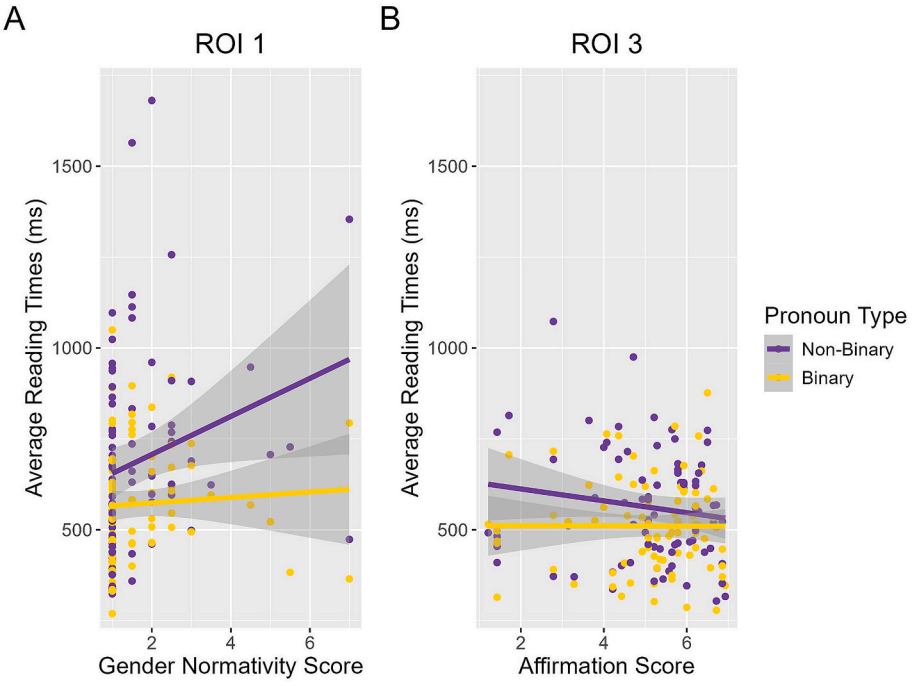

Fig. 3. *Note.* Visual display of the gender/sex diversity beliefs interaction with pronoun type of the non-binary Spanish self-paced reading task. Panel A shows that, as gender normativity scores increase (i.e., as people have more traditional views on gender), reading times on pronouns with non-binary morphemes increases. Panel B shows that the stronger people believe in affirming diverse gender identities, the spillover effect at the second word after pronouns with non-binary morphemes is reduced.

Table 11
Regression Coefficients by Region of Interest for the Grammatical Gender Violation SPR Task.

Region of Interest	Pronoun		Pronoun +1		Pronoun +2	
	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Fixed effects						
Intercept	2.709***	0.011	2.697***	0.016	2.671***	0.013
Gender[Masculine]	−0.002	0.003	0.001	0.004	0.0009	0.003
Congruency[Congruent]	−0.0001	0.003	−0.009*	0.003	-0.005	0.003
Language dominance	−0.032**	0.011	−0.060***	0.013	−0.046***	0.011
Working memory			−0.033*	0.013	−0.023*	0.011
Random effects	Variance	*SD*	Variance	*SD*	Variance	*SD*
Subject	0.008	0.091	0.013	0.115	0.009	0.094
Item	0.0004	0.021	0.002	0.043	0.002	0.042

Note. SPR = Self-paced reading. Estimates are in the $\log_{10}$ scale. For gender, +1 represents masculine, while feminine represents −1. For congruency, +1 represents congruent, −1 represents incongruent. All continuous variables were standardized.

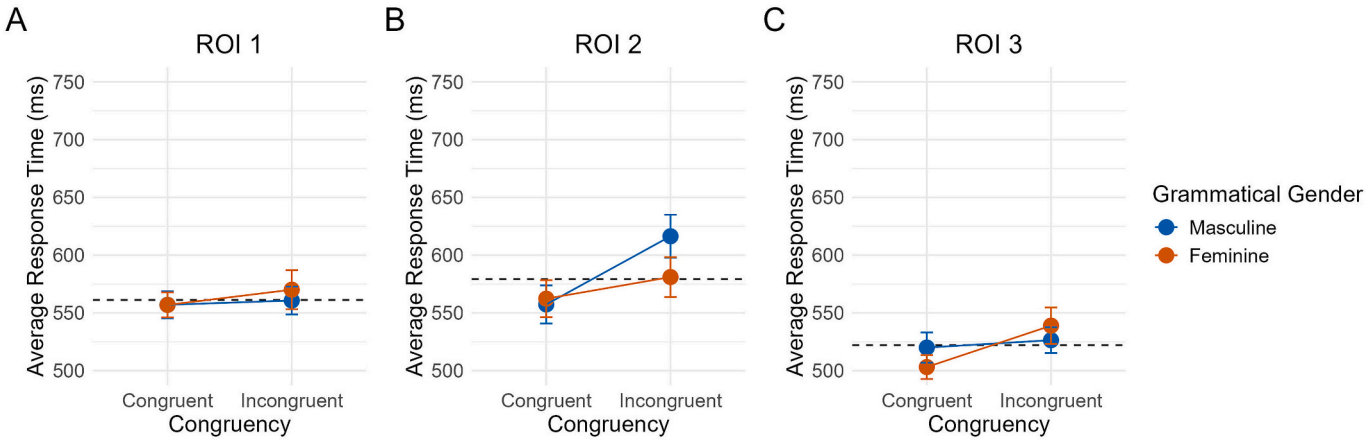

Fig. 4. *Note.* Mean differences between gender and congruency levels of the grammatical gender violation self-paced reading task. Whiskers represent the standard error of the mean. The dashed line represents the grand mean. Panel A shows mean differences at the pronoun level. Panel B shows the only significant difference between congruent and incongruent conditions one word after the pronoun. Panel C shows mean differences two words after the pronoun.

sensitivity reported in the literature. Possible explanations are offered in the discussion section. A language dominance main effect was also detected at all 3 ROIs ($b = -0.032$, $SE = 0.011$, $p < .01$; $b = -0.060$, $SE = 0.013$, $p < .001$; $b = -0.046$, $SE = 0.011$, $p < .001$). Specifically, a one unit increase in language dominance led to overall slower RTs in general. We also explored the possibility of a gender*congruency interaction, but none of them were significant.

3.5.2. *Individual differences in processing grammatical gender violations*

Working memory was expected to reduce the processing cost of grammatical gender violations, however this was not the case (see Table 11). Instead, there was a working memory main effect at ROIs 2 and 3 ($b = -0.033$, $SE = 0.013$, $p < .05$; $b = -0.023$, $SE = 0.011$, $p < .05$), where a one unit increase in working memory reduced the RTs at both spillover regions after the pronoun (see Fig. 2 panels C and D).

Gender/sex diversity beliefs were not hypothesized to moderate the processing of grammatical gender violations. To test this hypothesis, correlations between RTs and each GSDB subscale were conducted for each ROI. The results (see Table 12) showed very low correlations between GSDB subscales and the gender and congruency variables. To compare with our non-binary Spanish self-paced reading task, we also chose the gender normativity and affirmation subscales to include in our alternate models for ROI 1 and 3. The addition of these gender/sex diversity beliefs did not produce any significant interactions with the congruency variable, nor did they improve overall model fit.

3.5.3. *Overview of open-ended responses*

Open-ended questions asked participants about their strategies when reading non-binary pronouns and whether they agreed with the Royal Spanish Academy's view on the subject. We also considered whether strategies when reading non-binary pronouns differed by gender/sex diversity beliefs. Given that gender normativity and affirmation beliefs were the GSDB subscales that moderated the processing of non-binary pronouns, we chose these two subscales to examine whether people's strategies differed or not according to whether they had more positive or less positive gender/sex diversity beliefs. This was done by splitting people into 'more' and 'less' categories by gender/sex diversity beliefs (see Table 13). For the affirmation subscale, the 'more' category had responses that were > 3.6 (greater than $M - SD$), while the 'less' category had responses that were < 3.6. For gender normativity, the scoring was as follows: 'less' < 2.9 (less than $M + SD$) and 'more' > 2.9. A total of 20 participants reported reading non-binary morphemes as equivalents to the masculine and feminine forms either used together (e.g., *todos y todas*, 'all' masculine and 'all' feminine) or separately depending on the context. Out of the remaining participants, 12 of them read –x as 'o' but –e as 'e', and 7 of them read –x as 'e.' Regarding other strategies, 17 participants reported using one of the following: reading words as they were, reading the word in Spanish and translating into English 'they/

Table 12
Correlations Between Reaction Times and GSDB Subscale by Grammatical Gender Congruency.

		Region of Interest		
	GSDB Subscale	Pronoun	Pronoun +1	Pronoun +2
Masculine	Affirmation	−0.04	−0.10**	−0.12***
	Gender Normativity	0.07*	0.14***	0.15***
	Surgery	0.05	0.15***	0.08**
	Upbringing	0.04	0.08*	0.09**
	n	1087	1083	1077
Feminine	Affirmation	−0.10**	−0.14***	−0.07*
	Gender Normativity	0.11***	0.15***	0.09**
	Surgery	0.02	0.16***	0.14***
	Upbringing	0.07*	0.07*	0.07*
	n	1079	1075	1065
Congruent	Affirmation	−0.09**	−0.13***	−0.11***
	Gender Normativity	0.13***	0.17***	0.14***
	Surgery	0.07*	0.13***	0.12***
	Upbringing	0.08**	0.07*	0.09**
	n	1086	1081	1072
Incongruent	Affirmation	−0.05	−0.11***	−0.07*
	Gender Normativity	0.06	0.13***	0.11***
	Surgery	0.01	0.18***	0.11***
	Upbringing	0.04	0.08*	0.07*
	n	1080	1077	1070

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 13
Non-binary Morphemes Reading Strategies by Gender/Sex Diversity Beliefs.

		Gender Normativity		Affirmation of Diverse Gender Identities	
Strategy	Full sample	More	Less	More	Less
1. Reverted non-binary pronouns to masculine or feminine pronouns.[a]	20	4	16	16	4
2. Read –x as 'o' but –e as 'e'	12	0	12	12	0
3. Read –x as 'e'	7	0	7	7	0
4. Other strategy	17	3	14	13	4
5. No strategy	22	2	20	19	3
Total	78	9	69	66	12

[a] *Note.* Read *todxs* and *todes* as *todos y todas* 'all' or as masculine or feminine pronouns depending on the context.

them', focusing on remembering the meaning of the word, thinking about human beings in general. Finally, the group that reported no strategy included those who were already used to reading non-binary Spanish or those that did not answer. In summary, it seems that gender/sex diversity beliefs do not differ that much by reading strategy. Instead, the mean of each subscale, that is less gender normative beliefs and stronger affirmation of diverse gender identities beliefs, is represented across the different reading strategies. Moreover, the results also show that not all Spanish speakers read 'x' as 'e', thus adding variability in how different speakers conceptualize the 'x.'

