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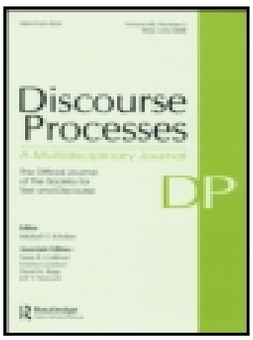

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Grammatical Gender in German Influences How Role-Nouns Are Interpreted: Evidence from ERPs

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ABSTRACT

Grammatically masculine role-nouns (e.g., *Studenten*masc.'students') can refer to men *and* women but may favor an interpretation where only men are considered the referent. If true, this has implications for a society aiming to achieve equal representation in the workplace since, for example, job adverts use such role descriptions. To investigate the interpretation of role-nouns, the present ERP study assessed grammatical gender processing in German. Twenty participants read sentences where a role-noun (masculine or feminine) introduced a group of people, followed by a congruent (masculine–*men*, feminine–*women*) or incongruent (masculine–*women*, feminine–*men*) continuation. Both for feminine-*men* and masculine-*women* continuations a P600 (500 to 800 ms) was observed; another positivity was already present from 300 to 500 ms for feminine-*men* continuations but critically not for masculine-*women* continuations. The results imply a male-biased rather than gender-neutral interpretation of the masculine—despite widespread usage of the masculine as a gender-neutral form—suggesting that masculine forms are inadequate for representing genders equally.

Introduction

Gender is a social category we encounter on a daily basis, with gender equality having become an important sociopolitical issue. Gender has also been described as "almost universally present in language" (Irmen, Holt, & Weisbrod, 2010, p. 133), as the gender of a person can be indicated linguistically via diverse means. Generally speaking, across languages, referential nouns fall into one of the three following gender categories: carrying natural gender, grammatical gender, or no gender (genderless languages; see Stahlberg, Braun, Irmen, & Sczesny, 2007). While lexical information (e.g., *woman*) can cue gender explicitly, role-nouns (e.g., *mathematicians*) often imply gender information too. In natural gender languages, such as English, role-nouns are not grammatically gendered in the singular or plural. Only via the use of pronouns and only in the singular can the gender of, for example, the *mathematician* be revealed as *she* or *he*. In contrast, many grammatically gendered languages, such as German or Spanish, categorize all nouns as belonging to specific grammatical gender categories—for example, as masculine, feminine, and occasionally also neuter. In the case of masculine and feminine gender categories, nouns referring to people tend to indicate male or female gender of the referent. Thus, role-nouns are realized differently across languages, depending on the grammatical system. In German, the suffix *–innen* marks feminine grammatical gender in the plural, making a reference to females explicit.

Previous research has investigated how role-nouns are understood across various languages. In the absence of grammatical gender, referent gender is cued by stereotypicality (Gygax, Gabriel,

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Sarrasin, Oakhill, & Garnham, 2008; Sato, Gygax, & Gabriel, 2013). For example, in English, the noun *mathematicians* implies male referents because native speakers think mathematicians are stereotypically male (Misersky et al., 2014), whereas in gendered languages, such as German, grammatical gender indicates referent gender since distinct forms are used to describe females versus males. Feminine role-nouns (e.g., *Mathematikerinnen*fem.) cue specifically for females; the masculine (e.g., *Mathematiker*masc.), is used for males but can also be used for a mixed-gender group (i.e., including both males and females, see also Stahlberg et al., 2007). As such, the masculine may yield a generic as well as a specific interpretation.

Using a form such as *Mathematiker*masc. for a mixed-gender group therefore results in a potential ambiguity in interpretation. Gygax et al. (2008) examined the interpretation of such role-nouns by comparing English, which has natural gender, to French and German, both of which have grammatical gender. Participants were presented with a stereotypically male or female role-noun (in the masculine for French and German) in one sentence and with an anaphoric noun (*men* or *women*) in a second. Participants had to indicate whether the sentence continuation was sensible. In English, participants' judgments and response times were linked to the stereotypicality of the role-noun. There was no such effect of stereotypicality for French and German. Instead, participants judged continuations with *men* to be more sensible than continuations with *women* anaphors. This was also reflected in response times: Participants were faster to judge *men* continuations as sensible compared to *women* continuations.

Recent studies have found similar effects in German and Dutch primary school children (Vervecken, Gygax, Gabriel, Guillod, & Hannover, 2015; Vervecken & Hannover, 2015). Grammatical form was found to affect ratings of status ("How important is it to be ___?") and difficulty ("How hard is it to do the job of ___?") associated with job roles. Importantly, children reported lower self-efficacy—that is, they were more likely to think they could not succeed in the job—when presented with a masculine form. In sum, this research suggests that grammatical gender is relevant for guiding our interpretation of language and may even override stereotype information (Gygax et al., 2008; Irmen & Roßberg, 2004). Specifically, these examples indicate that despite being intended for all genders (Stahlberg et al., 2007), the masculine is interpreted as male-specific. However, because these studies used explicit post hoc measures of language processing, it is unclear whether the effects found reside in early online language processing or result from later decision-making processes.

The current study used event-related potentials (ERPs) to assess the online interpretation of grammatically gendered role-nouns in German. We investigated the specific neural signature of how masculine role-nouns are processed with the view to determine whether the male-specific or generic interpretation is favored earlier.

