

TEMPORAL PROSODIC FEATURES IN PRONOMINAL ANAPHORA RESOLUTION IN SPANISH

Luz Rello^a & Joaquim Llisterri^b

^aDepartment of Information and Communication Technologies, Pompeu Fabra University, Spain;

^bDepartment de Filologia Espanyola, Universitat Autònoma de Barcelona, Spain

luzrelo@gmail.com; Joaquim.Llisterri@uab.cat

ABSTRACT

This research considers the role of temporal prosodic features for pronominal anaphora resolution in ambiguous discourse contexts in Spanish. Results suggest that duration cues alone are not sufficient to predict the antecedent but could provide helpful supplementary information to be integrated in anaphora resolution systems.

Keywords: anaphora resolution, prosody, duration

1. INTRODUCTION

Although the role of temporal prosodic features in the resolution of pronominal anaphora has been studied for other languages (see §2), the relation between prosodic parameters and pronominal anaphors has not been yet experimentally described for Spanish. Previous work has focused on the perceptual identification of antecedents [1, 10, 12], while we tackle the problem by performing an acoustic analysis of the production of anaphora.

This study investigates pronominal anaphora. Normally, to identify the antecedent of a pronominal anaphor it is sufficient to look back at the preceding two or three clauses [13]. However, when discourse knowledge is required to resolve anaphora, the anaphor scope is expanded to the discourse segment. To determine the antecedent in these cases, theories that model local coherence such as the Centering Theory [4, 8] provide a convenient approach. We consider the first rule proposed in [4]: if there is only one pronoun in an utterance, then this pronoun should be the (backward looking) centre [14].

2. RELATED WORK

Our research is based on the hypothesis that prosodic prominence might contribute to the resolution of semantic ambiguities in anaphoric pronouns; thus, a prosodically prominent element should be more accessible for anaphoric reference than a non-prominent one, as shown in [11]:

- (1) John_j called Bill_j a republican and then he_j hit him_j.
- (2) John_j called Bill_j a republican and then HE_j hit HIM_i.

The results of the first empirical studies did not fully support the initial prediction. In [6], significant relationships between discourse structure and prosodic phrasing for English were not found, and in [15] prosodic information alone was insufficient for predicting antecedents in pronoun resolution. In Swedish [9], the prosodically prominent constituent is not necessarily the most accessible one for anaphoric reference.

While previous experiments [6, 7, 9] use isolated utterances composed of one or two clauses with an ambiguous anaphoric pronoun, recent studies [1, 2, 3, 5, 10, 12] take into account the postulates of the Centering Theory [4, 8] in the design of the corpus. Consequently, the ambiguous anaphoric pronoun is introduced in a discourse where the antecedent corresponds with the most salient reference. According to anaphora resolution theory, when antecedent ambiguity occurs, among all the candidates for antecedent the front-runner is usually the most salient or the most central element [13]. This is based on the idea that the centre of the clause is more likely to be pronominalised or to become a zero pronoun.

In general terms, the results of these last works are more promising. In [10, 12], the most central element corresponds to the antecedent and stress has an effect on the interpretation of the ambiguous pronoun. The corpus in these studies consists in three isolated clauses: the first two ones introduce two different antecedent candidates (one more salient) and the third clause contains an ambiguous pronoun as anaphor. To increase the naturalness of our corpus (§3.1), the equivalents of these three clauses are included in a story adding discourse knowledge to point out the most salient entity.

3. METHOD

3.1. Corpus

Since a strict control of the variables was needed in this first stage of the study, the experiment is based on an *ad hoc* corpus composed of six stories including a target clause. If this target clause were isolated, the pronoun that it contains would be

ambiguous. The discourse knowledge of the story points out the most salient element in order to disambiguate the pronoun.

Target clauses with the ambiguous pronoun are as shown in (3). The candidates for antecedent appear in italics and the anaphor in bold.

- (3) Esta noche, Clara estaba consultando el correo mientras Sofía hablaba por teléfono; luego, ella se fue a hacer la cena¹.

The pronoun *ella* ('she') could point to any of both candidates (*Clara* and *Sofía*) depending on their salience in the discourse. In each story, the most salient candidate is explicitly mentioned five times before the target clause appears:

- (4) Clara y Sofía son compañeras de piso y viven en un pequeño apartamento en Barcelona. Todas las noches, Sofía se hace la remolona a la hora de hacer la cena, con lo que Clara siempre termina preparándola. Pero a Clara no le importa, porque a ella le encanta cocinar; de hecho, ha seguido varios cursos de cocina, uno de ellos especializado en cocina india. Además, por las mañanas Clara tiene mucho tiempo libre para poder hacer la compra. Por eso, Clara siempre elige con cuidado los ingredientes con los que preparar la cena. Esta noche, Clara estaba consultando el correo mientras Sofía hablaba por teléfono; luego, ella se fue a hacer la cena. En el fondo, Clara siempre estaba encantada de cocinar para su amiga, pues desde pequeña le gustaba el ritual de ir a la compra, preparar la comida y poner la mesa².