Regarding participant's agreement with the Royal Spanish Academy, the open-ended responses express a variety of differing opinions that are hard to quantify. Nevertheless, some of the main arguments were the following. Several participants stated the Royal Spanish Academy's view was outdated because languages change constantly as a response to the social and cultural contexts in which they are embedded. Therefore, the refusal to acknowledge these emerging forms of language seems biased by not acknowledging the communities that do use non-binary morphemes in Spanish. Others in contrast, expressed agreement with the Royal Spanish Academy because the masculine gender is not only the default generic they grew up with, but also the generic form used by the rest of the Spanish speaking world. For these participants conflating the natural use of the generic masculine with homophobia and transphobia is wrong. Some of these same participants that agreed with the Royal Spanish Academy also stated that although they would stick to the masculine as the generic plural, they wouldn't have a problem with using non-binary forms with speakers who requested their use. Others, however, expressed agreement with the Royal Spanish Academy by labelling the use of non-binary morphemes as unnecessary and improper. In conclusion, the open-ended responses showcase what other researchers have pointed out, that is that speakers' perceptions of non-binary morphemes in Spanish can be traced back to the linguistic sexism debate. In other words, that some individuals consider language and gender are connected, while others consider them to be separate things (further discussed in Cabeza Pereiro & Rodríguez Barcia, 2013; Román Irizarry, 2021). The responses also show the power and influence prescriptive language institutions can have over their speakers. Whether beliefs in these prescriptive norms can impede language processing of innovative forms remains a question for future research.

3.5.4. Summary

While non-binary morphemes affected both early and late processing, the grammatical gender violations were only costly at the word after the pronoun, a difficulty that only lasted one spillover region. Moreover, when looking at individual differences, working memory effectively reduced the reading times at the spillover regions in both self-paced reading tasks. With respect to gender/sex diversity beliefs, gender normativity and affirmation moderated the processing of non-binary pronouns. Altogether, the quantitative results suggest that processing non-binary morphemes differs from processing grammatical gender violations, while the qualitative data highlight the complex relationship between language and sociocultural factors.

4. Discussion

The overarching goal of this study was to compare the processing of non-binary morphemes against the processing of canonical grammatical gender violations in Spanish pronouns, both in terms of language processing as well as the individual differences in cognitive resources and sociocultural beliefs surrounding gender/sex diversity. Unlike the canonical grammatical gender which the Spanish speakers in this study acquired from an early age, the non-binary morphemes represent linguistic forms introduced later in life, with a quarter of our participants being exposed to non-binary morphemes for the first time in this study. Therefore, the comparison of processing non-binary morphemes against the processing of canonical grammatical gender violations allows us to account for how different the potential cost of processing non-binary morphemes compares to the cost of processing pre-existing grammatical gender structures in their incongruent forms. Below, we discuss our findings around the three main goals first outlined in section 1.8.

The first goal of this study was to examine the processing of non-binary morphemes in contrast to binary morphemes in Spanish pronouns. According to the data from all three ROIs, the major finding was that processing pronouns with non-binary morphemes incurred greater processing costs than processing pronouns with canonical binary morphemes. The fact that this was true at the pronoun region and both spillover regions indicates that using non-binary morphemes in pronouns affects both early and late stages of processing. However, the lack of a difference in accuracy between sentences that included non-binary pronouns versus sentences with only canonical binary pronouns, suggests that the processing cost of non-binary morphemes is not enough to affect overall sentence comprehension. This notion is also supported by the lack of a difference between the RTs of comprehension questions that included non-binary pronouns versus canonical binary pronouns. This is a new finding since previous studies on non-binary morphemes have been conducted on nouns, not pronouns.

The findings also help clarify some of the mixed findings reported in the past, in which some studies found that nouns with non-binary morphemes were harder to process than nouns with binary morphemes (Zarwanitzer, 2019), while others found the opposite (Stetie & Zunino, 2022). If we had only examined differences at all 3 ROIs and excluded the accuracy data and comprehension question RT data, our findings would have been similar to Zarwanitzer (2019), who in fact used the RTs of the sentence that contained the non-binary morphemes as their dependent variable. Instead, by examining different levels of language processing that lead to overall sentence comprehension, we find that the use of non-binary pronouns poses a temporary cost on processing but that this cost is not enough to pose an extra cost for overall reading comprehension. Although Stetie and Zunino (2022) found higher processing costs for the masculine generic –o in nouns, and we did not find this effect for pronouns with –o, our results align with theirs in the sense that using non-binary morphemes does not imply an additional cost for sentence comprehension in the form of response time RTs. Instead, the differences found between binary and non-binary morphemes at all 3 ROIs could be due to their later introduction into the grammatical gender system, so readers slow down when reading them, but this effect is not enough to affect their overall sentence comprehension. This suggests that processing non-binary morphemes in pronouns results in good-enough interpretations which lead to sentence comprehension (Ferreira et al., 2002). Moreover, this finding aligns with the small processing cost found for Swedish *hen* in later processing stages (Vergoossen et al., 2020). Just like Vergoosen et al., we attribute the small processing cost of our non-binary pronouns to their novelty, as well as their later insertion into Spanish's grammatical gender system.

Another possible reason for why we found higher processing costs for words with non-binary morphemes and Stetie and Zunino did not, could be due to the difference in functionality between nouns versus pronouns. While Stetie and Zunino examined non-binary morphemes in Spanish role names, which belong to linguistically open classes that admit newer members more easily, the non-binary morphemes of our study were presented in pronouns, which belong to linguistically closed classes that rarely admit newer forms (Paterson, 2014). It could have been the case that the non-binary morphemes affected the anaphora resolution process when linking the pronoun to its gender-neutral antecedent, thus resulting in longer RTs at all 3 ROIs. This resolution process could have also been affected by the possible gender stereotypes of some of our gender-neutral words. To further investigate this possibility, we used the gender bias ratings from an unpublished study we conducted to remove any of the items that included masculine or feminine biased nouns. This resulted in excluding 1 item from each participant (see Appendix B for details). However, this exclusion did not affect the main results reported. We don't think this eliminates the possibility of a mismatch effect

between non-binary pronouns and biased gender-neutral nouns, but rather that the current study does not include an equal number of biased vs unbiased antecedents to be able to detect the mismatch effect reported for non-binary pronouns and biased antecedents in the literature (Arnold et al., 2021; Vergoossen et al., 2020). A final possibility for why our results might have differed from Stetie and Zunino's first study, could be due to the GSDB scale being presented prior to the sentence comprehension task. However, the GSDB scale does not contain any written forms using non-binary forms; instead, it uses neutralization strategies to present each statement. In case the GSDB might have influenced participants' reading times on non-binary morphemes, we should have expected this to have a priming effect, but that was not the case.

The second goal of this study was to examine the role of working memory and gender/sex diversity beliefs in processing non-binary morphemes in Spanish pronouns. The major finding was that working memory did not moderate the processing of non-binary forms, while gender normative beliefs and affirmation beliefs did. The lack of a moderating effect between working memory and non-binary pronouns came as a surprise to us, particularly because we expected some participants to revert the forms created by non-binary morphemes (e.g., *todxs*) to the binary morpheme counterparts they grew up with (i.e., *todos*, *todas*, 'all') as a strategy to facilitate their comprehension, and that in doing so they would engage domain general cognitive resources like working memory. Here, the qualitative data collected from the open-ended results of the question regarding strategy use when reading non-binary forms can shed some light. Although not all participants reported using a strategy, those that had a strategy for reading pronouns with –x mentally substituted the 'x' for either –e, –a, or –o, with one of the most common strategy being reading non-binary pronouns as pronouns with –o or –a (*todos y todas,* 'all' masculine and 'all' feminine, *todos*, or just *todas*). These data show that not all Spanish speakers are aware that '–x' is pronounced as 'e'(Vidal-Ortiz & Martínez, 2018), and thus they revert to forms that feel more familiar to them. Some participants even reported ignoring the specific morpheme because the overall word allowed them to access its meaning. As informative as these qualitative data are in terms of what some participants are doing, these strategies were not globally consistent enough to affect how working memory moderated the processing of non-binary pronouns. It could also be that because most of our sample reported being exposed to non-binary Spanish previously, they either are efficient in executing their strategy of choice or the self-paced reading technique is not sensitive enough to pick up on the potential relationship between working memory and processing non-binary morphemes. A final possibility is that the study may not have had sufficient power to detect the moderating effect of working memory, which was marginally significant at ROI 3. With higher statistical power, this effect might have reached significance. What the study did find regarding working memory was that it was able to reduce processing costs in both spillover regions after the pronoun regardless of the condition, something that is to our knowledge, a new finding. This suggests higher working memory can generally aid in the second stage of anaphora resolution that occurs once the link between the anaphor and the antecedent has been resolved (Garrod & Terras, 2000). Therefore, working memory remains an important variable for future work on non-binary pronouns.

Returning to the second goal of this study, sociocultural factors not typically considered in language processing studies such as gender/sex diversity beliefs (López et al., 2021), seem to play a bigger role in moderating the processing of non-binary pronouns than working memory. This is a new finding, since previous studies conducted on non-binary Spanish did not include gender/sex diversity beliefs as a variable, and studies on Swedish had found a link between the acceptability of non-binary pronoun *hen* and broader gender beliefs like gender as a binary category and general interests in gender issues (Gustafsson Sendén et al., 2021; Renström et al., 2022), but language processing had yet to be compared against these type of beliefs. In our sample, 68 % of participants did not have gender normative beliefs, meaning their responses fell in the 7-point Likert scale range of "completely disagree" and "somewhat disagree" when presented with gender normative statements, while the remaining 32 % of the sample fell in the range of "neither disagree or agree" and "completely agree." This suggests that being undecided or clearly decided on gender normative beliefs results in an additional processing cost for non-binary pronouns. Although this result is informative, we believe that it might be confounded with exposure and degree of use of non-binary forms in Spanish. In other words, those with more traditional views on gender might have had less exposure to non-binary Spanish in comparison to those with less traditional views on gender. For this purpose, we checked the self-reported use of non-binary Spanish of the participants that fell one standard deviation above the gender normativity mean. Out of these participants, 7 of them were Spanish heritage speakers while the other 2 were SC bilinguals. We speculate that the reason why the heritage speakers had more gender normative beliefs is because most of their Spanish exposure comes from gender normative contexts where they interact with their family members. In the future, it will be important to assess Spanish heritage speaker's processing of singular "they" as well to further flesh out the relationship between gender normative beliefs and exposure to non-binary forms in both languages heritage speakers actively use. Returning to the participants who were a standard deviation above the mean, five out of nine of them reported no exposure to non-binary Spanish, while the remaining four of them reported being exposed to non-binary Spanish in less than 3 contexts. This data appears to confirm the confounding relationship between gender normative beliefs and exposure to non-binary Spanish. However, this should also be taken with caution. Although we asked participants about their use of non-binary Spanish, this information is difficult to interpret as we do not have a way of knowing which forms they consider to be part of non-binary Spanish. Furthermore, the labels used when asking for the exposure data might have been confusing to some participants, possibly misleading them to think that non-binary Spanish is different from Spanish. For example, in the open-ended responses some people wrote they did not use non-binary forms with morphemes 'x' and 'e', but rather that either the generic 'o' was already inclusive in its ability to include non-binary individuals and thus considered as a "non-binary form" to them, or they alluded to the use of collective nouns instead of binary gendered expressions, a use that has been called indirect non-binary Spanish (López, 2020) or a neutralization gender-fair strategy (Sczesny et al., 2016). Future studies on non-binary Spanish should create more detailed assessments that allow researchers to get a better grasp of the type of non-binary forms speakers use in different contexts. This will allow researchers to address the question of whether it is a matter of having traditional beliefs surrounding gender or whether it is a matter of exposure to specific non-binary Spanish forms which moderates their processing.