Previous ERP studies shed some light on how grammatical gender is processed online and help to hone the specific predictions. This literature has focused largely on two classical ERP components, the N400 and the P600. The N400, a negative deflection from 300 to 500 ms after stimulus presentation, is related to lexical-semantic processing (Kutas & Hillyard, 1980a and 1980b; for a review see Kutas & Federmeier, 2011); whereas the P600 is sensitive to processing of syntactic information (Osterhout & Holcomb, 1992) and is characterized by a positive deflection around 500 to 800 ms after stimulus onset. In these studies, researchers investigate how grammatical agreement between object nouns and their corresponding pronouns, determiners, or adjectives is processed (e.g., Barber & Carreiras, 2005; Caffarra, Siyanova-Chanturia, Pesciarelli, Vespignani, & Cacciari, 2015; Hammer, Jansma, Lamers, & Münte, 2005). Looking at coreferential pronoun processing at the sentence level, Hammer et al. (2005) found that for both objects (e.g., *der Apfel*masc. 'the apple') and role-nouns in the singular (e.g., *die Frau*fem./female 'the woman'), mismatches between the grammatical gender of the noun and the coreferential pronoun elicited a P600 effect. This effect was larger in the role-noun condition, when there was a mismatch in both the grammatical gender and biological gender. In a follow-up study again manipulating grammatical gender, Hammer, Jansma, Lamers, and Münte (2008) found P600 and N400 effects for coreferential pronoun mismatches, depending on the type of antecedent noun (animate role-noun or object) and the distance between

the antecedent and pronoun. Specifically, they found an N400-like effect only for pronouns following an animate noun with a short distance between antecedent and pronoun. When there was a longer distance between animate antecedent and pronoun, a P600 was elicited at grammatically incongruent pronouns. The authors highlight the relevance of both semantics and syntax in coreferential processing of grammatically gendered role-nouns and pronouns and suggest that the parser can flexibly switch between the use of semantic and syntactic information to establish coreference.

Other ERP studies examining the processing of role-nouns with embedded stereotype information have found similar effects. Testing English speakers, White, Crites, Taylor, and Corral (2009) used a match-mismatch paradigm and found word-pairs, which mismatched in gender stereotypicality (e.g., *secretary–aggressive*) resulted in a larger N400 effect than matching word-pairs (e.g., *secretary–caring*). Similarly, Osterhout, Bersick, and McLaughlin (1997) examined English participants' processing of reflexive pronouns (*himself/herself*) following a role-noun. Pronouns either did or did not match an antecedent role-noun's gender definition (e.g., *bachelor*) or stereotype (e.g., *doctor*). Osterhout et al., (1997) found a P600 effect for both types of gender mismatches, but the amplitude of the P600 was larger for mismatches between reflexives and definitional role-nouns (e.g., *bachelor … herself*) than stereotype ones, suggesting they were considered more anomalous.

Testing German speakers, Irmen et al. (2010) investigated how stereotypicality of role-nouns affected the processing of a subsequent referent. Their participants read sentences consisting of a stereotypically male or female role-noun (e.g., *computer scientist*; stereotypically male), and a coreferential continuation, which was either neutral (e.g., *these people*), matching (e.g., *these men*), or mismatching (e.g., *these women*) with regards to gender. An N400 effect across all continuations following a stereotypically male role-noun was observed. A later P600 effect showed an interaction between the stereotypicality of the role-noun and the continuation and was taken to reflect the integration of the two nouns. Irmen et al. (2010) suggest that this is consistent with a two-stage model of reference resolution (Garrod & Terras, 2000). According to Garrod and Terras (2000), the first stage ("bonding") assumes more superficial processing of the plausibility between role-noun and continuation. During the second stage (reference resolution), the sentence as a whole is evaluated against this initially established bond. If the bond appears inappropriate given the context, processing difficulties occur. Irmen et al. (2010) suggest that initial bonding between role-noun and continuation based on lexical-semantic information was reflected in the N400, while difficulties in reference resolution were observed in the later P600 time window.

In sum, two ERP components are most regularly observed in research on gender cues—the N400 and P600. Both conceptual and syntactic information are relevant to successfully build coreference (Schmitt, Lamers, & Münte, 2002), and this might be especially true for languages where semantics is increasingly subject to syntactic constraints as a result of grammatical gender. In German, for example, the semantic and grammatical gender of words describing human referents (e.g., *Frauen*fem. 'women') tend to agree (Irmen et al., 2010). This means lexical-semantic and syntactic processing difficulties may co-occur during the processing of grammatical gender.

In recent years, the use of gender-fair language as a means to advance gender equality has become grounds for heated debate. While a role-noun in the singular mostly refers to a specific person whose gender is known, role-nouns in the plural—which are frequently used in the media, job adverts, and the workplace—can be ambiguous about the intended gender. Remarkably, research examining the online processing of plural role-nouns referring to groups remains sparse. The existing work on plural role-nouns has approached the issue from the viewpoint of gender stereotypes (e.g., Irmen et al., 2010; Osterhout, McLaughlin, & Bersick, 1997), yet in gendered languages stereotype and grammatical information often coincide, requiring a systematic study of these two gender cues separately. In particular, the role of grammatical gender—particularly of masculine grammatical gender—in reference processing demands further research in order to assess whether masculine forms are as problematic in their interpretation as behavioral research suggests.

The present study investigates how masculine grammatical gender affects the online processing of differently gendered human referents. Specifically, the study aims to assess whether the masculine in the

Table 1. Example of the Sentence Stimuli and Conditions.

