# PROSODIC CORRELATES OF PRONOUN DISAMBIGUATION IN SPANISH

# CORRELATOS PROSÓDICOS DE LA DESAMBIGUACIÓN PRONOMINAL EN ESPAÑOL

LUZ RELLO
*Universitat Pompeu Fabra*
luz.rello@ufp.edu

JOAQUIM LLISTERRI
*Universitat Autònoma de Barcelona*
Joaquim.Llisterri@uab.cat

## ABSTRACT

One of the major challenges in pronominal anaphora resolution occurs when the anaphor is ambiguous. This paper explores the interplay between prosodic features and pronominal anaphora in ambiguous discourse in Spanish. The results for duration, fundamental frequency and amplitude of the segment in the speech signal corresponding to the pronoun, complemented by data on pause occurrence and pause duration, suggest the potential role of prosody in anaphora resolution.

Keywords: *pronominal anaphora, prosody, discourse, Spanish.*

## RESUMEN

La ambigüedad del antecedente es uno de los mayores retos que se plantean en la resolución de la anáfora pronominal. Este trabajo explora la interrelación entre los rasgos prosódicos y la anáfora pronominal ambigua en el discurso en español. Los resultados obtenidos en lo que respecta a la duración, la frecuencia fundamental y la amplitud del segmento de la señal sonora que contiene el pronombre anafórico, junto con los datos sobre la presencia de pausa y la duración de la misma, sugieren que los rasgos prosódicos podrían jugar un papel en la resolución de la anáfora.

Palabras clave: *anáfora pronominal, prosodia, discurso, español.*

## 1. INTRODUCTION

This study focuses on the resolution of pronominal anaphora, one of the major challenges in current discourse studies, both from a theoretical and from an applied perspective. Pronominal anaphora resolution requires the identification of the antecedent of the anaphor (Mitkov 2002). If the anaphor has more than one candidate for antecedent, the ambiguity can be resolved by using additional information such as discourse knowledge. Prosody might be another source of information, since perceptual studies show that prosodic cues can enrich the discourse knowledge and help the listener to identify the antecedent of the ambiguous pronoun (see Section 2). Complementarily, this research tackles the problem by performing an acoustic analysis of the production of ambiguous anaphora. To the best of our knowledge, the role of prosodic features in the resolution of pronominal anaphora has not been experimentally described for Spanish so far.

The theoretical backgrounds of our study are anaphora resolution theory (Mitkov 2002) and Centering Theory (Grosz, Joshi & Weinstein 1995; Brennan, Friedman & Pollard 1987). According to Mitkov (2002), the identification of a pronominal anaphor requires looking back at the preceding two or three clauses, since the scope of pronominal anaphors is limited. Nevertheless, when discourse knowledge is necessary to resolve anaphora, the anaphor scope is expanded to the discourse segment. In this case, the pronoun in an utterance corresponds with the (backward looking) centre or the most salient element in the discourse segment (Brennan et al. 1987; Mitkov 2010). To identify the antecedent of a pronominal anaphor it is sufficient to look back at the preceding noun phrases, since the scope of pronominal anaphors is usually limited to the current and two or three preceding clauses (Mitkov 2010).

## 2. RELATED WORK

Following the seminal ideas on the role of stress in the interpretation of pronouns presented in Lakoff (1971, 1976), we assume 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.

The first studies that pursued the empirical proof of this assumption were not conclusive with respect to the role of prosody. In Dogil, Kuhn, Mayer, Möhler and

Rapp (1997), the presence of a pitch accent on an anaphoric pronoun did not have a perceptual effect in the choice of the antecedent, and Gustafson-Capková (2000) concluded that the prosodically prominent constituent is not necessarily the most accessible one for anaphoric reference. As far as production is concerned, in Wolters and Byron (2000) prosodic information alone was shown to be insufficient to predict antecedents in pronoun resolution. These earlier experiments did not take into account the postulates of the Centering Theory; hence, with the exception of Wolters and Byron (2000), the corpora used were mainly composed of one or two clauses with an ambiguous pronoun, without incorporating further discourse knowledge.