Another important consideration is whether people who disagree with gender normative beliefs only accept the non-binary morphemes as gender-neutral referents when replacing the masculine generic (to which they may be opposed), but reject non-binary morphemes when referring to non-binary individuals. The present study is limited in this sense because we did not ask participants which referents were elicited by non-binary morphemes in Spanish pronouns, that is whether they interpreted the forms as gender-neutral plural generics or non-binary plural forms. However, out of the 20 participants who reported reverting both non-binary pronouns to binary pronouns with –o and –a, 16 of them disagreed with gender normative beliefs. Their disagreement with gender normative beliefs and their refusal to acknowledge non-binary forms might have to do with another variable not examined in this study. Transphobia (or at least a cisnormative commitment to binary gender) may be a possibility, in which rejection of masculine generics is recognized but non-binary and transgender identities are rejected. It is also possible that individuals may disagree with gender normative beliefs, but still hold prescriptive views on language, or that they might be

more familiar with gender-neutral alternatives in other languages such as English. Future research should further explore the relationship between gender normative beliefs, non-binary pronouns, transphobia, and prescriptive views on language. They should also assess which referents non-binary morphemes elicit in contrast to pronouns with binary morphemes, and identify other gender-neutral strategies participants use in other languages.

Regarding affirmation of diverse gender identities, participants managed to reduce the reading times of non-binary pronouns at the second spillover region. This finding suggests that those that agreed with statements that affirm diverse gender identities beyond the gender binary were able to recover from the late processing effects of non-binary pronouns, a recovery process that took one spillover region to complete instead of two. Unlike the interaction between gender normative beliefs and processing of non-binary pronouns, the interaction between affirmation scores and non-binary pronouns did not result in the best fitting model for the data. This might mean that although a relationship was found, it was not as strong enough to compete against the model with the working memory main effect. In our sample, 68 % of the participants had gender affirmation scores that ranged from "indecisive" to "completely agree", while the remaining 32 % had scores between "indecisive" and "completely disagree." There was a total of 11 participants who had affirmation scores below one standard deviation from the mean, with 5 of them also having gender normative scores below one standard deviation of the mean. Similar to what we suggest above for gender normative beliefs, we believe the findings regarding affirmation scores may also be confounded with exposure to non-binary Spanish, since 54 % of the participants who had affirmation scores within one standard deviation above the mean also reported being exposed to non-binary Spanish in 3 contexts or more. As noted earlier, a more precise assessment is needed to disentangle the relationship between non-binary forms, gender/sex diversity beliefs and exposure to specific forms of non-binary Spanish.

The third and final goal of this study was to compare the processing of non-binary morphemes in pronouns to the processing of canonical grammatical gender violations in pronouns. The main finding in this study was that grammatical gender violations were only detected at the first spillover region. However, we expected the congruency effect to appear at all three ROIs, especially in the pronoun region when speakers first encounter the grammatical gender violation between the subject and pronoun. This is an unexpected finding, but may be due to the distance between the pronoun and its antecedent. Previous studies have found that when the distance between the gender agreement is less than 4 words, speakers are sensitive to grammatical gender violations (Keating, 2009), but with 7 words, speakers are not sensitive to grammatical gender violations (Keating, 2010). In both of our tasks, the distance between the noun and the pronoun was 5 words, so it is possible that this contributed to the lack of an effect of congruency and grammaticality. Another possible explanation for our lack of results at the first ROI could have been the differences in the type of grammatical gender violations, since previous studies used agreement at the noun phrase. In contrast, our study included grammatical gender violations at the pronoun level, and included antecedents that were marked for gender at both the noun phrase (word positions 1 and 2) as well as in the past participle (word position 4) to avoid the mismatch between the gender of the noun and its stereotype (Carreiras et al., 1996). Although participants were presented again with the grammatical gender of the subject in word position 4, it was apparently not sufficient to elicit an incongruency effect at the pronoun level, as other studies on grammatical gender and pronoun resolution have reported (Carreiras et al., 1996).

Regarding individual differences in processing grammatical gender violations, neither working memory nor gender/sex diversity beliefs moderated their processing. The absence of a moderating effect of working memory was unexpected. Especially since previous studies have found that Spanish speakers recruit cognitive resources to offset the cost of processing grammatical gender violations, whether in the form of cognitive control (Beatty-Martínez et al., 2021) or working memory (Sagarra, 2007; Sagarra & Herschensohn, 2010). Aside from the previously raised issue concerning power, one possible explanation for the lack of an effect in this study may be that self-paced reading is not sufficiently sensitive to detect the moderating relationship between working memory and the processing of grammatical gender violations. Although some self-paced reading studies have found a moderating effect for working memory in noun phrases (Sagarra, 2007; Sagarra & Herschensohn, 2010), others have not found this to be the case (Foote, 2011). In the case of Foote's study, the gender violation occurred with 3 words between the noun and adjective, while in our study the distance between noun and pronoun was 5 words. In contrast the studies that found a moderating effect for working memory and gender violations included a violation right after the noun was mentioned (Sagarra & Herschensohn, 2010). Taken together, this might suggest that more sensitive measures like eye tracking and ERPs are needed to further understand the role that working memory plays in processing grammatical gender violations at different mismatching distances. Another potential explanation for our lack of a moderating effect might suggest that while working memory might be a significant contributor to grammatical gender violation sensitivity for L2 learners, it might not be for native Spanish speakers (Omaki, 2005; Sagarra & Herschensohn, 2010). Instead, working memory reduced the reading times at both spillover regions regardless of gender and congruency. An effect that, just as in the non-binary self-paced reading task, might be linked to the anaphora resolution process that takes place in the spillover regions immediately after the pronoun has been linked to its antecedent.

4.1. Conclusion

This study was one of the first, to our knowledge, to study the processing of non-binary morphemes in Spanish pronouns. By doing so, it contributes to the understudied phenomenon of non-binary/gender-neutral pronouns in languages other than Swedish or English (Decock et al., 2023). Taking the results from both self-paced reading tasks into account, we conclude that non-binary morphemes in pronouns are processed differently than grammatical gender violations at the pronoun level. First, the only similarities between both self-paced reading tasks were the language dominance main effect at all 3 ROIs and the working memory effect at the spillover regions. The findings we have reported also highlight the variation in Spanish-English bilinguals, with those who are more Spanish dominant reading faster in general. Aside from this main effect, the results from both self-paced reading tasks are very different. Mainly because processing non-binary pronouns affected both early and late processing measures, while grammatical gender violations only lasted one spillover region before they were resolved. Another key difference between the two tasks was the moderating effect of gender/sex diversity beliefs for the non-binary pronouns but not for grammatical gender violations. In conclusion, although non-binary morphemes in pronouns affected both early and late processing, it was not at a cost to comprehension and seems to be due to the recent incorporation of these forms in the Spanish language, not because Spanish speakers process non-binary pronouns as grammatical gender violations. Taken together, the findings contribute to the emerging literature that seeks to incorporate sociocultural factors intro traditional psycholinguistic research (López et al., 2021; Pozniak et al., 2024).

5. Constraints on generality and future directions

Although the findings provide valuable insights, certain limitations must be acknowledged. The first concerns the broader definition of pronoun used in the study. The purpose of choosing an overarching pronoun definition was to achieve a general idea of how non-binary morphemes would affect this broader class overall. However, as noted by one of the reviewers, the pronoun 'otr_s' (i.e., *otros*, *otras*, *otrxs*, *otres*,

'others') as used in the grammatical gender violation task included a minor ellipsis (Eguren, 2010). As it was not possible to remove these items without losing significant power, we instead visually compared the RTs of each pronoun for each dependent variable. Appendix F, Fig. F1 visually displays 'otr_s' was similar to other pronouns in the non-binary Spanish self-paced reading task. Fig. F3 shows a similar pattern in the grammatical gender violation task. However, 'otr_s' had the highest incorrect response proportion (0.16) in this task (Fig. F4A), with a small emerging trend for the comprehension questions (Fig. F1D and Fig. F3D). This suggests that some participants might have been affected by ellipsis from these forms, though not significantly impacting overall results. Future work should explore how different types of pronouns affect the processing of non-binary morphemes.

A second limitation concerns the gender identity imbalance present in our sample, with 82 % of our sample identifying with the feminine gender, 15 % identifying with the masculine gender, and only 3 % identifying as non-binary. Therefore, the findings cannot be generalized to non-binary individuals and Spanish speaking LGBTQIA+ communities. Though similar gender imbalances have also been found in other studies on non-binary Spanish (Michnowicz et al., 2023; Stetie & Zunino, 2022, 2024), if researchers are to better understand how non-binary forms in Spanish are used by these underrepresented groups, future work should prioritize their recruitment. A third limitation of the study is the type of grammatical gender violation used. Although our study did not find any relationship between gender/sex diversity beliefs and grammatical gender violations we do not take this as evidence that canonical grammatical gender is exempt from sociocultural beliefs (e.g., Casado et al., 2021) but rather that processing violations at the pronoun level does not seem to be connected to gender/sex diversity beliefs. Future work could manipulate the distance between the pronoun and its antecedent to examine whether people who are more open to gender diversity might be able to reduce the cost of processing canonical grammatical gender violations. This work could also be done at multiple levels within the NP (e.g., Det + N, Det + N + Adj).