Grammatical gender	Continuation	Sentence example
masculine	congruent (*men*)	Die **Studenten**masc. gingen zur Mensa, weil manche der **Männer** Hunger hatten. 'The **students** went to the canteen because some of the **men** were hungry.'
	incongruent (*women*)	Die **Studenten**masc. gingen zur Mensa, weil manche der **Frauen** Hunger hatten. 'The **students** went to the canteen because some of the **women** were hungry.'
feminine	congruent (*women*)	Die **Studentinnen**fem. gingen zur Mensa, weil manche der **Frauen** Hunger hatten. 'The **students** went to the canteen because some of the **women** were hungry.'
	incongruent (*men*)	Die **Studentinnen**fem. gingen zur Mensa, weil manche der **Männer** Hunger hatten. 'The **students** went to the canteen because some of the **men** were hungry.'

plural is understood as gender-neutral (i.e., encompassing both females and males) or as specific to males, when no explicit decision making is required. Stereotypically neutral role-nouns were used to systematically focus on the effects of grammatical gender. The experimental sentences introduced a group of people via a role-noun (manipulated as grammatically masculine or feminine) and a sentence continuation specified the group as consisting in part of *men* or *women*. This meant role-noun and continuation either matched (masculine–*men*; feminine–*women*) or mismatched (masculine–*women*; feminine–*men*) in grammatical gender. Table 1 gives an example of the sentential stimuli.[1]

There is a clear grammatical gender incongruency for feminine role-nouns followed by *men* continuations. For this condition we expect processing difficulties to be reflected in larger N400 and/or P600 components when compared to the condition with feminine role-nouns followed by congruent *women* continuations. This helps establish a benchmark of the processing of incongruency between role-noun and continuation. For masculine role-nouns followed by *women* continuations, the expected congruency is less clear. Whereas the feminine is only used for female referents, the masculine is used as a default for both male and female referents. If the masculine indeed allows for a more flexible gender interpretation, a *women* continuation will not result in processing difficulties. If, however, a role-noun in the masculine favors a male-specific interpretation of the referent, masculine role-nouns followed by *women* continuations should lead to processing difficulties, resulting in similar ERP effects as those to *men* continuations after feminine role-nouns.

Methods

Participants

Twenty-four native speakers of German recruited from Radboud University's SONA system participated in this study. The sample size was based on a statistical power calculation using G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007). The estimated effect size *f* used for the power calculation was based on the partial eta-squared provided by SPSS for the N400 effect of role-noun typicality (Irmen et al., 2010). We calculated the partial eta-squared values using the actual data from Irmen et al. (2010) that we obtained from the authors (η^2_p = .18, *f* = .47). The power analysis (*F*-test, repeated measures, within factors) revealed a minimum required sample size of 20 participants to reach 80% power with alpha = 0.05. We tested 24 participants to allow for possible dropout. In total, four participants were excluded from further analysis (see the following). This resulted in a final sample of 20 participants (13 female, age range 19–29 years, *M* = 22.3, *SD* = 2.68). All participants provided written informed consent and received course credit or payment as appropriate. All had normal or corrected-to-normal vision and were right-handed. The study was approved by the local ethics committee (Commissie Mensgebonden Onderzoek, Regio Arnhem-Nijmegen).

[1]Gygax and Gabriel (2008) suggest that using materials with both feminine and masculine forms may amplify the interpretation of the masculine as specific to males, since the feminine is always specific to females. However, since we regularly encounter masculine and feminine forms in a variety of contexts, we believe inclusion of both forms in this study provides an appropriate representation of a real-life situation.

Materials and design

A total of 156 role-nouns were selected on the basis of their stereotypicality rating from a previous norming study (Misersky et al., 2014). Only role-nouns rated as stereotypically neutral in German (M = .47, SD = .08), on a scale of 1 (*stereotypically female*) and 0 (*stereotypically male*), were included in the materials. These role-nouns appeared at the beginning of the sentence, and coordinate clauses were then created. The sentence-initial role-noun introduced a group of people, and the role-noun's grammatical gender was either masculine or feminine. Later in the sentence, this group was referred to with a quantifier noun phrase: *einige* 'a few/some,' *mehrere* 'several,' *manche* 'some,' *einzelne* 'single ones,' or *viele* 'many' followed by *der Männer* 'of the men' or *der Frauen* 'of the women'; see Table 1. In addition, 80 filler items were created, half of which followed a similar format. This included coordinate clauses starting with either a gender-neutral role-noun (e.g., *die Eltern* 'the parents') or an inanimate noun (e.g., *der Streit* 'the argument'), and continued with either no coreferential word or a gender-neutral word (e.g., *die* Gruppe 'the group'). The other half of the filler items were not coordinate clauses and thus structurally different (e.g., *Nach ein paar sonnigen Tagen konnte man Knospen an den Bäumen sehen.* 'After a few sunny days, one could see buds on the trees.').

Procedure

Participants were seated in a dimly illuminated sound-attenuating testing booth. They were instructed to read sentences attentively, as they would have to answer questions about the text throughout the experiment. These instructions were presented orally by the experimenter, as well as visually on the testing PC. As eye-movements distort EEG recording, participants were asked to blink only between sentences or during breaks. Participants could speak to the experimenter using a microphone at any point during the experiment. The experiment was conducted entirely in German.

Experimental materials were presented using the Presentation software (Neurobehavioral Systems, www.neurobs.com). Each sentence was presented using word-by-word serial visual presentation in the center of a 24-inch PC monitor. The background was a dark gray with words presented in white letters (Helvetica, font size 26). The beginning of each sentence was preceded by a fixation cross (+). Each word was presented for 380 ms with a blank screen of 145 ms between words. The second and fourth word of each sentence was presented for slightly longer, i.e., 480ms, because of its longer length. Sentence-final words were followed by a full stop, then a 1,000-ms blank. Every 10 sentences, a comprehension question appeared on screen and required a *Yes* or *No* response via button press with the left or right index finger respectively. The question related to the activity referred to in the sentence; there was no repetition of the role-noun. The inter-trial-interval (ITI) was 2,000 ms during which the fixation-cross reappeared.

Participants first received nine practice sentences and then had the opportunity to ask questions about the task. Participants saw each role-noun once, resulting in 39 experimental sentences for each of the conditions (masculine–*men*, masculine–*women*, feminine–*men*, feminine–*women*). Together with the 80 fillers, this made a total of 236 sentences per participant, which were presented in a pseudorandomized order. The experiment proper was split into four blocks of 59 trials. There were self-paced pauses between blocks where a drink of water was offered to the participant.