More recent studies (Balogh 2003; Auran & Hirst 2004; Mayer, Jasinskaja & Kölsch 2006; Auran 2007; Jasinskaja, Kölsch & Mayer 2007; Wolters & Beaver 2001) consider the assumptions of the Centering Theory (Grosz et al. 1995; Brennan et al. 1987) or other discourse cohesion models 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 (Mitkov 2002). This is based on the idea that central elements are more likely to be pronominalized or to become a zero pronoun.

The results of these last works are, on the whole, more promising. Mayer et al. (2006:476) conclude that *global prosodic parameters such as pitch range and pause duration influence the resolution of anaphoric pronouns*, while Jasinskaja et al. (2007:11) found that *the placement of nuclear accent can affect pronoun interpretation*. The corpus used in these experiments consists of 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 the corpus designed for the present study (see Section 3.1), the equivalents of these three clauses are included in a story adding discourse knowledge to point out the most salient entity.

Finally, the properties of anaphoric pronouns have also been compared to other elements in the discourse. Cornish (2005) shows that contrastive pitch accent signals anaphora in third person pronouns as well as in demonstrative expressions, while Auran and Hirst (2004) found differences in the resets in fundamental frequency between anaphoric pronouns and discourse connectors. These results suggest that anaphoric pronouns have specific prosodic properties that deserve a more detailed investigation.

## 3. METHOD

### 3.1. Corpus

The experiment is based on an *ad hoc* corpus to allow the strict control of the variables that is needed in this first stage of the research. The corpus is composed of six stories, each of them with a target clause. The target clause contains an ambiguous pronoun, which is disambiguated by the discourse knowledge present in the story.

The target clauses with the ambiguous pronoun are as shown in (1). The candidates for the antecedent appear in italics and the anaphor underlined:

> (1) *Ainara* compraba una nube de azúcar mientras *Pilar* se comía un helado; luego, <u>ella</u> se subió a la noria.
>
> *Ainara* was buying a sugar cloud while *Pilar* was eating an ice cream; then, <u>she</u> got on to the Ferris wheel.

Depending on the interpretation, <u>she</u> can point to any of both candidates (*Ainara* or *Pilar*). The pronoun can only be disambiguated when one of the two candidates is more salient in the discourse. In each story, the most salient candidate is explicitly mentioned four times, plus an introductory mention, before the target clause appears:

> (2) Este domingo, Pilar ha decidido llevar por fin a su hija Ainara al parque de atracciones. Aunque Pilar nunca se monta en ninguna atracción porque le dan mucho miedo, a su hija Ainara le encantan los parques de atracciones y siempre está pidiendo a sus padres que la lleven. De hecho, este era el regalo que Ainara había pedido para su cumpleaños. Con tan solo nueve años Ainara se monta en todas las atracciones que puede y, aunque haya cola, Ainara siempre espera estoicamente. *Ainara* compraba una nube de azúcar mientras *Pilar* se comía un helado; luego, <u>ella</u> se subió a la noria. Era enternecedor ver cómo la niña saludaba a su madre desde las alturas, gritando de alegría.
>
> This Sunday, Pilar has finally decided to take her daughter Ainara to the amusement park. Although she never gets into any attraction because

she is scared of them, her daughter Ainara loves amusement parks and is always asking her parents to take her there. As a matter of fact, this was the present Ainara had asked for her birthday. Although she is only nine years old, Ainara rides all the attractions she can and, even if she has to queue, she always waits stoically. *Ainara* was buying a sugar cloud while *Pilar* was eating an ice cream; then, <u>she</u> got on to the Ferris wheel. It was touching to see how the girl was waving at her mother from the heights, shouting with joy.