Another limitation of the study is that the findings might not necessarily apply to other types of Spanish speakers. As noted by previous scholars, when studying language users, it is important to consider individual and contextual factors (López et al., 2021) whether they be monolingual or bilingual. The study's findings have the potential to serve as a starting point for future scholars that wish to examine non-binary Spanish in different language contexts. A final limitation concerns the use self-reported language measures for both language dominance as well as non-binary Spanish. Future work should incorporate more objective proficiency measures, since speakers may underestimate (heritage speakers) or overestimate their language abilities (bilinguals from Spanish speaking countries).

Despite these potential constraints on generality, the study we have reported illustrates the importance of considering different reading measurements (i.e., ROIs, accuracy, comprehension question RT) to uncover differences in language processing. It also showcases the delicate intricacies that come with achieving gender neutrality in a grammatically gendered language with masculine and feminine categories, particularly for those who did not come of age using non-binary morphemes. In the future, it will be important to reexamine and evaluate how non-binary morphemes are incorporated into the linguistic system should speakers begin acquiring these forms alongside the masculine and feminine grammatical gender. It will also be equally important to understand the specific contexts in which non-binary morphemes are used and whether their use will replace the use of masculine generics or whether they will be used solely to mark non-binary gender identities. To better understand how adults acquire non-binary morphemes in Spanish, more sensitive measures like event-related potentials may hold the promise to shed light on the semantic/syntactic interface of non-binary morphemes and how they compare to masculine and feminine morphemes. In the future it will also be important to examine differences between Spanish heritage speakers and bilinguals in Spanish speaking countries, as the linguistic context in which these speakers live are quite different in terms of how grammatical gender is marked (i.e., unmarked in English, marked in Spanish). Although both groups of bilinguals were included in the present study, this was not the primary question of focus. It will be interesting to see whether knowledge of non-binary pronouns in the societal language English can facilitate the acquisition of non-binary morphemes in Spanish. In short, research in the field of non-binary language and gender-neutrality is very much at the beginning but of great interest, particularly for those interested in the gender and language interface.

CRediT authorship contribution statement

Alexandra Román Irizarry: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Anne L. Beatty-Martínez:** Conceptualization, Writing – review & editing. **Julio Torres:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Judith F. Kroll:** Conceptualization, Funding acquisition, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

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Appendix A. Non-Binary Spanish Use Questions

1. Instructions

a. Original: *En esta sección, nos gustaría que contestara algunas preguntas sobre su uso de español no-binario marcando la casilla apropiada. Por ejemplo, el uso de expresiones como 'Todes mis amigues son simpátiques' o 'Todxs mis amigxs son simpáticxs' en lugar del masculino genérico 'Todos mis amigos son*

simpáticos'. El uso total del español y el español no-binario en cada pregunta debe llegar al 100 %. Por ejemplo: 50 % español + 50 % español no-binario. Si se equivoca o desea cambiar sus respuestas, pulse sobre 'Reset'. Si se encuentra satisfecho con sus respuestas, pulse 'Submit'.

b. Translation: "In this section, we would like for you to answer some questions regarding your use of non-binary Spanish by marking the appropriate box. For example, the use of expressions such as 'Todes mis amigues son simpátiques' or 'Todxs mis amigxs son simpáticxs' instead of the masculine generic 'Todos mis amigos son simpáaticos.' The total use of Spanish and non-binary Spanish must add up to 100 %. For example, 50 % Spanish, 50 % non-binary Spanish. If you make a mistake or wish to change your answers, press 'Reset.' If you are satisfied with your answers, press 'Submit.'

2. At home
   a. *En una semana normal, ¿qué porcentaje del tiempo **habla**… con su familia?* 'In a normal week, what percentage of the time do you **speak**… with your family?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   b. *En una semana normal, ¿qué porcentaje del tiempo **lee**… con su familia?* 'In a normal week, what percentage of the time do you **read**… with your family?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   c. *En una semana normal, ¿qué porcentaje del tiempo **escribe**… con su familia?* 'In a normal week, what percentage of the time do you **write**… with your family?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   d. *En una semana normal, ¿qué porcentaje del tiempo **escucha**… con su familia?* 'In a normal week, what percentage of the time do you **hear**… with your family?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
3. At school/work:
   a. *En una semana normal, ¿qué porcentaje del tiempo **habla**… en la escuela/el trabajo?* 'In a normal week, what percentage of the time do you **speak**… at school/work?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   b. *En una semana normal, ¿qué porcentaje del tiempo **lee**… en la escuela/el trabajo?* 'In a normal week, what percentage of the time do you **read**… at school/work?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   c. *En una semana normal, ¿qué porcentaje del tiempo **escribe**… en la escuela/el trabajo?* 'In a normal week, what percentage of the time do you **write**… at school/work?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   d. *En una semana normal, ¿qué porcentaje del tiempo **escucha**… en la escuela/el trabajo?* 'In a normal week, what percentage of the time do you **hear**… at school/work?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
4. In the community
   a. *En una semana normal, ¿qué porcentaje del tiempo **habla**… en su comunidad? Refiérase a una comunidad de la cual usted forma parte. Puede ser algún grupo de conciencia social o derechos humanos, algún grupo religioso, grupo cultural o étnico, grupo deportista, entre otros.* 'In a normal week, what percentage of the time do you **speak**… in your community? Think about a community you form part of. It can be a social justice or human rights group, a religious group, a cultural or ethnic group, a sports team, among others.'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   b. *En una semana normal, ¿qué porcentaje del tiempo **lee**… en su comunidad? Refiérase a una comunidad de la cual usted forma parte. Puede ser algún grupo de conciencia social o derechos humanos, algún grupo religioso, grupo cultural o étnico, grupo deportista, entre otros.* 'In a normal week, what percentage of the time do you **read**… in your community? Think about a community you form part of. It can be a social justice or human rights group, a religious group, a cultural or ethnic group, a sports team, among others.'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   c. *En una semana normal, ¿qué porcentaje del tiempo **escribe**… en su comunidad? Refiérase a una comunidad de la cual usted forma parte. Puede ser algún grupo de conciencia social o derechos humanos, algún grupo religioso, grupo cultural o étnico, grupo deportista, entre otros.* 'In a normal week, what percentage of the time do you **write**… in your community? Think about a community you form part of. It can be a social justice or human rights group, a religious group, a cultural or ethnic group, a sports team, among others.'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]

d. *En una semana normal, ¿qué porcentaje del tiempo **escucha**… en su comunidad? Refiérase a una comunidad de la cual usted forma parte. Puede ser algún grupo de conciencia social o derechos humanos, algún grupo religioso, grupo cultural o étnico, grupo deportista, entre otros.* 'In a normal week, what percentage of the time do you **hear**… in your community? Think about a community you form part of. It can be a social justice or human rights group, a religious group, a cultural or ethnic group, a sports team, among others.'
   i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]

5. With Peers
   a. *En una semana normal, ¿qué porcentaje del tiempo **habla** … con sus amigos?* 'In a normal week, what percentage of the time do you **speak**… with your friends?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   b. *En una semana normal, ¿qué porcentaje del tiempo **lee** … con sus amigos?* 'In a normal week, what percentage of the time do you **read**… with your friends?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   c. *En una semana normal, ¿qué porcentaje del tiempo **escribe** … con sus amigos?* 'In a normal week, what percentage of the time do you **write**… with your friends?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
   d. *En una semana normal, ¿qué porcentaje del tiempo **escucha** … con sus amigos?* 'In a normal week, what percentage of the time do you **hear**… with your friends?'
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]

6. Among yourself
   a. *Cuando se habla a usted mismo, ¿con qué frecuencia se habla a sí mismo en…?* 'When you talk to yourself, what percentage of the time do you speak to yourself in…?
      i. *Español* 'Spanish' [0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]
      ii. *Español no-binario* 'non-binary Spanish'[0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 %]

Appendix B. Gender stereotype ratings for gender-neutral nouns used in the study

Gender-neutral nouns		Gender Stereotype Rating		
Noun	Translation	Masculine	Neutral	Feminine
1. paciente	patient	3 %	90 %	7 %
2. habitante	inhabitant	10 %	84 %	6 %
3. oyente	auditing student	11 %	79 %	10 %
4. donante	donor	8 %	84 %	8 %
5. adolescente	adolescent	11 %	86 %	3 %
6. participante	participant	13 %	87 %	0 %
7. estudiante	student	3 %	90 %	7 %
8. envejeciente	elderly	18 %	82 %	0 %
9. agente	agent	44 %	53 %	2 %
10. navegante*	sailor	53 %	44 %	3 %
11. comediante	comedian	42 %	58 %	0 %
12. gerente	manager	45 %	53 %	2 %
13. manifestante	protester	14 %	81 %	5 %
14. contable	accountant	37 %	55 %	8 %
15. visitante	visitor	11 %	86 %	3 %
16. conserje	janitor	40 %	48 %	12 %
17. representante	representative	26 %	74 %	0 %
18. hispanoparlante	Spanish speaker	11 %	86 %	3 %
19. integrante	member	13 %	84 %	3 %
20. concursante	contestant	5 %	82 %	13 %
21. transeúnte	pedestrian	11 %	84 %	5 %
22. creyente	believer	10 %	79 %	11 %
23. aspirante	applicant	15 %	77 %	8 %
24. contribuyente	taxpayer	15 %	77 %	8 %
25. inmigrante	immigrant	22 %	76 %	2 %
26. principiante	beginner	10 %	87 %	3 %
27. bilingüe[a]	bilingual	NA	NA	NA
28. demandante	plaintiff	13 %	79 %	8 %
29. inocente	innocent	5 %	79 %	16 %
30. amante	lover	34 %	60 %	6 %
31. asistente	assistant	2 %	52 %	47 %
32. descendiente	descendant	8 %	87 %	5 %

Note. Gender-neutral nouns with a gender bias included in the study are marked with a star. These ratings were obtained from an unpublished study that surveyed 62 college students at a metropolitan university in Puerto Rico.

[a] This word was not included in the original study. We did not count it as a biased noun, because its closest equivalent, *hispanoparlante*, had a rating of 86 % neutral.

[*] Indicates the majority of the ratings were biased towards one gender.

Appendix C. Instructions provided to participants in the self-paced reading tasks

1. Welcome Text:

a. Original: *¡Gracias por aceptar participar en este estudio! El estudio está compuesto de siete partes: tres cuestionarios, dos tareas de lectura y dos tareas cognitivas. Se estima que le tomará aproximadamente una hora y media completar el estudio.*
b. Translation: "Thank you for your interest in participating in this study. The study is composed of seven parts: three[5] questionnaires, two reading tasks, and two[6] cognitive tasks. It will take you approximately an hour and a half to complete the study."