EEG recording

Continuous EEG was recorded from 32 active electrodes (10–20 system) attached to an elastic cap (actiCAP), with a BrainAmp DC amplifier (Brain Products, Gilching, Germany). The signal was sampled at 500 Hz. One electrode in the cap provided an active ground. Electrooculogram (EOG) was recorded from electrodes above and below the eye and at the outer canthi of the eyes. Electrode impedances were kept below 20 kΩ.

Data analysis

The data was preprocessed using the FieldTrip toolbox for EEG/MEG-analysis (www.fieldtriptoolbox.org, Oostenveld, Fries, Maris, & Schoffelen, 2011) in MATLAB. Segments ranging from before 200 ms until after 1,000 ms continuation onset (*men, women*) were chosen for further analysis. Off-line-filtering included a low-pass filter at 35 Hz and a high-pass filter at 0.1 Hz. The data were then inspected visually, and trials showing electrode jumps or drifting were removed in preparation for an independent component analysis (ICA). ICA was performed to remove remaining EOG and/or ECG artifacts from the data. All EEG channels were then rereferenced to the average of the signal of both mastoids (Luck, 2014). A baseline correction was applied in which the signal was normalized relative to a 200-ms stimulus-preceding window. Trials containing signal exceeding ± 75 μV were removed, and mean ERP amplitudes for the time windows of interest were calculated. The data sets of two participants were excluded from further analysis, since fewer than 29 trials per condition (< 75 percent) remained after preprocessing. The average number of trials kept per condition for the remaining participants was 34.7 (M = 89%, range 34.4 to 34.8 trials across all conditions). A further two data sets were excluded due to participants' performance on the content questions that resulted in accuracy at or below chance. Further analyses confirmed that trial rejection did not introduce differences between the means for the stereotypicality ratings of the role-nouns in each condition (range .465 to .468; p = .904).

Mean ERP amplitudes were statistically analyzed in two main time windows after the onset of the continuation noun; 300 to 500 ms for the N400, and 500 to 800 ms for the P600 (following Irmen et al., 2010; Osterhout et al., 1997) using SPSS. As in Irmen et al. (2010), nine electrodes in anterior, central, and posterior positions of the left and right hemisphere and the midline were used (F3/z/4, C3/z/4, P3/z/4).

The mean amplitudes of the ERPs for the time windows of interest were then subjected to a repeated-measures ANOVA, with Grammatical Gender of role-noun (masculine, feminine), Continuation (congruent, incongruent), Anteriority (anterior, central, posterior), and Laterality (left, midline, right) as within-subject factors. An alpha level of .05 was used for all statistical tests. Only the effects of Grammatical Gender, Continuation, and their interaction with the other factors (Anteriority, Laterality) are of relevance for our experimental question, so only those effects will be reported. When significant Grammatical Gender by Continuation interactions were found, separate ANOVAs were performed for each Grammatical Gender condition. Where interactions between Grammatical Gender or Continuation and the topographic factors (Laterality, Anteriority) were significant, ANOVAs on the relevant electrode groups were carried out separately.

Results

Behavioral results

Participants correctly answered the comprehension questions with high accuracy (M = 99.18% correct, SD = 3.26), indicating they understood the task and read the sentences attentively throughout the experiment.

ERP results

After both feminine and masculine role-nouns, a positive shift in the ERP was seen for incongruent continuations compared to congruent ones (see Figure 1 for continuations following the feminine role-nouns and Figure 2 for continuations following the masculine role-nouns; for illustrative purposes only, the grand-average ERPs were smoothed off-line using a 5 Hz low-pass filter). As defined beforehand, the mean amplitudes of the N400 (300 to 500 ms) and P600 (500 to 800 ms) time windows were compared statistically.

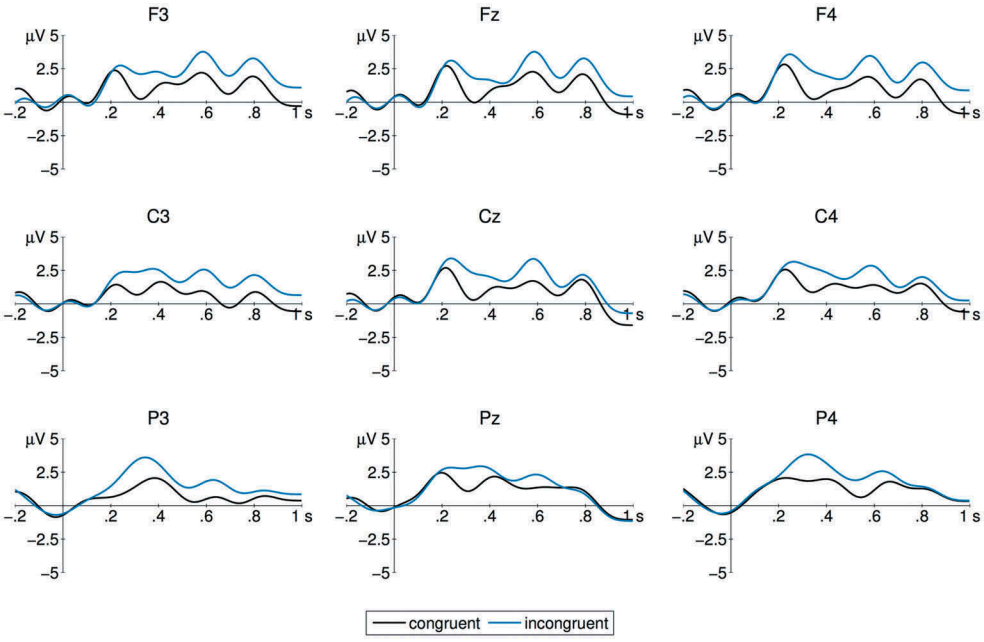

Figure 1. Congruency effect after feminine role-nouns. ERPs time-locked to the onset of continuations (men, women) following a role-noun with feminine grammatical gender at six electrode sites (F3, Fz, F4, C3, Cz, C4, P3, Pz, P4). Congruent (women) continuations are in black, incongruent (men) continuations are in blue. Negativity is plotted downward.