In (2), *Ainara* is the most salient and the most likely candidate to be the antecedent of the pronoun <u>ella</u> ('she'). If discourse knowledge were not available to the reader, *Pilar* could be interpreted as the antecedent of <u>ella</u> because it is closer to the pronoun than *Ainara*.

The stories have two variants: one in which the antecedent is not immediately followed by the pronoun, as in (2), and one in which the antecedent occurs close to the pronoun, as in (3):

(3) *Pilar* compraba una nube de azúcar mientras *Ainara* se comía un helado; luego, <u>ella</u> se subió a la noria.

*Pilar* was buying a sugar cloud while *Ainara* was eating an ice cream; then, <u>she</u> got on to the Ferris wheel.

In all cases, the pronoun <u>ella</u> 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 -as in (1)- and the pronouns whose antecedent is closer -as in (3)-. These differences would resolve the ambiguity created by the presence of another candidate between the antecedent and the pronoun, as shown in (2).

### 3.2. Participants

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

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

### 3.3. Procedure and analysis

The experiment began by a silent individual reading of the six stories, presented in random order, after which the participants had to answer a question about the antecedent of the anaphoric pronoun <u>ella</u> for each text (*¿Quién se subió a la noria? (Who got on to the Ferris wheel?*). Once the correct identification of the antecedent was ensured, we immediately proceeded with the recordings. The stories were again presented randomly, each of them printed on a separate page, and the participants were asked to read them aloud, keeping in mind who was the main character in the story (the most salient candidate); a prompt was added at the bottom of each page, making the antecedent explicit, i.e. *Ainara se subió a la noria (Ainara got on to the Ferris wheel).*

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 44.1 kHz and 16 bits.

The recordings were manually labeled (Figure 1) and acoustically analyzed with Praat (Boersma & Weenink 2012). Time, frequency and amplitude values were automatically extracted by means of a script and a manual checking was performed to correct fundamental frequency detection errors.

We performed the following measurements: (a) duration of the pause («p» in Figure 1) between the connector luego and the pronoun <u>ella</u>; (b) duration of the target clause (Luego, ella se subió a la noria in Figure 1); (c) duration of the part of the target clause beginning with the anaphor (ella se subió a la noria in Figure 1); (d) duration of the segment in the speech signal corresponding to the anaphoric pronoun; (e) mean, maximum, minimum and range of fundamental frequency of the segment in the speech signal corresponding to the anaphoric pronoun; (f) fundamental frequency reset before and after the pronoun (measured at points marked as «f01», «f02», «f03» and «f04» in Figure 1); and (g) mean, maximum, minimum and range of amplitude of the segment in the speech signal corresponding to the anaphoric pronoun.
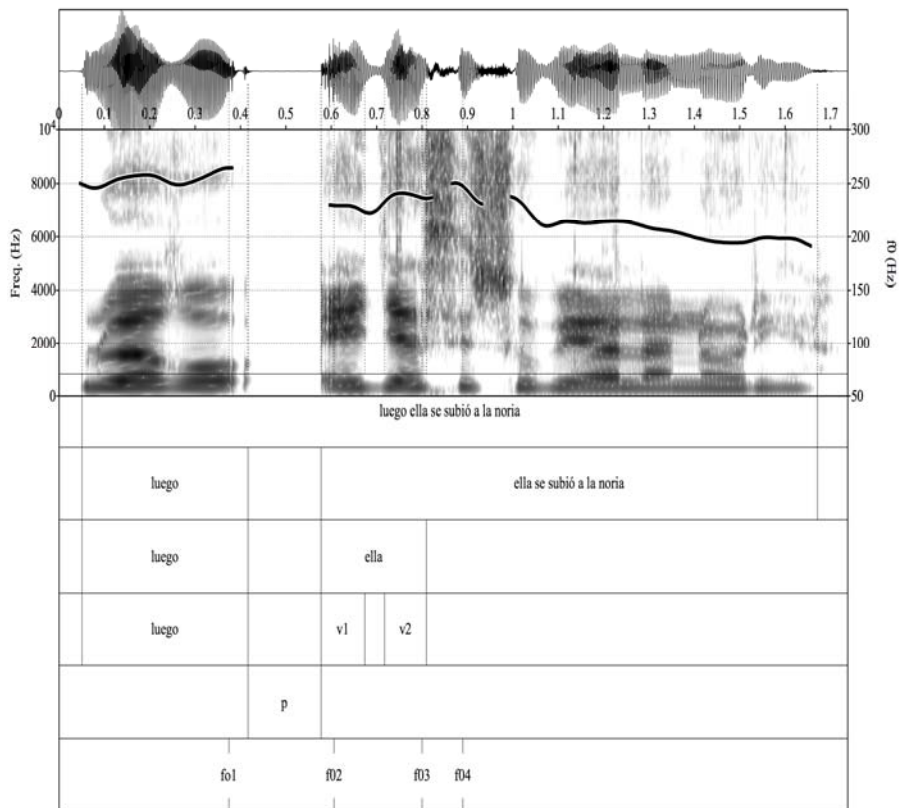
Figure 1. *Labeling of the clause* Luego, ella se subió a la noria. *The pause is marked with «p»; «v1» and «v2» correspond to the vowels of the anaphoric pronoun; «f01», «f02», «f03» and «f04» are the points chosen for the measurement of fundamental frequency resets.*