In (4), *Clara* is the most salient and the most likely candidate to be the antecedent of the pronoun *ella* ('she'). If discourse knowledge were not available to the reader, *Sofía* could be interpreted as the antecedent of *ella* because it is closer to the pronoun than *Clara*.

The stories have two variants: one in which the antecedent is not immediately followed by the pronoun, as in (4), and one in which the antecedent occurs close to the pronoun, as in (5).

- (5) Esta noche, Sofía estaba consultando el correo mientras Clara hablaba por teléfono; luego, ella se fue a hacer la cena³.

In all cases, the pronoun *ella* is preceded by the discourse connector *luego* ('then'); the antecedent is the same in both variants of the stories.

We expect to find prosodic prominence differences between the pronouns which point back to a further antecedent (4) and the pronouns whose antecedent is closer (5). These differences would resolve the ambiguity created by another candidate between the antecedent and the pronoun (4).

3.2. Participants

The participants were 16 female native speakers of central Peninsular Spanish, aged between 22 and 40 ($M = 27.6$). They had been living in Madrid for

an average period of residence of 15 years. Most participants have a higher university degree and 11 of them have a specialisation in language studies.

3.3. Procedure and analysis

The participants began the experiment by a silent reading of the six stories, presented in random order, after which they had to answer a question about the antecedent of the anaphoric pronoun *ella* for each text. After ensuring the correct identification of the antecedent, we proceeded with the recordings. Texts were again presented randomly and the participants were instructed to keep in mind the information about the antecedent during their reading. A prompt was added after each text, making the antecedent explicit (i.e. *Clara se fue a hacer la cena*).

Recordings were conducted in a sound treated room, using a headset wireless microphone AKG C444L and an Alesis Multimix 16USB mixing console. The signal was recorded with Adobe Audition 1.0 at 44,100 Hz and 16 bits. The recordings were acoustically analysed with Praat. We considered the following temporal measurements: (a) duration of the target clause; (b) duration of the part of the target clause beginning with the anaphor; (c) duration of the anaphoric pronoun *ella*; (d) duration of the discourse connector *luego*; and (e) duration of the pause (if present) between *luego* and *ella*. The statistical treatment was performed with the R package, and analysis of variance (ANOVA) was used to test differences between conditions.

Two conditions are compared: clauses in which the antecedent is not immediately followed by the pronoun (FA, further antecedent) and clauses in which the antecedent occurs in the closest position to the pronoun (CA, closer antecedent). A total of 96 clauses are analysed; 192 cases are obtained for values of the parameters (a)-(d) and 72 for (e), since not all the speakers produce a pause.

4. RESULTS

4.1. Anaphoric pronoun duration

First, we calculate the percentage of duration of the anaphor relative to the duration of the whole target clause and to the duration of the part of the clause beginning with *ella*. No significant differences between conditions in the mean relative values are found in both cases.

Secondly, the relative difference between the two conditions is calculated, using the formula $((FA \times 100)/CA) - 100$. The relative duration of *ella* is shorter in FA than in CA in 60.42% of

cases, while it is longer in 39.58% of the occurrences in the corpus. However, the comparison between mean differences in relative durations does not yield statistically significant results (FA < CA: $M = 11.77\%$, $SD = 10.91$; FA > CA: $M = 14.19\%$, $SD = 10.5$; $p = .45$). The same analysis is performed for a subset of the 6 participants in which the direction of the difference (positive or negative) between conditions was always the same. In this case, the relative duration of *ella* is shorter in FA than in CA in two thirds of the occurrences (FA < CA: $M = 13.38\%$, $SD = 11.96$; FA > CA: $M = 17.25\%$, $SD = 6.1$; $p = .46$).

As far as inter-speaker variability is concerned, the relative mean duration of *ella* in FA is shorter compared to CA in 10 speakers (62.5% out of the total number of participants) and longer in 6 of them (37.5%). A preference for shorter durations of *ella* when the antecedent is further is observed in 11 speakers (68.75%), while 5 speakers (31.25%) show a preference for longer durations of the anaphor in this same condition. In the subset of 6 participants, the relative mean duration of the anaphoric pronoun in FA is shorter than in CA in 4 speakers (66.6%) and longer in 2 of them (33.3%).

4.2. Frequency of occurrence of the pause

A pause between the discourse connector *luego* and the anaphoric pronoun *ella* appears in 75% of cases. The percentage of pauses is very similar in FA (38.5% out of the total number of pauses found in the corpus) and in CA (36.5%). When pauses are absent, we observe similar percentages in FA (11.5%) and CA (13.5%) conditions.

It is noticeable that 11 speakers (68.75% out of the total) show a coherent behaviour, producing pauses either in all utterances (56.25%) or in none of them (12.5%). Three speakers (18.75%) read the majority of the clauses with pauses.

4.3. Duration of the pause

The percentage of the duration of the pause in relation to the duration of the whole target sentence is calculated; no significant differences are found between the two conditions (FA: $M = 10.4\%$, $SD = 5.95$; CA: $M = 10\%$, $SD = 7.14$; $p = .81$).

We consider the relative differences between FA and CA for the 13 speakers who produced pauses in the same clauses in the two conditions. Pauses are shorter in FA than in CA in 48.48% of cases, while they are longer in 51.52% of cases.