2. Self-paced Reading Task Practice Instructions:
   a. Original: *Antes de proceder con la primera tarea del estudio, realizará una sesión de práctica. Esta tarea consiste en leer oraciones y contestar una pregunta de comprensión luego de cada una. Al comenzar la tarea, verá unas líneas en el centro de su pantalla que indican la longitud de la oración. Al oprimir la* ***barra de espacio****, aparecerá la primera palabra de la oración. Con cada presión de la barra de espacio, aparecerá la próxima palabra y desaparecerá la previa. Al llegar al final de la oración y oprimir la barra de espacio, aparecerá una pregunta de comprensión que contestará con "sí" (****tecla "D"****) o "no" (****tecla "L"****). Es su responsabilidad recordar que las tres teclas importantes para completar esta tarea son: la* ***barra de espacio****, para avanzar en la oración; la* ***tecla "D"****, para contestar "sí" a la pregunta; y la* ***tecla "L"*** *para contestar "no" a la pregunta. Una sugerencia útil es mantener los dedos sobre las teclas importantes durante la tarea.*
   b. Translation: "Before starting the first sentence comprehension task, you will complete a practice session to help you get familiarized with the task. This task consists of reading sentences and answering a yes/no comprehension question after each sentence. When you begin the task, you will see lines that indicate the length of the sentence. Pressing the **spacebar** will reveal the first word. With each press of the space bar, the next word will appear while the previous word will disappear. At the end of the sentence press the spacebar to reveal a comprehension question. To answer the question with "yes", press (**key 'D'**) or 'no' with (**key 'L'**). You must remember these three keys in order to complete this task: the **spacebar** to move forward in the sentence; the **key 'D'** to answer 'yes'; and the **key 'L'** to answer 'no'. Try keeping your fingers on the important keys during the task."
3. Post-practice instructions
   a. Original: *La sesión de práctica ha terminado. La sesión experimental comenzará ahora. La tarea es idéntica a la de la sesión de práctica. Recuerde:* ***barra de espacio*** *= avanzar en la oración,* ***tecla "D"*** *= contestar "sí",* ***tecla "L"*** *= contestar "no".*
   b. Translation: "The practice session has finished. The experimental session will now start. The reading task is identical to the practice session. Remember: **spacebar** = move forward in the sentence, **key "D"** = answer "yes", **key "L"** = answer "no."
4. Break Instructions
   a. Original: *Ha terminado la primera tarea de comprensión de lectura. Puede tomarse un breve descanso, si lo desea. Si no, puede continuar con la sesión. Recuerde:* ***barra de espacio*** *= avanzar en la oración, tecla* ***"D"*** *= contestar "sí",* ***tecla "L"*** *= contestar "no". La segunda tarea de comprensión de lectura comenzará ahora.*
   b. Translation: "You have finished the first reading comprehension task. You can take a short break if you would like. If not, you may continue the session. Remember: **spacebar** = move forward in the sentence, **key 'D'** = answer 'yes', **key 'L'** = answer 'no.' The second reading comprehension task will begin now."

Appendix D. Non-Binary Spanish Open-Ended Questions

1. Strategies for reading non-binary pronouns:
   a. *Cuando leyó oraciones con pronombres que estaban escritos en español no-binario (*e.g.*, 'todxs', 'todes'), ¿utilizó alguna estrategia para leerlos? Si utilizó estrategias diferentes para -x y -*e *indique cómo difirieron sus estrategias según la marca de género.*
   b. "When you read sentences with pronouns that were written in non-binary Spanish (e.g., 'todxs', 'todes'), did you use any strategies to read them? If you used different strategies for -x and -e please specify how your strategies differed by gender mark."
2. Royal Spanish Academy:
   a. Original*: ¿Qué opina sobre la siguiente cita de la Real Academia Española? 'No es admisible usar la letra «x» ni la «e» como marca de género. Es, además, innecesario, pues el masculino gramatical funciona en nuestra lengua, como en otras, como término inclusivo para aludir a colectivos mixtos, o en contextos genéricos o inespecíficos.'*
   b. Translation: "What do you think of the following quote from the Royal Spanish Academy? 'It is not admissible to use neither the letter 'x' nor the letter 'e' as a gender mark. It is unnecessary, since the grammatical masculine functions in our language, as in others, as the inclusive term when referring to mixed groups, generic or unspecified contexts.'"

[5] The third questionnaire is not a valid questionnaire, but rather a series of questions we asked our participants to gauge their attitudes and exposure to non-binary Spanish.

[6] AX-CPT data was also collected, but it is not presented in the paper.

Appendix E

Table E1
Non-Binary Spanish SPR Task Affirmation*Pronoun Type Interaction at ROI 3.

Region of Interest	Pronoun +2	
	Estimate	*SE*
Fixed effects		
Intercept	2.686***	0.014
Morpheme[NB]	0.013***	0.003
Language dominance	−0.038***	0.011
Affirmation	−0.003	0.011
Affirmation*morpheme[NB]	−0.006*	0.003
Random effects	Variance	*SD*
Subject	0.008	0.091
Item	0.002	0.054

Note. SPR = self-paced reading. Estimates are in the $\log_{10}$ scale. The morpheme variable was sum coded with non-binary morphemes as +1 and binary morphemes as −1. All continuous variables were standardized.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table E2
Model Fit Indices for the Non-Binary Spanish Self-Paced Reading Task.

Model	Parameters	AIC	BIC	Log likelihood	Deviance	Chi-square	df	*p* value
ROI 1: Pronoun								
1a. log10rt ~ morpheme + lang_dom + (1|subject) + (1|item)	6	−1325.6	−1291.2	668.8	−1337.6			
1b. log10rt ~ morpheme*WM + lang_dom + (1|subject) + (1|item)	8	−1326.5	−1280.7	671.2	−1342.5	4.9	2	0.09
1c. log10rt ~ morpheme*GN + lang_dom + (1|subject) + (1|item)	8	−1330.2	−1284.4	673.1	−1346.2	8.6	2	<0.05*
ROI 2: Pronoun +1								
2a. log10rt ~ morpheme + lang_dom + (1|subject) + (1|item)	6	−1165.6	−1131.3	588.8	−1177.6			
2b. log10rt ~ morpheme*WM + lang_dom + (1|subject) + (1|item)	8	−1166.4	−1120.6	591.2	−1182.4	4.7	2	0.09
2c. log10rt ~ morpheme + WM + lang_dom + (1|subject) + (1|item)	7	−1168.4	−1128.3	591.2	−1182.4	4.7	1	<0.05*
ROI 3: Pronoun +2								
3a. log10rt ~ morpheme + lang_dom + (1|subject) + (1|item)	6	−2058.6	−2024.3	1035.3	−2070.6			
3b. log10rt ~ morpheme*WM + lang_dom + (1|subject) + (1|item)	8	−2062.5	−2016.7	1039.2	−2078.5	7.9	2	<0.05*
3c. log10rt ~ morpheme + WM + lang_dom + (1|subject) + (1|item)	7	−2060.9	−2020.8	1037.5	−2074.9	4.3[a]	1	<0.05*
3d. log10rt ~ morpheme*AF + lang_dom + (1|subject) + (1|item)	8	−2058.5	−2012.8	1037.3	−2074.5			

Note. *p* value shows the results of the likelihood-ratio test through the ANOVA function from the lmerTest R-package (Kuznetsova et al., 2017). WM = working memory, GN = gender normativity, AF = affirmation. Models *a* correspond to the baseline model of each region of interest (ROI).
[a] This chi-square value corresponds to the model 3a vs 3b comparison. Because model 3b included a marginally significant WM*morpheme interaction, we dropped the interaction in favor of a more parsimonious model. Model 3c was a better fit than both models 3a and 3b. The chi-square value for the 3b vs 3c comparison is 3.6, and its *p* value = .06.

Table E3
Model Fit Indices for the Grammatical Gender Violation Self-paced Reading Task.

Model	Parameters	AIC	BIC	Log likelihood	Deviance	Chi-square	df	*p* value
ROI 1: Pronoun								
1a. log10rt ~ gender + congruency + lang_dom + (1|subject) + (1|item)	7	−1955.2	−1915.4	984.6	−1969.2			
1b. log10rt ~ gender + congruency*WM + lang_dom + (1|subject) + (1 | item)	9	−1954.7	−1903.6	986.4	−1972.7	3.6	2	0.17
1c. log10RT ~ gender + congruency*GN + lang_dom_z + (1|part_number) + (1|item)	9	−1955.3	−1904.1	986.6	−1973.3	4.1	2	0.13
ROI 2: Pronoun +1								
2a. log10rt ~ gender + congruency + lang_dom + (1|subject) + (1|item)	7	−1409.4	−1369.7	711.7	−1423.4			
2b. log10rt ~ gender + congruency*WM + lang_dom + (1|subject) + (1| item)	9	−1411.3	−1360.2	714.7	−1429.3	5.9	2	0.05
2c. log10rt ~ gender + congruency + WM + lang_dom + (1|subject) + (1 | item)	8	−1413.2	−1367.8	714.6	−1429.2	5.8	1	<0.05
ROI 3: Pronoun +2								

(*continued on next page*)

Table E3 (*continued*)

Model	Parameters	AIC	BIC	Log likelihood	Deviance	Chi-square	df	*p* value
3a. log10rt ~ gender + congruency + lang_dom + (1|subject) + (1|item)	7	−1947.6	−1907.9	980.8	−1961.6			
3b. log10rt ~ gender + congruency*WM + lang_dom + (1|subject) + (1|item)	9	−1948.3	−1897.3	983.2	−1966.3	4.8	2	0.09
3c. log10rt ~ gender + congruency + WM + lang_dom + (1|subject) + (1|item)	8	−1949.8	−1904.4	982.9	−1965.8	4.2	1	<0.05
3d. log10rt ~ gender + congruency*AF + lang_dom + (1|subject) + (1|item)	9	−1944.8	−1893.8	981.4	−1962.8	0[a]	1	1

Note. p value shows the results of the likelihood-ratio test through the ANOVA function from the lmerTest R-package (Kuznetsova et al., 2017). WM = working memory, GN = gender normativity, AF = affirmation. Models *a* correspond to the baseline model of each region of interest (ROI).

[a] This chi-square test shows the result of the model 3c vs 3d comparison. When compared to model 3a, 3d did not result in a better fit, chi-square = 1.2, *p* value = .55.