Fundamental frequency and amplitude ranges are obtained by calculating the difference between the maximum and the minimum values found in the segment of the speech signal corresponding to the anaphor (ella in the third annotation tier in

Figure 1)[1]. Resets are calculated as the difference between the fundamental frequency values at the points annotated as «f01» (end of luego) and «f02» (beginning of <u>ella</u>) on the one hand, and the points marked as «f03» (end of <u>ella</u>) and «f04» (beginning of se) on the other (Figure 1). A reset occurs if the difference f01-f02 or f03-f04 has a negative value, meaning that the fundamental frequency contour does not follow a declination pattern (Garrido 1999).

A total of 96 target clauses were analyzed; 72 values were obtained for (a), since not all the speakers produced a pause, 96 for (b), (c) and (d) and 384 for (e), (f) and (g). Thus, 1.608 values are considered in total.

Two conditions are compared: clauses in which the antecedent is not immediately followed by the pronoun –FA, further antecedent, as in example (1)–, and clauses in which the antecedent occurs in the closest position to the pronoun –CA, closer antecedent, as in example (3)–. Figures 2 and 3 illustrate the realization of this contrast by the same speaker.
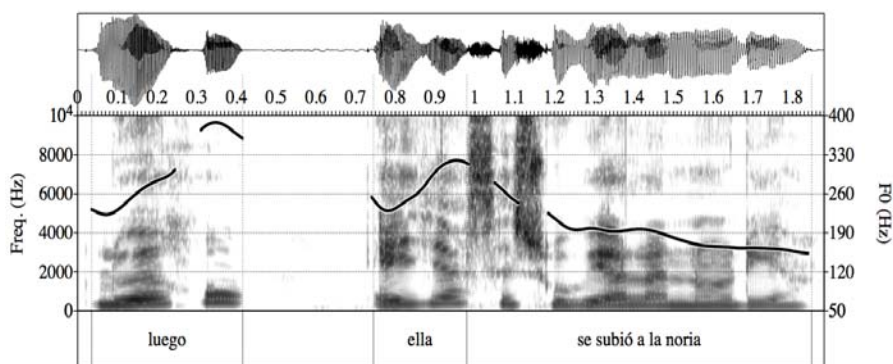


Figure 2. *Waveform, spectrogram and f_0 contour of the clause* Luego, ella se subió a la noria *(FA, further antecedent condition).*