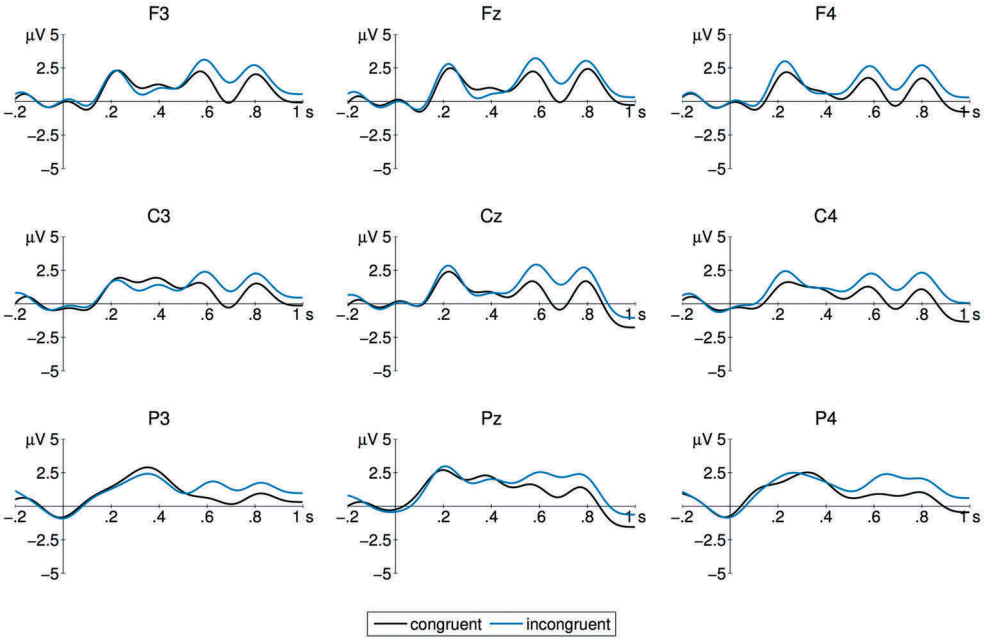

Figure 2. Congruency effect after masculine role-nouns. ERPs time-locked to the onset of continuations (men, women) following a role-noun with masculine grammatical gender at six electrode sites (F3, Fz, F4, C3, Cz, C4, P3, Pz, P4). Congruent (men) continuations are in black, incongruent (women) continuations are in blue. Negativity is plotted downward.

300 to 500 ms time window

In the 300 to 500 ms time window there were no main effects of Grammatical Gender, $F(1,15) = 3.718$, $p = .073$, $\eta_p^2 = .199$, or Continuation, $F(1,15) = 2.228$, $p = .156$, $\eta_p^2 = .129$, but there was an interaction between Grammatical Gender and Continuation, $F(1,15) = 5.828$, $p = .029$, $\eta_p^2 = .280$ (see Figure 3, top).

For role-nouns with feminine grammatical gender, responses to congruent Continuations differed significantly from those to incongruent ones, $F(1,15) = 4.783$, $p = .045$, $\eta_p^2 = .242$. Incongruent Continuations elicited more positive responses ($M = 2.295$ μV, $SEM = .436$) compared to congruent Continuations ($M = 1.180$ μV, $SEM = .469$). The effect was equally distributed over electrode sites, $F_{\text{Continuation} \times \text{Anteriority}}(2,30) = .025$, $p = .975$, $\eta_p^2 = .002$; $F_{\text{Continuation} \times \text{Laterality}}(2,30) = .739$, $p = .486$, $\eta_p^2 = .047$; $F_{\text{Continuation} \times \text{Anteriority} \times \text{Laterality}}(4,60) = .751$, $p = .561$, $\eta_p^2 = .048$.

For role-nouns with masculine Grammatical Gender, there was no significant difference between congruent ($M = 1.231$ μV, $SEM = .418$) and incongruent ($M = 1.185$ μV, $SEM = .365$) continuations, $F(1,15) = .019$, $p = .891$, $\eta_p^2 = .001$, and no interactions between Continuation and Anteriority, $F(2,30) = .028$, $p = .973$, $\eta_p^2 = .002$, or Continuation and Laterality, $F(2,30) = 1.601$, $p = .218$, $\eta_p^2 = .096$.

500 to 800 ms time window

Analysis of the 500 to 800 ms time window showed a main effect of Continuation, $F(1,15) = 5.133$, $p = .039$, $\eta_p^2 = .255$. Regardless of the Grammatical Gender of the role-noun, incongruent Continuations elicited significantly more positive responses ($M = 2.094$ μV, $SEM = .461$) compared to congruent Continuations ($M = 1.074$ μV, $SEM = .316$, see Figure 3, bottom). The effect was equally distributed over electrode sites, $F_{\text{Continuation} \times \text{Anteriority}}(2,30) = .811$, $p = .454$, $\eta_p^2 = .051$; $F_{\text{Continuation} \times \text{Laterality}}(2,30) = .223$, $p = .802$, $\eta_p^2 = .015$; $F_{\text{Continuation} \times \text{Anteriority} \times \text{Laterality}}(4,60) = .403$, $p = .806$, $\eta_p^2 = .026$.