Appendix F

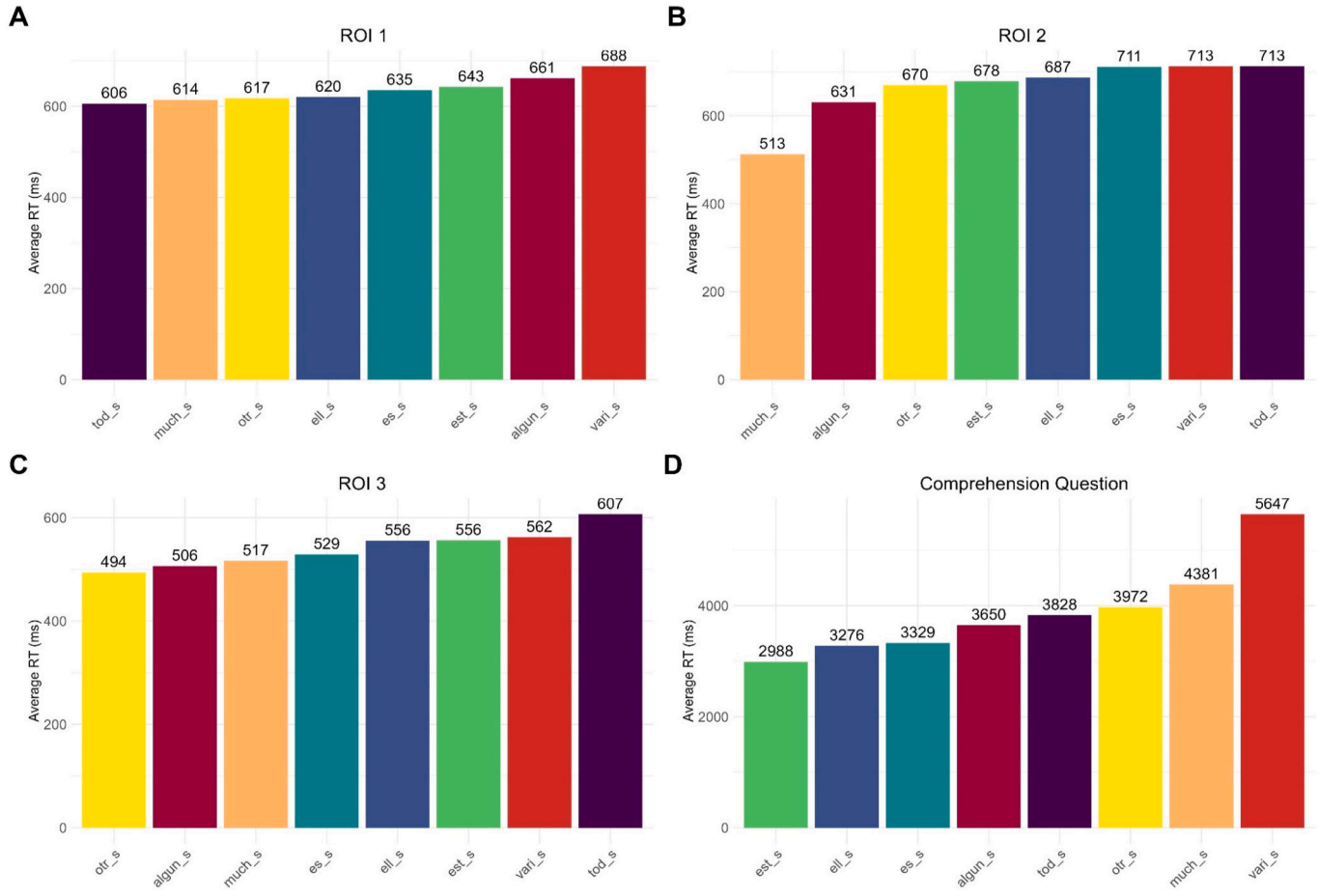

Fig. F1. Non-Binary Spanish Self-paced Reading Task Average Reaction Time by Pronoun and Dependent Variable.
Note. This figure displays the average reaction time (RT) for each pronoun across all conditions, ordered by dependent variable (A-D) from the non-binary Spanish self-paced reading task. Pronouns are consistently colored across all panels and figures in Appendix F. ROI = region of interest.

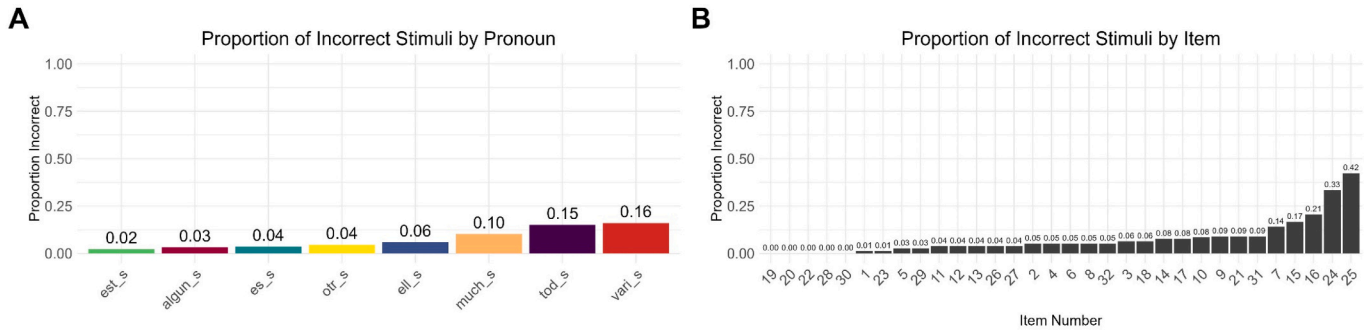

Fig. F2. Non-Binary Spanish Self-paced Reading Proportion of Incorrect Stimuli by Pronoun and Item.
Note. This figure displays the proportion of incorrect stimuli by pronoun (panel A) and item (panel B) from the non-binary self-paced reading task across all conditions, arranged in ascending order. Each pronoun is consistently represented in the same color as in all figures in Appendix F.

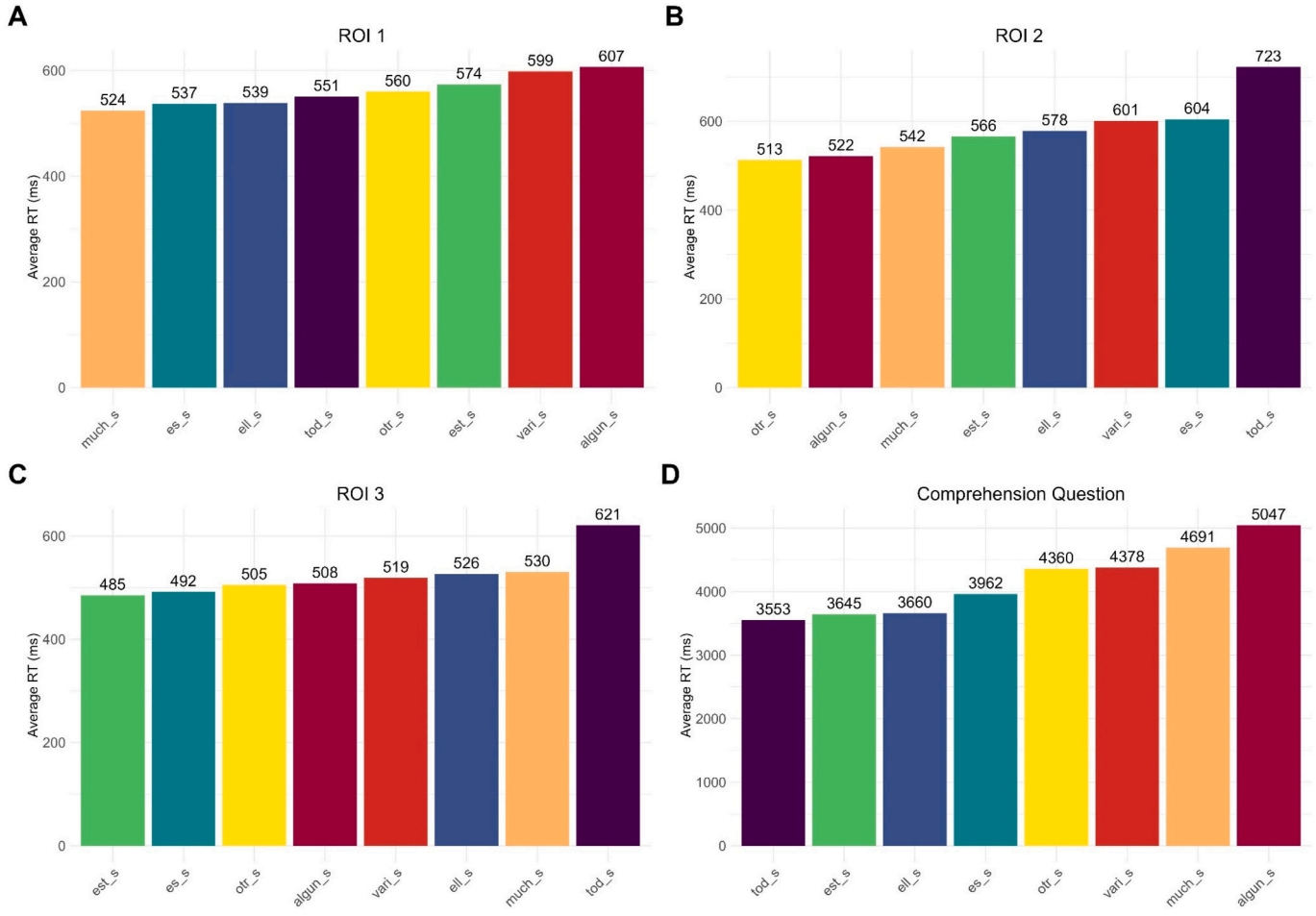

Fig. F3. Grammatical Gender Violation Self-paced Reading Task Average Reaction Time by Pronoun and Dependent Variable.
Note. This figure displays the average reaction time (RT) for each pronoun across all conditions, ordered by dependent variable (A-D) from the grammatical gender violation self-paced reading task. Pronouns are consistently colored across all panels and figures in Appendix F. ROI = region of interest.

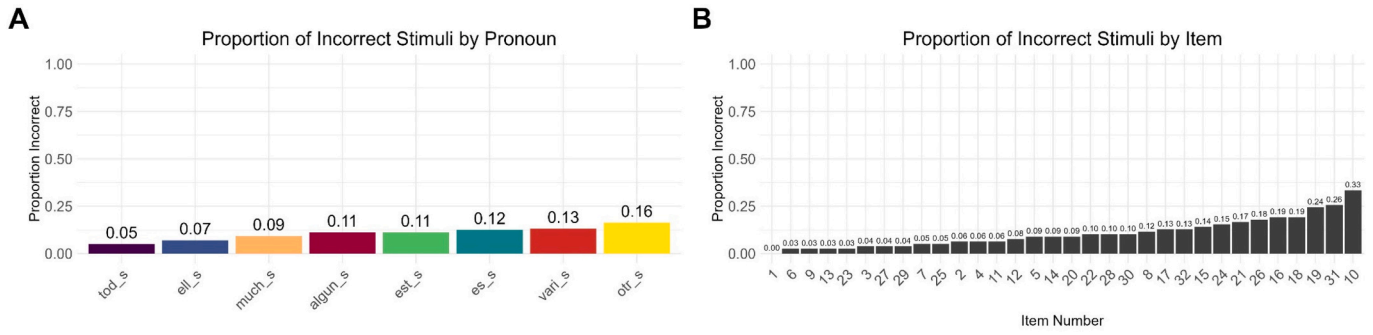

Fig. F4. Grammatical Gender Violation Self-paced Reading Proportion of Incorrect Stimuli by Pronoun and Item.
Note. This figure displays the proportion of incorrect stimuli by pronoun (panel A) and item (panel B) from the grammatical gender violation self-paced reading task across all conditions, arranged in ascending order. Each pronoun is consistently represented in the same color as in all figures in Appendix F.

