Predictability affects both pronoun production and interpretation: evidence from an interactive task

When do speakers decide to use a personal pronoun, like 'she', instead of a full referential expression, like 'Rosalía' or 'the singer in white'? What then guides the interpretation of these alternative expressions? Two factors have been examined: contextual factors that impact the predictability of the pronominal referent (i.e., how obvious it is that we are talking about Rosalía) and the grammatical properties of the pronominal antecedent (Kehler & Rohde, 2013). While there is consensus that grammatical function impacts both production and interpretation, it is less clear whether predictability equally affects both speaker and listener. Previous studies have focused on either interpretation or production, mainly through Discourse Completion Tasks (Weatherford & Arnold, 2021; Kehler & Rohde 2013; Fukuruma & van Gompel, 2010), but no study has tested the effects of referent predictability and grammatical role in a truly interactive setting, where speakers and listeners have a pressure for efficient communication. Using such an interactive setup, we find that both contextual and grammatical factors play a role in pronoun interpretation and production.

Background Three main models of pronoun use have been proposed. The Bayesian Model (Kehler et al. 2008) links production and interpretation through Bayesian principles, proposing that pronoun interpretation is affected both by the predictability of the referent (*predictability bias*) and by the likelihood that a pronoun is used to refer to that referent (*production bias*). In addition, in its strong form, it predicts that these two biases are influenced by different types of factors: while the production bias is influenced by structural factors, it is not affected by contextual factors that do affect the predictability bias. As a result, pronoun production is not expected to be affected by contextual factors. The Bayesian Model contrasts with models that only use one of the two biases. According to the Mirror Model (e.g., Ariel 1990), production and interpretation mirror each other: interpretation is mostly driven by the production bias and interpreters understand pronoun by taking into account which entities the speaker would most likely refer by using a pronoun. Finally, the Expectancy Model (Arnold, 2001) posits that interpreters mostly use the predictability bias to interpret a pronoun and that, in turn, more predictable entities are more likely to be pronominalized. Under this view, both predictability and pronoun production are affected by contextual factors.

Most evidence for these theories relies on Discourse Completion experiments, where participants read a prompt (sometimes starting with a pronoun) and provide a continuation. Here, we introduce a novel methodology in which participants must produce and interpret referring expressions to communicate quickly and accurately. Our goal is to explore the factors influencing pronominal use in an interactive setup that more closely mimics naturalistic scenarios. Specifically, we test whether pressures for communicative efficiency cause referent predictability to influence not only pronominal interpretation, but also production, contrary to the Bayesian Model. Using Spanish, we compare null pronouns (a maximally reduced form) with full DPs and evaluate whether the likelihood of producing a null pronoun is partly determined by the referent predictability, or only by structural considerations, such as the grammatical role of the pronominal antecedent.

A. Main transitive event
El hombre de gorro moja al de gafas.
The man with the hat gets the one with glasses wet.

B. Production of continuation
Select a description for the continuation.
El hombre de gafas tiembla. | Tiembla.
The man with glasses shakes. | *He shakes.*

C. Interpretation of continuation
El hombre de gorro moja al de gafas. **Tiembla.**
The man with the hat gets the one with glasses wet. ***He shakes.***
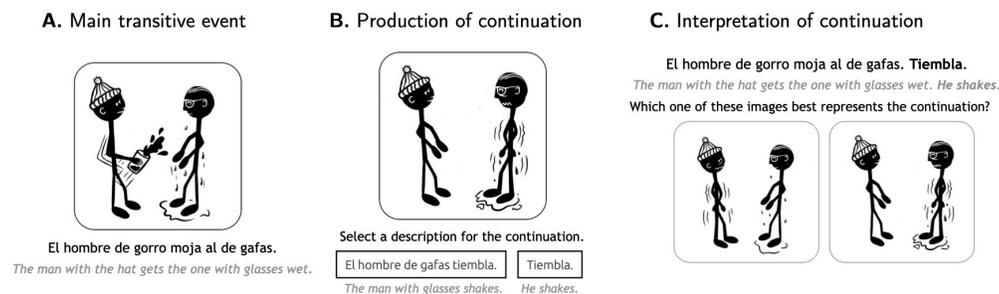Which one of these images best represents the continuation?

