



## Short Communication

## Stereotypes override grammar: Social knowledge in sentence comprehension

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## ABSTRACT

Many studies have provided evidence for the automaticity and immediacy with which stereotypical knowledge affects our behavior. However, less is known about how such social knowledge interacts with linguistic cues during comprehension. In this ERP sentence processing study we took advantage of the rich grammatical gender morphology of Spanish to explore the processing of role nouns in which stereotype and grammatical cues were simultaneously manipulated, in a factorial design. We show that stereotypical knowledge overrides syntactic cues, highlighting the immediacy with which stereotype knowledge is activated during language comprehension and supporting proposals claiming that social knowledge impacts on language processing differently from other forms of semantics.

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## 1. Introduction

Many words are associated to gender-oriented stereotypes, i.e., beliefs concerning the gender properties of certain social groups (English: Banaji & Hardin, 1996; Kreiner, Sturt, & Garrod, 2008; Spanish: Carreiras, Garnham, Oakhill, & Cain, 1996; German: Irmen & Roßberg, 2004). Stereotypical knowledge is automatically activated (and difficult to inhibit) for words referring to people (*nurse, doctor*; Oakhill, Garnham, & Reynolds, 2005), but also for object entities (*bikini, cigar*; Garnham, Oakhill, & Reynolds, 2002) and adjectives (*aggressive, nurturing*; White, Crites, Taylor, & Corral, 2009). Many studies have shown that the activation of stereotypical knowledge is immediate and not based on conscious inferences (Carreiras et al., 1996; Garnham et al., 2002). Nonetheless, the influence that stereotypical cues exert on language processing is still a matter of debate. In fact, while a high number of studies have focused on the interaction between other sources of semantic knowledge and syntactic information during language processing (e.g., Osterhout & Nicol, 1999), it is unknown how simultaneous stereotypical and syntactic cues modulate language comprehension processes. Interestingly, the distinction between stereotypes and other types of semantic knowledge is mainly

motivated by the fact that the brain processes information about categories of objects and living things (i.e., semantic knowledge) differently from information about categories of people (i.e., stereotypes; Contreras, Banaji, & Mitchell, 2012, and references therein). In the present study, we employed event-related potentials (ERPs) to evaluate the processing of stereotypes and of morphosyntactic cues.

Previous studies on stereotype processing during sentence comprehension have focused on anaphoric constructions. Osterhout, Bersick, and McLaughlin (1997) reported qualitatively similar ERP effects for pronouns mismatching with either the gender definition (*mother, father*) or the gender stereotype (*nurse, doctor*) of the previous antecedent. They reported increased positive amplitude shifts starting after 600 ms in the posterior scalp regions that they identified as P600s (similar results in Canal, Garnham, & Oakhill, 2015; Su et al., 2016). While some authors have claimed that the P600 reflects syntactic processing (e.g., Kim & Osterhout, 2005), recent views suggest that it can reflect more general language integration (e.g., Brouwer, Fitz, & Hoeks, 2012), repair and reanalysis (e.g., Friederici, 2011) or more general conflict monitoring (e.g., van de Meerendonk, Kolk, Vissers, & Chwilla, 2010; for a review Kuperberg, 2007). Independently of the functional interpretation of the P600 effect, the similar ERP correlates observed for stereotypical and definitional gender led Osterhout et al. (1997) to conclude that stereotypical cues syntactically constrain pronoun resolution (see similar claims by Esaulova, Reali, & von Stockhausen, 2014).

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Osterhout et al.'s (1997) conclusions were mainly driven by the fact that no semantic-related ERP effect was observed for the stereotypical condition, in which world-knowledge inferences (known to elicit semantic ERP correlates such as the N400, Hagoort, Hald, Bastiaansen, & Petersson, 2004) could potentially have driven pronoun resolution processes. A number of studies have indeed reported stereotype-related modulations of the N400 ERP component triggered by isolated role nouns in semantic priming paradigms (e.g., Siyanova-Chanturia, Pesciarelli, & Cacciari, 2012). The N400 is a negative-amplitude deflection around 400 ms, more evident in right posterior brain regions (Kutas & Hillyard, 1984). It is sensitive to a large number of lexical-semantic parameters and has also been associated to stereotype congruity. White et al. (2009), for example, reported a stereotype-related negativity and interpreted this as a N400 effect even though the distribution of the effect was evident across the whole scalp, including anterior electrodes.

Potential explanations for the lack of the N400 effect in Osterhout et al. (1997) rely on the fact that the authors did not estimate stereotype processing by focusing on the ERPs time-locked to the role noun, but to a distant pronoun. Given that previous behavioral studies have shown the immediacy with which stereotypical knowledge is activated upon reading a word (Carreiras et al., 1996; Garnham et al., 2002), it is relevant to evaluate the ERP correlates time-locked to a stereotypical target word. As an example, in an eye-tracking experiment, Kreiner et al. (2008) observed processing differences between definitional and stereotypical gender in cataphoric (but not in anaphoric) constructions in which pronouns preceded the stereotypical nouns where the experimental effects were measured.