Data availability

All of the materials and data, including the data used for the power analysis, can be readily accessed online at https://osf.io/hjfyk/?view_only=182f4b1e174046878083d6322de0fd97.

References

Acosta Matos, M. (2016). *Subversiones lingüísticas del español: @, x, e Como morfemas de género inclusivo y otros recursos estilísticos en publicaciones anarquistas contemporáneas [linguistic subversions of Spanish: @, x, e as inclusive gender morphemes and other stylistic resources in contemporary anarchist publications, Master's tesis]*. City University of New York.

Arnold, J. E. (2023). Pronoun comprehension. In *The Routledge handbook of pronouns* (pp. 120–134). Taylor and Francis. https://doi.org/10.4324/9781003349891-11.

Arnold, J. E., Mayo, H. C., & Dong, L. (2021). My pronouns are they/them: Talking about pronouns changes how pronouns are understood. *Pyschonomic Bulletin & Review, 28*(5), 1688–1697. https://doi.org/10.3758/s13423-021-01905-0/Published

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Beatty-Martínez, A. L., Bruni, M. R., Bajo, M. T., & Dussias, P. E. (2021). Brain potentials reveal differential processing of masculine and feminine grammatical gender in native Spanish speakers. *Psychophysiology, 58*(3). https://doi.org/10.1111/psyp.13737

Beatty-Martínez, A. L., & Dussias, P. E. (2019). Revisiting masculine and feminine grammatical gender in Spanish: Linguistic, psycholinguistic, and neurolinguistic evidence. *Frontiers in Psychology, 10*(751), 1–11. https://doi.org/10.3389/fpsyg.2019.00751

Bengoechea, M. (2008). Lo femenino en la Lengua: Sociedad, cambio y Resistencia normative [the feminine in language: Society, change, and normative resistance]. *Lenguaje y Textos, 27*, 37–68.

Bengoechea, M. (2015). Cuerpos hablados, cuerpos negados y el fascinante devenir del género grammatical [Spoken bodies, denied bodies, and the fascinating evolution of grammatical gender]. *The Bulletin of Hispanic Studies, 92*(1), 1–24. https://doi.org/10.3828/bhs.2015.01

Billard, T. J. (2018). The crisis in content validity among existing measures of transphobia. *Archives of Sexual Behavior, 47*, 1305–1306. https://doi.org/10.1007/s10508-018-1191-

Birdsong, D. (2016). Dominance in bilingualism: Foundations of measurement, with insights from the study of handedness. In C. Silva-Corvalán, & J. Treffers-Daller (Eds.), *Language dominance in bilinguals: Issues of measurement and operationalization* (pp. 85–105). Cambridge University Press. https://doi.org/10.1017/CBO9781107375345.005.

Birdsong, D., Gertken, L. M., & Amengual, M. (2012). *Bilingual language profile: An easy-to- use instrument to assess bilingualism*. COERLL, University of Texas at Austin.

Braver, T. S. (2012). The variable nature of cognitive control: A dual-mechanisms framework.*Trends in. Cognitive Sciences, 16*(2), 106. https://doi.org/10.1016/J.TICS.2011.12.010

Brysbaert, M., & Stevens, M. (2018). Power analysis and effect size in mixed effects models: A tutorial. In *, 1(1). Journal of Cognition*. Ubiquity Press. https://doi.org/10.5334/joc.10.

Cabeza Pereiro, M. D. C., & Rodríguez Barcia, S. (2013). Aspectos ideológicos, gramaticales y léxicos del sexismo lingüístico [Ideological, gramatical, and lexical aspects of linguistic sexism]. *Estudios Filologicos, 52*, 7–27. https://doi.org/10.4067/S0071171320130000200001

Carreiras, M., Garnham, A., Oakhill, J., & Cain, K. (1996). The use of stereotypical gender information in constructing a mental model: Evidence from English and Spanish. *Quarterly Journal of Experimental Psychology, 49*(3), 639–663. https://doi.org/10.1080/713755647

Casado, A., Palma, A., & Paolieri, D. (2021). The scope of grammatical gender in Spanish: Transference to the conceptual level. *Acta Psychologica, 218*. https://doi.org/10.1016/j.actpsy.2021.103361

Conklin, K., & Pellicer-Sánchez, A. (2016). Using eye-tracking in applied linguistics and second language research. *Second Language Research, 32*(3), 453–467. https://doi.org/10.1177/0267658316637401

Conrod, K. (2021). *How to ask the gender question [PowerPoint slides]*. Google Slides. https://docs.google.com/presentation/d/19DIRtZjNHNBzcv7FSP_frt1X2ULMiwFNnEznDxiOszI/edit#slide=id.p.

Conway, A., Jarrold, C., Kane, M., Miyake, A., & Towse, J. (Eds.).. (2007). *Variation in working memory*. Oxford University Press.

Corbett, G. G. (1991). *Gender*. Cambridge University Press.

Cruz, J.. 25). ¿Qué dice la RAE sobre el lenguaje inclusivo? [what does the RAE say about inclusive language?]. ABC Noticias. https://abcnoticias.mx/tendencia/2021/8/25/que-dice-la-rae-sobre-el-lenguaje-inclusivo-145563.html.

Decock, S., van Hoof, S., Soens, E., & Verhaegen, H. (2023). The comprehensibility and appreciation of non-binary pronouns in newspaper reporting. The case of hen and die in Dutch. *Applied Linguistics*. https://doi.org/10.1093/applin/amad028

Dussias, P. E., Kroff, J. R. V., Guzzardo Tamargo, R. E., & Gerfen, C. (2013). When gender and looking go hand in hand: Grammatical gender processing in L2 Spanish. *Studies in Second Language Acquisition, 35*(2), 353–387. https://doi.org/10.1017/S0272263112000915

Eguren, L. (2010). Contrastive focus and nominal ellipsis in Spanish. *Lingua, 120*(2), 435–457. https://doi.org/10.1016/j.lingua.2009.05.004

Fábregas, A. (2022). Hacia Una Caracterización Sintáctica Del Género Del Sustantivo en español [Towards a syntactic characterization of the gender of nouns in Spanish]. *Revista Española de Lingüística, 52*(1), 39–96. https://doi.org/10.31810/rsel.52.1.2

Fahl, H. (2014). *Hen med i ordlistan [hen in the dictionary]*. Dagens Nyheter. https://www.dn.se/kultur-noje/hen-med-i-ordlistan/.

Ferreira, F., Bailey, K. G., & Ferraro, V. (2002). Good-enough representations in language comprehension. *Current Directions in Psychological Science, 11*(1), 11–15. https://doi.org/10.1111/1467-8721.00158

FindingFive Team. (2019). FindingFive: A web platform for creating, running, and managing your studies in one place. In *FindingFive corporation (nonprofit), NJ, USA*. https://www.findingfive.com.

Foertsch, J., & Gernsbacher, M. A. (1997). In search of gender neutrality: Is singular they a cognitively efficient substitute for generic he? *Psychological Science, 8*(2), 106–111. https://doi.org/10.1111/j.1467-9280.1997.tb00691.x

Foote, R. (2011). Integrated knowledge of agreement in early and late English-Spanish bilinguals. *Applied PsychoLinguistics, 32*(1), 187–220. https://doi.org/10.1017/S0142716410000342

Fox, J., & Weisberg, S. (2018). *An R companion to applied regression*. Sage Publications.

Garnham, A. (2001). *Mental models and the interpretation of anaphora*. Psychology Press. https://doi.org/10.4324/9780203782873

Garrod, S., & Terras, M. (2000). The contribution of lexical and situational knowledge to resolving discourse roles: Bonding and resolution. *Journal of Memory and Language, 42*(4), 526–544. https://doi.org/10.1006/jmla.1999.2694

Green, P., & MacLeod, C. J. (2016). Simr: An R package for power analysis of generalised linear mixed models by simulation. *Methods in Ecology and Evolution, 7*(4), 493–498. https://doi.org/10.1111/2041-210X.12504

Gustafsson Sendén, M., Bäck, E. A., & Lindqvist, A. (2015). Introducing a gender-neutral pronoun in a natural gender language: The influence of time on attitudes and behavior. *Frontiers in Psychology, 6*, 893. https://doi.org/10.3389/fpsyg.2015.00893

Gustafsson Sendén, M., Renström, E., & Lindqvist, A. (2021). Pronouns Beyond the Binary: The Change of Attitudes and Use Over Time. *Gender and Society, 35*(4), 588–615. https://doi.org/10.1177/08912432211029226

Gygax, P. M., Elmiger, D., Zufferey, S., Garnham, A., Sczesny, S., von Stockhausen, L., … Oakhill, J. (2019). A language index of grammatical gender dimensions to study the impact of grammatical gender on the way we perceive women and men. *Frontiers in Psychology, 10*(JULY). https://doi.org/10.3389/fpsyg.2019.01604

Hellinger, M., & Bußmann, H. (Eds.). (2001). *Vol. 1. Gender across languages: The linguistic representation of women and men*. John Benjamins Publishing Company. https://doi.org/10.1075/impact.9.

Hopp, H. (2016). Learning (not) to predict: Grammatical gender processing in second language acquisition. *Second Language Research, 32*(2), 277–307. https://doi.org/10.1177/0267658315624960

Jegerski, J., & VanPatten, B. (2013). Self-paced reading. In *Research methods in second language psycholinguistics* (pp. 20–49). Taylor & Francis Group. http://ebookcentral.proquest.com/lib/uci/detail.action?docID=1582610.

Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review, 99*(1), 122. https://doi.org/10.1037/0033-295X.99.1.122

Keating, G. D. (2009). Sensitivity to violations of gender agreement in native and nonnative Spanish: An eye-movement investigation. *Language Learning, 59*(3), 503–535. https://doi.org/10.1111/j.1467-9922.2009.00516.x

Keating, G. D. (2010). The effects of linear distance and working memory on the processing of gender agreement in Spanish. In B. VanPatten, & J. Jegerski (Eds.), *Research in second language processing and parsing* (pp. 113–134). John Benjamins Publishing Company.