Figure 1: Illustration of Trials

Method. Spanish-speaking participants (N=140) were paired to play a communication game (pre-registered here), in which they either played the role of director or matcher. Both participants first saw a picture with one character (subject) doing something to another character (non-subject), accompanied by a descriptive

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A. Production

Grammatical Role of the antecedent
Subject   Non-Subject

Selection of null pronoun

Predicted Referent in the Context

B. Interpretation

Referent matching the subject
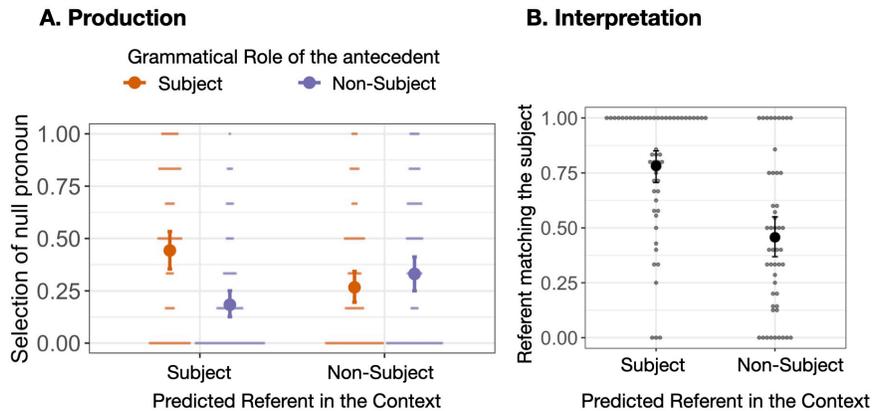
Predicted Referent in the Context

Figure 2: Results

sentence; the *main transitive* event (Fig. 1A). Directors then saw another vignette that continued the story (the *continuation story* event) and had to convey the continuation to their partner by choosing between two sentences: one with a full DP and one with a null pronoun (Fig. 1B). To send a message, the director had to click a button a number of times proportional to the length of the message, making messages with nulls faster and less costly. After the director made a choice, the message appeared letter-by-letter on the matcher's screen, followed by two images differing in whether the agent corresponded to the subject or the non-subject of the main transitive event (Fig. 1C). The matcher had to decide which of the two images matched the director's message. After each trial, participants received feedback on accuracy and message length. They had been instructed to perform the task as accurately and fast as possible, and bonuses rewarded fast correct answers. The experiment included 24 trials and manipulated (a) whether the character doing the action in the continuation story was the subject or the non-subject of the main transitive event (Grammatical Role), and (b) whether this character was the more predictable one (Referent Predictability). The predictability of the referent was determined through a norming experiment, where participants viewed a vignette and then had to select the most likely continuation between two vignettes differing on the character doing the action.

Results. Fig. 2A shows the proportion of responses where participants in the production experiment selected the null pronoun continuation, as a function of the Grammatical Role of the antecedent and Referent Predictability. Results from a logistic mixed-effects regression reveal an interaction between Grammatical Role and Referent Predictability in participants' responses ($\beta = 0.54; z = 9.3; p < 0.001$). Participants are more inclined to use a null pronoun to refer to whichever referent is more likely given the preceding discourse, either subjects or non-subjects. This effect is stronger when the predicted referent was the subject of the previous sentence compared to when it was not the subject. This difference ultimately leads to a main effect of Grammatical Role ($\beta = 0.35; z = 5.1; p < 0.001$). Concerning interpretation, Fig. 2B shows the proportion of responses where participants interpreted the null pronoun as referring to the subject of the previous sentence, as a function of Referent Predictability. As predicted, pronoun interpretation is affected by the predictability of the referent ($p < 0.001$): Participants are more likely to think that the antecedent of the null pronoun is the most likely referent given the context (either the subject or the non-subject).

Conclusion. We explored the factors influencing the production and interpretation of null pronouns in Spanish in an interactive setting. Our results show that when speakers are pressured to be efficient, contextual factors influencing referent predictability impact not only pronoun interpretation but also production. This contrasts with the predictions of the Bayesian Model and implies that variations in communicative pressures may play a role in pronominal use, potentially explaining some of the contradictory findings in the literature.

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