---

[1] From now on, for the sake of brevity, we will use *anaphoric pronoun* or *anaphor* to refer to the segment of the speech signal corresponding to the anaphoric pronoun <u>ella</u>.
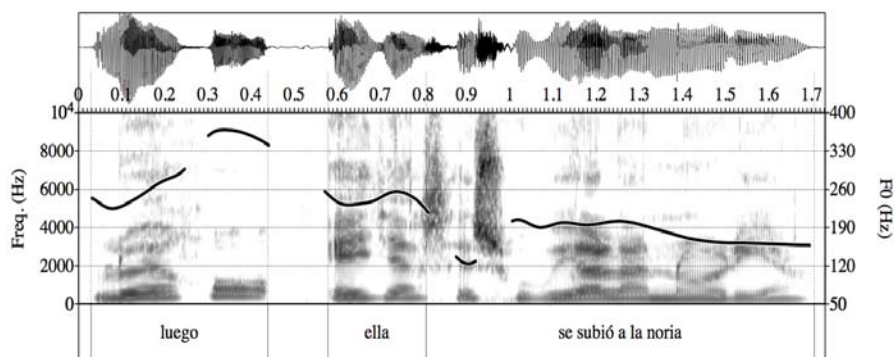
Figure 3. *Waveform, spectrogram and $f_0$ contour of the clause* Luego, ella se subió a la noria *(CA, closer antecedent condition).*

To neutralize inter-speaker variation, we do not use absolute values, but the percentage of the difference between conditions calculated as ((FA x 100)/CA) - 100. Then, we separate the results into two further conditions: the cases in which the values found with further antecedents are higher than those found with closer antecedents (FA > CA) and the cases in which the values for further antecedents are lower than those with closer antecedents (FA < CA). Thus, for example, if speaker A produced the anaphoric pronoun with a fundamental frequency range of 22 Hz in condition FA and with a range of 72 Hz in condition CA, there is a difference of -69%, that is, an instance of FA < CA; if the fundamental frequency range of the pronoun for speaker B is 44 Hz in condition FA and 31 Hz in condition CA, the calculated difference is 40%, being an instance of FA > CA. Since the signs > and < indicate the direction of the difference, all percentages are reported as positive values.

The statistical treatment was performed with the R package (R Development Core Team 2011), and analysis of variance (ANOVA) was used to test differences between conditions. In the next section, the mean is abbreviated as *M*, standard deviation as *SD* and *N* is used for the number of instances.

## 4. RESULTS

In this section we summarize the results from the analysis of the corpus in relation to the relative differences between conditions and to inter-speaker variability. We present in the first place the frequency of occurrence and the duration of pauses (4.1), followed by the duration (4.2), the fundamental frequency (4.3) and the amplitude of the segment in the speech signal corresponding to the anaphoric pronoun (4.4).

### 4.1. Frequency of occurrence and pause duration

A pause between the discourse connector *luego* and the anaphoric pronoun <u>ella</u> appears in 75% of cases ($N = 72$). There are no significant differences ($\chi^2$ (1, N = 72) = 0.056, p = .813) between the percentage of occurrence of pauses with further antecedents (39% out the total number of pauses in the corpus, $N = 37$) and with closer ones (37%, $N = 35$).

Twelve speakers (75% out of the total number of participants) produce pauses in more than 50% of the cases; three speakers (19%) show pauses in less than 50% of the cases or do not produce them at all. Since in 9 speakers (56%) pauses occur in all their utterances, separate analyses are carried out for this subset of participants in the next sections.

To avoid effects due to inter-speaker variability in speech rate, we calculate the percentage of the duration of the pause in relation to the duration of the target clause. There are no significant differences between the two conditions (FA: $M = 10\%$, $SD = 5.95$; CA: $M = 10\%$, $SD = 7.14$; $p = .818$) and in the direction of the difference between conditions (FA < CA: $M = 8\%$, $SD = 6.17$; FA > CA: $M = 6\%$, $SD = 3.7$; $p = .376$), but there are significant inter-speaker differences in relative pause duration ($p < .001$ for the whole group; $p = .012$ for the subset of 9 speakers). The duration of the pause with respect to the duration of the clause tends to be higher in FA than in CA in 67% of cases in the corpus and in 67% of the speakers.