The trends are similar if the analysis is restricted to the subset of 9 participants who produced pauses in all clauses (FA < CA: 42.31%;

FA > CA: 57.69%). However, we observe a large variability in the mean values of the differences between conditions in cases in which FA > CA, as opposed to cases in which FA < CA.

The analysis of the inter-speaker variability shows that pauses in clauses with FA are always longer than in clauses with CA in 2 participants (15.38% out of the 13 speakers who produced pauses in the same clause in the two conditions). The other 11 speakers show opposite trends in their distributions of pause duration across conditions.

4.4. Other temporal factors

4.4.1. Duration of the discourse connector

Equivalent analysis to those performed for the anaphoric pronoun are carried out for the discourse connector *luego*.

Differences between the two conditions with respect to the duration of the clause are not significant (FA: 20.81%, CA: 21.37%, $p = .41$). We find the same trend for the subset of 9 speakers who systematically produced a pause between *luego* and the anaphoric pronoun. Moreover, the analysis of the relative differences between the two conditions reveals that *luego* shows shorter relative durations in CA with respect to FA in 57.45% of cases and longer relative durations in 42.55% of cases. The difference in the mean percentage values between the two conditions is not significant ($p = .13$).

There is a similar and clearer trend in the subset of 9 speakers who produced pauses in all conditions: *luego* shows shorter relative durations in CA when compared to FA in 61.54% of cases and presents longer relative durations in 38.46% of cases. Although the difference in mean percentage values is not significant ($p = .22$), there is a tendency for longer relative durations to be associated to further antecedents.

4.4.2. Duration of the clause

The analysis of the relative differences in duration of the whole clause for the speakers who produced pauses in equivalent clauses in both conditions reveals that in 55.88% of the cases, the relative clause duration is shorter in FA than in CA ($M = 7.36\%$, $SD = 5.20$) and is longer in 44.12% of cases ($M = 8.64\%$, $SD = 4.88$). Differences between relative means are not significant ($p = .46$).

4.4.3. Correlation between pause and target words

The correlation between the duration of the pause and the duration of the anaphoric pronoun *ella* is tested for the subset of 9 participants who

produced pauses in all conditions. The values of the Pearson correlation coefficient are -0.23 ($p = .23$) in FA and -0.43 ($p = .02$) in CA. Both the duration of *ella* and the duration of the pause are shorter in FA than in CA for 3 speakers, while they are both longer for 2 speakers.

We compute the correlation between the duration of the pause and the duration of *luego* for the same subset of participants. In this case, the values obtained are 0.19 ($p = .32$) in FA and 0.20 ($p = .30$) in CA. Both the duration of *luego* and the duration of the pause are shorter in FA than in CA for 4 speakers, being both longer for 1 speaker.

4.5. Global differences between conditions

In this global analysis, the absolute duration values obtained for the elements measured (See §3.4) in clauses with FA are subtracted from the corresponding values obtained in clauses with CA.

Overall, target words and clause durations are shorter in FA than in CA in 59.9% of cases ($N = 115$) while they are longer in 39.58% of cases ($N = 76$). Pause, target words and clause durations are shorter in FA than in CA in 60% of cases ($N = 81$) and longer in 38.52% of cases ($N = 52$) for the subset of 9 participants who produced pauses in all clauses in the two conditions.

As for speaker variability, target word and clause durations are shorter in FA than in CA in 68.75% of the participants, and longer in 31.25% of them. Pause, target words and clause durations are shorter in FA than in CA in 8 speakers (88.89%) and longer in one of them (11.11%) in the 9 participants who systematically produced pauses.

5. DISCUSSION AND CONCLUSIONS

The analyses reveal that the mean values of the differences between the two conditions considered do not allow to distinguish clauses in which the pronoun points back to a further antecedent (FA) from those in which the antecedent of the pronoun is closer (CA). Inter-speaker variability is a major factor to be taken into account. Considering the direction of the differences between conditions, a tendency towards shorter temporal values in FA is observed, specially for the anaphor and for the global differences.

Our results are consistent with previous work in English [15] and German [12]. Duration might influence the resolution of anaphoric pronouns although the large variation among subjects do not allow us to determine any numerical heuristics for helping pronoun resolution.

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¹ Tonight, Clara was reading her email while Sofía was speaking on the phone; then, she started to cook dinner.

² Clara and Sofía are flatmates and live in an small apartment in Barcelona. Every night Sofía feels tired and Clara ends up cooking dinner. But Clara doesn't mind because she loves cooking; as a matter of fact, she has taken several cooking courses, one of them specialised in Indian cuisine. Besides, Clara has plenty of free time in the mornings to go shopping. This is why Clara always chooses carefully the ingredients which she will use for cooking dinner. Tonight, Clara was reading her email while Sofía was speaking on the phone; then, she started to cook dinner. Actually, Clara was happy to cook for her friend, since she enjoyed the ritual of shopping, cooking and setting the table since she was a child.

³ Tonight, Sofía was reading her email while Clara was speaking on the phone; then, she started to cook dinner.