Crucially, there was no interaction between Grammatical Gender and Continuation in this time window, $F(1,15) = .081$, $p = .780$, $\eta_p^2 = .005$, indicating that the Continuation of *women* after masculine role-nouns elicited an incongruency effect that was just as large as the continuation of *men* after feminine role-nouns (see Figure 3, bottom). There were also no interactions between Grammatical Gender, Continuation, and the topographic factors, $F_{\text{GrammaticalGender} \times \text{Continuation} \times \text{Anteriority}}(2,30) = .298$, $p = .744$, $\eta_p^2 = .020$; $F_{\text{GrammaticalGender} \times \text{Continuation} \times \text{Laterality}}(2,30) = 1.366$, $p = .271$, $\eta_p^2 = .083$; $F_{\text{GrammaticalGender} \times \text{Continuation} \times \text{Anteriority} \times \text{Laterality}}(4,60) = .752$, $p = .561$, $\eta_p^2 = 0.48$.

Discussion

The present study assessed how grammatical gender affects referent processing. More specifically, the study focused on how grammatically masculine role-nouns, which are used for males—but also for mixed-gender groups—influence the processing of differently gendered referents when no explicit decision making is required. Based on the previous literature, we reasoned that if readers encounter processing difficulties due to the interpretation of grammatical gender, then this should result in changes in the ERPs during the N400 and P600 time windows and thereby shed light on the underlying processing mechanisms. Accordingly, when exposed to an incongruency following a grammatically feminine role-noun (feminine–*men*), we found a positive shift in the ERPs in both the 300 to 500 ms and the 500 to 800 ms time windows. Critically, for an incongruency following a grammatically masculine role noun (masculine–*women*), a positive shift was only present in the 500 to 800 ms time window.

In the 300 to 500 ms time window, incongruent continuations elicited a positive shift for the *men* continuations after feminine role nouns only. This positive shift is unlikely to be a reflection of an N400 response but is possibly a P300-like effect similar to the one that has been found previously by Siyanova-Chanturia, Pesciarelli and Cacciari (2012). Their study was in Italian, which is also a gendered language. Using only word-pairs, Siyanova-Chanturia,

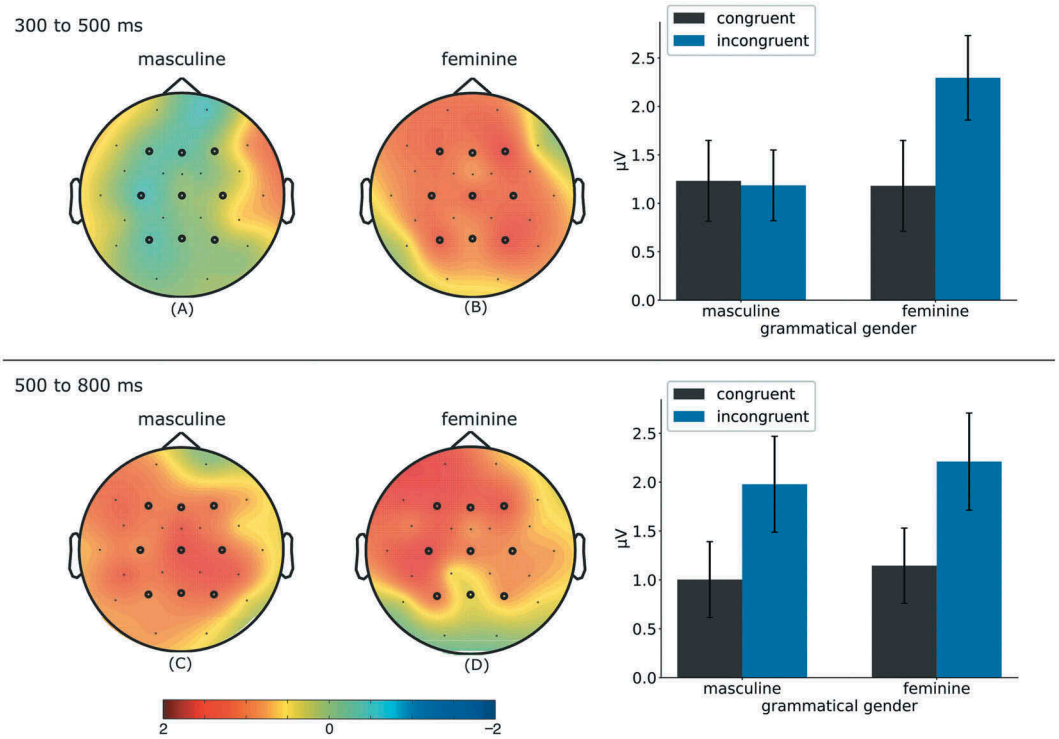

Figure 3. Top: Topography of differences of ERPs between congruent and incongruent. Continuations for (a) masculine role-nouns and (b) feminine role-nouns and mean amplitudes for the 300 to 500 ms time window; bar chart reflects the mean amplitudes in the 300 to 500 ms time window as a factor of Grammatical Gender (masculine vs. feminine) and Continuation (men vs. women) ± 1 SEM. Bottom: Topography of differences of ERPs between congruent and incongruent continuations for (c) masculine role-nouns and (d) feminine role-nouns and mean amplitudes for the 500 to 800 ms time window; bar chart reflects the mean amplitudes in the 500 to 800 ms time window as a factor of Grammatical Gender (masculine vs. feminine) and Continuation (men vs. women) ± 1 SEM.Black circles give the electrodes included in the statistical analysis.

Pesciarelli, and Cacciari (2012) examined the processing of pronouns (*lei* 'she'/*lui* 'he') following stereotypically gendered (e.g., *insegnante*masc./fem. 'teacher') and grammatically gendered (e.g., *pensionato*masc. 'pensioner') role-nouns. For female participants, they observed positive responses to incongruencies between grammatically gendered roles and pronouns and interpreted this effect as P300-like.