Then we compute the relative difference (in percentages) in pause duration between FA and CA conditions. When pauses are longer in FA than in CA, the range of the difference between conditions is greater than in the opposite situation (FA < CA: 72%; FA > CA: 1046%). For the whole group of speakers, differences are statistically significant if we consider the direction (positive or negative) of the

difference (FA < CA: $M$ = 45%, $SD$ = 21.44; FA > CA: $M$ = 195%, $SD$ = 247.86; $p$ = .022). Nevertheless, in the subset of 9 speakers differences do not reach statistical significance (FA < CA: $M$ = 51%, $SD$ = 18.17; FA > CA: $M$ = 193%, $SD$ = 264.89; $p$ = .089). We do not observe significant inter-speaker differences for all the participants who produced pauses ($p$ = .113) and for the subset of 9 speakers ($p$ = .067).

## 4.2. Duration of the anaphoric pronoun

We calculate the percentage of duration of the anaphor with respect to the duration of the target clause (LC, long clause) and with respect to the duration of the clause beginning with ella (SC, short clause). In both cases, relative mean values do not differ significantly between FA and CA (FA = 13%, CA = 13%, $p$ = .64 for LC; FA = 18%, CA = 19%, $p$ = .59 for SC).

A comparison of the relative differences in anaphor duration taking into account the direction of the difference between FA and CA does not yield statistically significant results (FA < CA: $M$ = 12%, $SD$ = 10.91; FA > CA: $M$ = 14%, $SD$ = 10.5; $p$ = .45 for all the speakers; FA < CA: $M$ = 9%, $SD$ = 7.29; FA > CA: $M$ = 9%, $SD$ = 7.69; $p$ = .792 for the 9 speakers who always produced pauses). However, the relative duration of ella is shorter in FA than in CA in 60% ($N$ = 29) of cases in all the speakers, and in 70% ($N$ = 19) of cases in the speakers who produced pauses in all conditions. We find the same trend considering inter-speaker variability: anaphor duration in FA tends to be shorter than in CA in 69% ($N$ = 11) of the speakers in the whole group and in 78% ($N$ = 7) of the speakers in the subset of 9 participants.

Significant inter-speaker variability appears when comparing the relative differences between AC and FA for all the participants ($p$ = .005), although not for the speakers who produced pauses in all cases ($p$ = .466). Moreover, in the comparison of the mean values of the differences across conditions, significant differences also appear between clauses with pause and those without pause (without pause: $M$ = 18%, $SD$ = 12.36, $N$ = 21; with pause: $M$ = 9%, $SD$ = 7.27, $N$ = 27; $p$ = .002). Relative differences in the duration of the anaphor are always smaller when pauses are present in the utterance (without pause: FA < CA = 14%, FA < CA = 11%; with pause: FA < CA = 7%, FA > CA = 8%).

**4.3. Fundamental frequency of the anaphoric pronoun**

The relative difference between FA and CA conditions and the direction of these differences are calculated in percentages for mean, maximum, minimum and range of fundamental frequency ($f_0$) values (Table 1).

We find significant results for the differences between FA and CA in the mean value of $f_0$ range when all participants are taken into account ($p = .033$). In this case, values for the condition FA > CA ($M = 79\%$, $SD = 106.21$) are higher than in FA < CA ($M = 31\%$, $SD = 26.09$); however, a large standard deviation is observed for FA > CA, suggesting the presence of high inter-speaker variability. The rest of the differences between FA and CA for the mean value of fundamental frequency parameters does not appear to be significant, as shown in Table 1.