Keating, G. D., & Jegerski, J. (2015). Experimental designs in sentence processing research. *Studies in Second Language Acquisition, 37*(1), 1–32. https://doi.org/10.1017/S0272263114000187

Kennison, S. M., & Trofe, J. L. (2003). Comprehending pronouns: A role for word-specific gender stereotype information. *Journal of Psycholinguistic Research, 32*(3), 355–378. https://doi.org/10.1023/A:1023599719948

Klein, K., & Fiss, W. H. (1999). The reliability and stability of the Turner and Engle working memory task. *Behavior Research Methods, Instruments, & Computers, 31*(3), 429–432. https://doi.org/10.3758/BF03200722

Knisely, K. A. (2020). Le français non-binaire: Linguistic forms used by non-binary speakers of French. *Foreign Language Annals, 53*(4), 850–876. https://doi.org/10.1111/flan.12500

Körner, A., Abraham, B., Rummer, R., & Strack, F. (2022). Gender representations elicited by the gender star form. *Journal of Language and Social Psychology, 41*(5), 553–571. https://doi.org/10.1177/0261927X221080181

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software, 82*(13). https://doi.org/10.18637/jss.v082.i13

Lee, C. (2019, October 31). *Welcome, singular "they"*. APA Style. https://apastyle.apa.org/blog/singular-they.

López, Á. (2020). Cuando el lenguaje excluye: Consideraciones sobre el lenguaje no binario indirecto [when language excludes: Considerations on indirect non-binary language]. *Cuarenta Naipes, 2*(3), 295–312.

López, B. G., Luque, A., & Piña-Watson, B. (2021). Context, intersectionality, and resilience: Moving toward a more holistic study of bilingualism in cognitive science. *Cultural Diversity & Ethnic Minority Psychology, 29*(1), 24–33. https://doi.org/10.1037/cdp0000472

Michnowicz, J., Ronquest, R., Armbrister, B., Chisholm, N., Green, R., Bull, L., & Elkins, A. (2023). Perceptions of inclusive language in the Spanish of the southwest: Data from a large classroom project. *Spanish in Context, 20*(1), 96–129. https://doi.org/10.1075/sic.00084.mic

Mitkov, R. (2013). *Anaphora resolution* (1st ed.). Routledge.

Olson, D. J. (2023). Measuring bilingual language dominance: An examination of the reliability of the bilingual language profile. *Language Testing*. https://doi.org/10.1177/02655322221139162

Omaki, A. (2005). *Working memory and relative clause attachment in first and second language processing*. Master's thesis. University of Hawaii at Manoa. https://scholarspace.manoa. Hawaii.Edu /server/api/core/bitstreams/6253745e-73c9-4967-8945-a7353048664b/content.

Papadopoulos, B. (2021). A brief history of gender-inclusive Spanish. *DEP. Deportate, Esuli, Profughe, 48*(1), 41–48.

Papadopoulos, B., Duarte, J., Duran, J., Fliege, C., Nierotka, I., & Reynolds, K. (2022). *Global Spanish*. Gender in Language Project. www.genderinlanguage.com/spanish/.

Paterson, L. L. (2014). *British pronoun use, prescription, and processing: Linguistic and social influences affecting 'they'and 'he'*. Palgrave Macmillan.

Popič, D., & Gorjanc, V. (2018). Challenges of adopting gender-inclusive language in Slovene. *Suvremena lingvistika, 44*(86), 329–350. https://doi.org/10.22210/suvlin.2018.086.07

Pozniak, C., Corbeau, E., & Burnett, H. (2024). Contextual dilution in French gender inclusive writing: An experimental investigation. *Journal of French Language Studies*. https://doi.org/10.1017/S0959269523000236

Proceso. (2021, August 31). Le preguntan a la RAE sobre el uso de "elle" en personas no binarias y esto respondió [They asked the RAE about the use of 'elle' for non-binary people, and this was their response]. https://www.proceso.com.mx/nacional/2021/8/31/le-preguntan-la-rae-sobre-el-uso-de-elle-personas-no-binarias-esto-respondio-270997.html.

R Core Team. (2024). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.

RAEinforma. [@RAEinforma]. (2021a). #RAEconsultas El uso de la letra «e» como supuesta marca de género inclusivo es ajeno a la morfología del español, además de innecesario, pues el masculino gramatical ya cumple esa función como término no marcado de la oposición de género [The use of the letter 'e' as a supposed marker of inclusive gender is foreign to Spanish morphology, and also unnecessary, since the grammatical masculine already fulfills that function as the unmarked term in the gender opposition, Tweet]. August 25 X https://x.com/RAEinforma/status/1430783768206401544.

RAEinforma. [@RAEinforma]. (2021b). #RAEconsultas La forma «elle» y las terminaciones en «-e» en voces con flexión «-o/−a» son recursos facticios promovidos en ciertos ámbitos para referirse a quienes no se identifican con ninguno de los géneros del par binario, pero su uso no está generalizado ni asentado [The form 'elle' and the endings in '-e' in words with '-o/−a' inflection are artificial resources promoted in certain contexts to refer to those who do not identify with either gender of the binary pair, but their use is neither widespread nor established, Tweet]. X. August 26 https://x.com/RAEinforma/status/1430783768206401543.

Real Academia Española. (2024). Pronombre ['pronoun']. In *Diccionario de la lengua española*. https://dle.rae.es/pronombre?m=form.

Renström, E. A., Lindqvist, A., & Sendén, M. G. (2022). The multiple meanings of the gender- inclusive pronoun hen: Predicting attitudes and use. *European Journal of Social Psychology, 52*(1), 71–90. https://doi.org/10.1002/ejsp.2816

Román Irizarry, A. (2021). Todxs, todes, o todos? Actitudes de la juventud puertorriqueña hacia los morfemas de lenguaje inclusivo [*¿Todxs, todes, o todos*? Attitudes of Puerto Rican youth towards language inclusive morphemes]. In B. L. Figueroa (Ed.), *Proceedings of the VIII Coloquio ¿Del otro la'o?: Arte y activismo cuir en el Puerto Rico contemporáneo* (pp. 282–310). Editora Educación Emergente. https://www.researchgate.net/publication/361980392_Todxs_todes_o_todos_Actitudes_de_la_juventud_puertorriquena_hacia_los_morfemas_de_lenguaje_inclusivo.

Rossi, E., Kroll, J. F., & Dussias, P. E. (2014). Clitic pronouns reveal the time course of processing gender and number in a second language. *Neuropsychologia, 62*(1), 11–25. https://doi.org/10.1016/j.neuropsychologia.2014.07.002

Sagarra, N. (2007). Online processing of gender agreement in low proficient English–Spanish late bilinguals. In M. J. Cabrera, J. Camacho, V. Déprez, N. Flores, & L. Sánchez (Eds.), *Current issues in linguistic theory series* (pp. 240–253). John Benjamins.

Sagarra, N., & Herschensohn, J. (2010). The role of proficiency and working memory in gender and number agreement processing in L1 and L2 Spanish. *Lingua, 120*(8), 2022–2039. https://doi.org/10.1016/J.LINGUA.2010.02.004

Schad, D. J., Vasishth, S., Hohenstein, S., & Kliegl, R. (2020). How to capitalize on a priori contrasts in linear (mixed) models: A tutorial. *Journal of Memory and Language, 110*. https://doi.org/10.1016/j.jml.2019.104038

Schudson, Z. C., & van Anders, S. M. (2021). Gender/sex diversity beliefs: Scale construction, validation, and links to prejudice. *Group Processes & Intergroup Relations, 00(0)*, 1–26. https://doi.org/10.1177/1368430220987595

Sczesny, S., Formanowicz, M., & Moser, F. (2016). Can gender-fair language reduce gender stereotyping and discrimination?. In , *Vol. 7. Frontiers in psychology*. Frontiers Media S.A. https://doi.org/10.3389/fpsyg.2016.00025.

Speyer, L. G., & Schleef, E. (2019). Processing "gender-neutral" pronouns: A self-paced Reading study of learners of English. *Applied Linguistics, 40*(5), 793–815. https://doi.org/10.1093/applin/amy022

Stahlberg, D., Braun, F., Irmen, L., & Sczesny, S. (2007). Representation of the sexes in language. In *Social communication* (pp. 163–187). Psychology Press.

Stetie, N. A., & Zunino, G. M. (2022). Non-binary language in Spanish? Comprehension of non- binary morphological forms: A psycholinguistic study. *Glossa: a journal of general linguistics, 7*(1). https://doi.org/10.16995/glossa.6144

Stetie, N. A., & Zunino, G. M. (2024). Do gender stereotypes bias the processing of morphological innovations? The case of gender-inclusive language in Spanish? *Psychology of Language and Communication, 28*(1), 446–469. https://doi.org/10.58734/plc-2024-0016

Taalunie. (2022, May 30). Adviezen genderbewust taalgebruik [Advice texts on gender-aware language use]. https://taalunie.org/actueel/311/adviezen-genderbewust-taalgebruik-beschikbaar-op-taaladviesnet.

Tibblin, J., Granfeldt, J., van de Weijer, J., & Gygax, P. (2023). The male bias can be attenuated in reading: On the resolution of anaphoric expressions following gender-fair forms in French. *Glossa Psycholinguistics, 2*(1). https://doi.org/10.5070/g60111267

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28*, 127–154. https://doi.org/10.1016/0749-596X(89)90040-5

Veloso, L., Coheur, L., & Ribeiro, R. (2023, December). A rewriting approach for gender inclusivity in Portuguese. In *Findings of the Association for Computational Linguistics: EMNLP 2023* (pp. 8747–8759). https://doi.org/10.18653/v1/2023.findings-emnlp.585

Vergoossen, H. P., Pärnamets, P., Renström, E. A., & Gustafsson Sendén, M. (2020). Are new gender-neutral pronouns difficult to process in Reading? The case of hen in SWEDISH. *Frontiers in Psychology, 11*. https://doi.org/10.3389/fpsyg.2020.574356

Vidal-Ortiz, S., & Martínez, J. (2018). Latinx thoughts: Latinidad with an X. *Latino Studies, 16*, 384–395. https://doi.org/10.1057/s41276-018-0137-8

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D. A., François, R., & Yutani, H. (2019). Welcome to the Tidyverse. *Journal of open-source software, 4*(43), 1686. https://doi.org/10.21105/joss.01686

Winter, B. (2019). *Statistics for linguists: An introduction using R*. Routledge. https://doi.org/10.4324/9781315165547

Zarwanitzer, A. (2019). *Procesamiento de oraciones con lenguaje inclusivo [processing sentences with inclusive language, Bachelor's thesis]*. Argentina: Universidad de San Andrés. https://repositorio.udesa.edu.ar/jspui/handle/10908/166.