The P300 has been linked to stimulus evaluation (Kutas & Hillyard, 1980a, 1980b) and is sensitive to the evaluation being task-relevant (Holcomb, 1988). In line with this, Siyanova-Chanturia et al. (2012) attributed their findings to decision-making processes of the participants required by the experiment. Unlike Siyanova-Chanturia et al. (2012), the present study used full sentences. Additionally, participants did not need to explicitly evaluate the continuations but did have to occasionally answer questions about the sentence content. Upon reading a role-noun in the masculine, participants may have had a broader set of possible interpretations (i.e., the sentence could have been about males, females, or a mixed-gender group of referents) compared to when they read a role-noun in the feminine, which always denotes female referents. As such, possible interpretations may have been narrowed down in the feminine condition already in the earlier time window, leading to the observed differential processing patterns. For the masculine role noun, the lack of early processing difficulties suggests a generic interpretation, at least in this early time window.

Regardless of the grammatical gender of the role noun, incongruent continuations resulted in a more positive response relative to congruent continuations in the 500 to 800 ms time window. This result likely reflects a P600 effect, indicating participants encountered processing difficulties upon

reading *women* when preceded by a grammatically masculine role-noun and upon reading *men* when preceded by a grammatically feminine role-noun. This P600 effect is similar to the P600 found by Hammer et al. (2005) for mismatches in both the biological and the grammatical gender of singular role-nouns and coreferential pronouns in a sentential context. In Hammer et al.'s experiments (2005, 2008), the singular role-nouns often mentioned a person whose gender was known (e.g., *die Frau*fem. 'the woman'). In contrast, our study focused on role-nouns in the plural where the referent gender was genuinely ambiguous. Regardless, we found a clear P600 effect similar to Hammer et al. (2005, 2008).

Our stimuli manipulated the syntactic presentation of role-nouns in the absence of stereotypical gender information. In line with previous research (Hagoort, Brown, & Osterhout, 1999; Van Berkum, Koornneef, Otten, & Nieuwland, 2007), participants may have had a syntactic expectation based on the role-noun they read (i.e., a preference for the role-noun and continuation to match in terms of grammatical gender). Thus, the effects in our study may reflect a violation of participants' preferences for the upcoming syntactic category of the coreferential continuation.

Our results fit well with the Garrod and Terras (2000) two-stage reference processing model (see also Irmen et al., 2010). During an initial bonding stage, we propose that each continuation was linked to the role-noun by an automatic process. The positive ERP amplitude in the 300 to 500 ms time window of the incongruent continuations following a feminine role-noun was likely due to the feminine effectively constraining processing early on. For role-nouns in the masculine, however, all continuations were processed similarly in this early time window. The absence of differential processing in this initial stage could be the result of the masculine form being pragmatically used to describe mixed-gender groups. Only later, during the reference resolution stage, did incongruent continuations lead to processing difficulties. Importantly, in this later time window there was no difference between the two grammatical gender conditions, suggesting that both masculine and feminine forms were interpreted as similarly specific to men and women referents respectively. The increased processing difficulties seen in the later time window could be the result of situational updating during the reference resolution stage (Burkhardt, 2006; Ferretti, Singer, & Harwood, 2013). Further, these results hark to findings from behavioral studies (Gygax et al., 2008; Vervecken & Hannover, 2015), suggesting that the processing during this reference resolution stage may underlie the interpretational decision-making patterns previously observed.

To summarize, the observed pattern of effects suggests that readers' interpretation was guided by the grammatical gender of the role-noun during the processing of sentences. A role-noun in the feminine led to differential processing for *men* and *women* continuations early in comprehension. The potential mismatch between *women* continuations following a masculine went unnoticed during initial processing. This suggests that the feminine effectively constrains the possible future referents, while the masculine does not. However, this same mismatch between *women* continuations following a masculine resulted in processing difficulties later, when different cues to referent gender have to be integrated (Irmen et al., 2010). Crucially, the results suggest that *women* continuations after a masculine role-noun are less easily integrated than *men* continuations (500 to 800 ms time window) but might not be perceived as a mismatch per se (300 to 500 ms time window). So readers seem to be biased in interpreting the grammatically masculine form as male-specific, despite it being used regularly to refer to both females and males.

Masculine role-nouns are pragmatically common and regularly used in society for mixed-gender groups. Indeed, the lack of early processing difficulties speaks against a strong bias in favor of a male representation. However, the results from the later time window do indicate that participants had difficulties integrating *women* with a masculine role-noun. Our findings are thus in line with behavioral research in this field, implying that the masculine form does not represent genders equally in German.

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References

Barber, H., & Carreiras, M. (2005). Grammatical gender and number agreement in Spanish: An ERP comparison. *Journal of Cognitive Neuroscience*, *17*(1), 137–153. doi:10.1162/0898929052880101

Burkhardt, P. (2006). Inferential bridging relations reveal distinct neural mechanisms: Evidence from event-related brain potentials. *Brain and Language*, *98*(2), 159–168. doi:10.1016/j.bandl.2006.04.005

Caffarra, S., Siyanova-Chanturia, A., Pesciarelli, F., Vespignani, F., & Cacciari, C. (2015). Is the noun ending a cue to grammatical gender processing? An ERP study on sentences in Italian. *Psychophysiology*, *52*(8), 1019–1030. doi:10.1111/psyp.12429

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. doi:10.3758/BF03193146

Ferretti, T. R., Singer, M., & Harwood, J. (2013). Processes of discourse integration: Evidence from event-related brain potentials. *Discourse Processes*, *50*(3), 165–186. doi:10.1080/0163853X.2013.766123

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. doi:10.1006/jmla.1999.2694

Gygax, P. M., & Gabriel, U. (2008). Can a group of musicians be composed of women? Generic interpretation of French masculine role names in the absence and presence of feminine forms. *Swiss Journal of Psychology*, *67*(3), 143–151. doi:10.1024/1421-0185.67.3.143

Gygax, P. M., Gabriel, U., Sarrasin, O., Oakhill, J., & Garnham, A. (2008). Generically intended, but specifically interpreted: When beauticians, musicians, and mechanics are all men. *Language and Cognitive Processes*, *23*(3), 464–485. doi:10.1080/01690960701702035

Hagoort, P., Brown, C. M., & Osterhout, L. (1999). The neurocognition of syntactic processing. In C. M. Brown & P. Hagoort (Eds.), *The neurocognition of language* (pp. 273–317). Oxford: Oxford University Press.