| MEASURE | MAX. | MIN. | RANGE | *M* | *SD* | *N* |
|---------|------|------|-------|-----|------|-----|
| Mean $f_0$ |  |  |  | $p = .620$ |  |  |
| FA > CA | 29.25 | 0.29 | 28.96 | 6.28 | 6.32 | 27 |
| FA < CA | 26.64 | 0.50 | 26.14 | 5.38 | 6.09 | 21 |
| Max. $f_0$ |  |  |  | $p = .266$ |  |  |
| FA > CA | 47.72 | 0.50 | 47.21 | 9.52 | 11.27 | 24 |
| FA < CA | 31.89 | 0.10 | 31.78 | 6.26 | 8.63 | 24 |
| Min. $f_0$ |  |  |  | $p = .888$ |  |  |
| FA > CA | 105.89 | 0.31 | 105.58 | 8.30 | 19.48 | 28 |
| FA < CA | 53.06 | 0.35 | 52.71 | 7.58 | 12.08 | 19 |
| Range $f_0$ |  |  |  | $p = .033$ |  |  |
| FA > CA | 405.48 | 1.35 | 404.13 | 79.02 | 106.21 | 23 |
| FA < CA | 87.54 | 0.58 | 86.95 | 31.03 | 26.08 | 25 |

Table 1. *Relative differences (in %) between conditions in the* $f_0$ *values of the anaphor for all the speakers.*

The direction of the differences does not show a clear trend, with almost similar number of cases of FA < CA (average for the 4 parameters: 46% for all speakers; 51% for the subset of 9 speakers) and of FA > CA (average for the 4 parameters: 53% for all speakers; 49% for the subset of 9 speakers).

As for inter–speaker variability, there does not seem to be a clear preference for the dominance of higher or lower $f_0$ values in FA with respect to CA: the average for the 4 parameters in the prevalence of FA < CA is 48% for all participants and 50% for the subset of 9 speakers; in the case of a prevalence of FA > CA, 52% for all participants and 50% for the subset of 9. Significant differences ($p = .005$) only appear in the relative differences in maximum $f_0$ values when all participants are considered, and there is no significant inter-speaker variation in the relative differences for the rest of the $f_0$ parameters.

The presence or the absence of a pause in the clause causes significant differences between conditions for $f_0$ range ($p = .027$), although it does not result in significant differences in the mean relative differences between FA and CA for the other parameters. In all cases, values in clauses with pauses are lower than in clauses without pauses.

Reset of $f_0$ values between the discourse marker *luego* and the anaphor is observed in 17% of cases ($N = 8$) in FA and in 23% of cases ($N = 11$) in CA. Taking into account only the 9 speakers who produced pauses in both conditions, there is reset in 7% of cases ($N = 2$) in FA and in 22% of cases ($N = 6$) in CA.

### 4.4. Amplitude of the anaphoric pronoun

The relative differences between FA and CA and their direction are computed in percentages for mean, maximum, minimum and range of amplitude values (Table 2). We find significant differences (p = .020) in the relative mean value for range; in this case, values for the condition FA > CA (M = 46%, SD = 25.22) are higher than in FA < CA (M = 31%, SD = 18.38). Differences also appear for maximum (p = .065) and mean (p = .092) amplitudes, although they fail to reach statistical significance.

| MEASURE | MAX. | MIN. | RANGE | *M* | *SD* | *N* |
|---------|------|------|-------|-----|------|-----|
| Mean A | | | | *p* = .09 | | |
| FA > CA | 4.34 | 0.14 | 4.20 | 1.37 | 1.14 | 25 |
| FA < CA | 7.52 | 0.14 | 7.39 | 1.94 | 1.90 | 20 |
| Max. A | | | | *p* = .06 | | |
| FA > CA | 5.96 | 5.71 | 5.71 | 1.54 | 1.36 | 24 |
| FA < CA | 7.52 | 0.14 | 7.38 | 2.20 | 1.86 | 21 |
| Min. A | | | | *p* = .42 | | |
| FA > CA | 24.01 | 0.30 | 23.71 | 5.82 | 5.23 | 28 |
| FA < CA | 15.09 | 0.30 | 14.78 | 4.70 | 3.97 | 20 |
| Range A | | | | *p* = .02 | | |
| FA > CA | 113.24 | 12.70 | 100.54 | 46.15 | 25.22 | 18 |
| FA < CA | 68.95 | 4.76 | 64.19 | 31.17 | 18.38 | 29 |