In contrast to previous studies that separately compared stereotypical and definitional anaphoric mismatches, we here analyzed the ERP correlates triggered by the reading of stereotypically-biased role nouns, while manipulating the gender of the target word (identified by the noun ending) and the syntactic context preceding the target word (the gender marked determiner). We followed the rationale of ERP studies that evaluate the interaction between syntactic and semantic mismatches in a factorial design. The literature focusing on the interaction between syntax and semantics has observed dissociable ERP correlates for semantic and syntactic violations. The double mismatch condition has either confirmed the independence and autonomy between semantic and syntactic processing, showing additive effects (Gunter, Friederici, & Schriefers, 2000; Osterhout & Nicol, 1999) or has provided evidence for the vulnerability of the semantic processor to syntactic cues, but not the opposite (Hagoort, 2003). Martin-Loeches, Nigbur, Casado, Hohlfeld, and Sommer (2006) proposed the relative prevalence of semantics over syntax in Spanish (the language investigated in the present experiment). However, they reported qualitatively different effects for syntactic and semantic errors and an additive effect for the double anomaly when considering the pre-stimulus ERP baseline (as Osterhout & Nicol, 1999).

Brain sensitivity to the stereotypicality of the target word is studied in the present experiment by manipulating the role noun ending (congruent: *miner-os*, male miners; incongruent: *miner-as*, female miners). The syntactic context is manipulated by taking advantage of the gender markedness of the Spanish article, so that it could agree with a following role noun (... *los mineros*..., the<sub>[+m]</sub> male miners) or not (... *las mineros*..., the<sub>[+f]</sub> female miners). The double anomaly condition (... *los mineras*..., the<sub>[+m]</sub> female miners) will provide additional evidence about the interaction between stereotypical and syntactic cues during language comprehension (see Table 1).

We contrasted two possible outcomes for the present experiment. On the one hand, stereotypical knowledge could be processed in the same way as other sources of semantic knowledge,

**Table 1**

Example of the experimental sentences. The target stereotypical role noun is underlined in bold.

Condition	Example sentences
Control (stereotypically congruent/syntactic agreement)	Ayer, <b>los mineros</b> fueron a una cena para celebrar el fin de la asamblea Yesterday, the <sub>[+m]</sub> (male) miners went to a dinner for the celebration of the end of an assembly
Stereotypically incongruent (and syntactic agreement)	Ayer, <b>las mineras</b> fueron a una cena para celebrar el fin de la asamblea Yesterday, the <sub>[+f]</sub> (female) miners went...
Syntactic violation (and stereotypically congruent)	*Ayer, <b>las mineros</b> fueron a una cena para celebrar el fin de la asamblea *Yesterday, the <sub>[+f]</sub> (male) miners went...
Double anomaly (stereotypically incongruent/syntactic violation)	*Ayer, <b>los mineras</b> fueron a una cena para celebrar el fin de la asamblea. *Yesterday, the <sub>[+m]</sub> (female) miners went...

so that we should observe a relative independence between the ERP effects elicited by grammatical and stereotypical anomalies (Gunter et al., 2000; Martin-Loeches et al., 2006; Osterhout & Nicol, 1999; but also see Hagoort, 2003). We would therefore expect different ERP correlates for the stereotypicality and the syntactic manipulations, i.e., an increased N400-like effect for stereotypes (White et al., 2009), and for grammatical anomalies a P600 that could be preceded by an Left Anterior scalp distributed Negativity (LAN) around 400 ms, an ERP correlate typically observed for morphosyntactic anomalies in morphology-rich languages (Barber & Carreiras, 2005; Molinaro, Barber, Caffarra, & Carreiras, 2015; Molinaro, Barber, & Carreiras, 2011a; Molinaro, Vespignani, & Job, 2008; Molinaro, Vespignani, Zamparelli, & Job, 2011b). This last prediction is motivated by previous studies which employed a similar linguistic construction (determiner-noun gender agreement error involving animate nouns, e.g., Sabourin & Stowe, 2008) and by previous research on stereotypes involving gender agreement mismatches (Canal et al., 2015; Osterhout et al., 1997; Su et al., 2016). In the double anomaly condition, additive ERP effects could be observed (Gunter et al., 2000; Martin-Loeches et al., 2006; Osterhout & Nicol, 1999).

On the other hand, if we take to the extreme the “immediacy hypothesis” discussed by some authors (Carreiras et al., 1996; Garnham et al., 2002), stereotypical knowledge (activated by the word stem *miner-*, male stereotyped) could possibly have more weight than other forms of linguistic cues. In this case, we would expect that any incongruence with the stereotypical gender of the role noun (i.e., either morphological, the noun ending *-as*, or syntactic, the previous gender marked determiner, *las*) would trigger a similar brain reaction. Plausibly, this effect would be the N400-like effect observed for isolated word stereotypical processing (White et al., 2009). Under this assumption, no syntactic ERP correlates should be observed (i.e., LAN and P600) even in sentences involving grammatical errors.

Twenty-four native Spanish speakers took part in the EEG session (half female). They attentively read sentences (Table 1) and answered comprehension questions after one third of the trials. We analyzed ERP responses in specific time windows of interest time-locked to target noun presentation. The statistics focused on the following factors for the four-way ANOVAs in each time interval: StereoCong (congruent vs. incongruent), GenAgree (agreement vs. disagreement), Hemisphere (three levels: left electrode group, medial group, right group) and Latitude (three levels: anterior electrode group, central group, posterior group). Post-hoc FDR corrected comparisons focused on the comparison between each anomalous condition and the control (see Table 1). For further details see Section 4.

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