Hammer, A., Jansma, B. M., Lamers, M., & Münte, T. F. (2005). Pronominal reference in sentences about persons or things: An electrophysiological approach. *Journal of Cognitive Neuroscience*, *17*(2), 227–239. doi:10.1162/0898929053124947

Hammer, A., Jansma, B. M., Lamers, M., & Münte, T. F. (2008). Interplay of meaning, syntax and working memory during pronoun resolution investigated by ERPs. *Brain Research*, *1230*, 177–191. doi:10.1016/j.brainres.2008.07.004

Holcomb, P. J. (1988). Automatic and attentional processing: An event-related brain potential analysis of semantic priming. *Brain and Language*, *35*(1), 66–85.

Irmen, L., Holt, D. V., & Weisbrod, M. (2010). Effects of role typicality on processing person information in German: Evidence from an ERP study. *Brain Research*, *1353*, 133–144. doi:10.1016/j.brainres.2010.07.018

Irmen, L., & Roßberg, N. (2004). Gender markedness of language: The impact of grammatical and nonlinguistic information on the mental representation of person information. *Journal of Language and Social Psychology*, *23*(3), 272–307. doi:10.1177/0261927X04266810

Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: Finding meaning in the N400 component of the event-related brain potential (ERP). *Annual Review of Psychology*, *62*, 621–647.

Kutas, M., & Hillyard, S. A. (1980a). Event-related brain potentials to semantically inappropriate and surprisingly large words. *Biological Psychology*, *11*(2), 99–116. doi:10.1016/0301-0511(80)90046-0

Kutas, M., & Hillyard, S. A. (1980b). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science*, *207*(4427), 203–205. doi:10.1126/science.7350657

Luck, S. J. (2014). *An introduction to the event-related potential technique*. Cambridge, Massachusetts: The MIT press.

Misersky, J., Gygax, P. M., Canal, P., Gabriel, U., Garnham, A., Braun, F., … Sczesny, S. (2014). Norms on the gender perception of role-nouns in Czech, English, French, German, Italian, Norwegian, and Slovak. *Behavior Research Methods*, *46*(3), 841–871. doi:10.3758/s13428-013-0409-z

Oostenveld, R., Fries, P., Maris, E., & Schoffelen, J.-M. (2011). FieldTrip: Open source software for advanced analysis of MEG, EEG, and invasive electrophysiological data. *Computational Intelligence and Neuroscience*, *2011*, 9. doi:10.1155/2011/156869

Osterhout, L., Bersick, M., & McLaughlin, J. (1997). Brain potentials reflect incongruencies of gender stereotypes. *Memory & Cognition*, *25*(3), 273–285. doi:10.3758/BF03211283

Osterhout, L., & Holcomb, P. J. (1992). Event-related brain potentials elicited by syntactic anomaly. *Journal of Memory and Language*, *31*(6), 785–806.

Osterhout, L., McLaughlin, J., & Bersick, M. (1997). Event-related brain potentials and human language. *Trends in Cognitive Sciences*, *1*(6), 203–209. doi:10.1016/S1364-6613(97)01073-5

Sato, S., Gygax, P. M., & Gabriel, U. (2013). Gender inferences: Grammatical features and their impact on the representation of gender in bilinguals. *Bilingualism: Language and Cognition*, *16*(4), 792–807. doi:10.1017/S1366728912000739

Schmitt, B. M., Lamers, M., & Münte, T. F. (2002). Electrophysiological estimates of biological and syntactic gender violation during pronoun processing. *Cognitive Brain Research*, *14*(3), 333–346.

Siyanova-Chanturia, A., Pesciarelli, F., & Cacciari, C. (2012). The electrophysiological underpinnings of processing gender stereotypes in language. *PloS ONE*, *7*(12), 1–11. doi:10.1371/journal.pone.0048712

Stahlberg, D., Braun, F., Irmen, L., & Sczesny, S. (2007). Representation of the sexes in language. In K. Fiedler (Ed.), *Social communication* (pp. 163–187). New York, NY: Psychology.

Van Berkum, J. J., Koornneef, A. W., Otten, M., & Nieuwland, M. S. (2007). Establishing reference in language comprehension: An electrophysiological perspective. *Brain Research*, *1146*, 158–171. doi:10.1016/j.brainres.2006.06.091

Vervecken, D., Gygax, P. M., Gabriel, U., Guillod, M., & Hannover, B. (2015). Warmhearted businessmen, competitive housewives? Effects of gender-fair language on adolescents' perceptions of occupations. *Frontiers in Psychology*, *6*, 1–10. doi:10.3389/fpsyg.2015.00001

Vervecken, D., & Hannover, B. (2015). Yes I can! Effects of gender fair job descriptions on children's perceptions of job status, job difficulty, and vocational self-efficacy. *Social Psychology*, *46*(2), 76–92. doi:10.1027/1864-9335/a000229

White, K. R., Crites, S. L., Taylor, J. H., & Corral, G. (2009). Wait, what? Assessing stereotype incongruities using the N400 ERP component. *Social Cognitive and Affective Neuroscience*, *4*, 191–198. doi:10.1093/scan/nsp004