Table 2. *Relative differences (in %) between conditions in the amplitude values of the anaphor for all the speakers.*

There are no clear global trends in the direction of the differences, with very similar percentages of cases in which FA > CA (average for the 4 parameters: 49%) or in which FA < CA (average for the 4 parameters: 47%). However, minimum amplitude tends to be higher in FA than in CA (58% of cases) and range tends to be lower in FA than in CA (60% of cases).

Similarly, the participants do not seem to exhibit a preference for higher or lower values in FA with respect to CA (prevalence of FA > CA: 50%, average for the 4 parameters; prevalence of FA < CA: 44%, average for the 4 parameters).

We find significant inter-speaker variation in the relative difference in mean ($p$ = .005) and maximum ($p$ = .004) amplitude values when comparing FA > CA with FA < CA; there are no differences for minimum mean values ($p$ = .318) and those for mean range approach significance ($p$ = .062).

The comparison between clauses with pause and clauses without pause does not yield statistically significant results for any of the relative differences in amplitude between conditions.

## 5. DISCUSSION AND CONCLUSIONS

As far as the pause is concerned, its duration with respect to the duration of the clause tends to be longer with further antecedents than with closer antecedents. The difference in the range of pause duration between conditions is more accentuated when the duration of the pause is longer in FA than in CA. This trend in production seems to be consistent with the perceptual role of pause duration for the resolution of anaphoric pronouns (Jasinskaja, Kölsch & Mayer 2005).

The duration of the anaphoric pronoun tends to be shorter with further antecedents. There are no statistically significant differences in the relative differences between conditions, but inter-speaker differences are significant at least within the whole group of participants. On average, mean differences between FA and CA are reduced by around a 50% if the clause has been realized with a pause, suggesting a trading relationship between anaphor duration and presence or absence of a pause.

We observe clear trends in the $f_0$ parameters in the case of range: differences between conditions are larger when the mean $f_0$ range of the pronoun is greater in FA than in CA, a fact that can be related to the presence of significant inter-speaker variation in the maximum value of $f_0$. Differences in the $f_0$ range of anaphoric pronouns when speakers attempted a referent switch were also observed in Dogil et al. (1997). As we found for duration, the presence of a pause in the clause results in lower differences between conditions, particularly in $f_0$ range.

No regular tendencies appear in the analysis of the amplitude parameters for the anaphor. However, differences between conditions are larger when the mean amplitude range of the pronoun is greater in FA than in CA; again, this can be related to significant inter-speaker variation in the maximum amplitude values. We do not find interactions between the presence or absence of a pause and the relative differences in amplitude.

Despite the design of a set of stories that provided a wide discursive context and the methodological precautions taken to ensure the correct understanding of the texts (see Section 3), inter-speaker variability appears to be a major factor in the

analysis of our data. However, the study of more realistic corpora such as those used by Wolters and Byron (2000) and Wolters and Beaver (2001) reveals very similar trends concerning variation among speakers due to individual differences in speaking style. The results of our exploratory experiment suggest that prosodic information might play a role in pronominal anaphora disambiguation in Spanish, but further work is still needed to understand the interaction between the acoustic parameters considered and to assess the effects of corpus type and speaker variability.

## 6. BIBLIOGRAPHIC REFERENCES

AURAN, C. (2007): «Discourse cohesion and its prosodic marking in French: Interactions between intonation unit onsets and anaphoric pronouns in speech perception», in J. Trouvain and W. J. Barry (eds): *Proceedings of the 16th International Congress of Phonetic Sciences,* Saarbrücken (Germany), pp. 1109-12.
http://www.icphs2007.de [25/09/2012]

AURAN, C. and D. HIRST (2004): «Anaphora, connectives and resetting: Prosodic and pragmatic parameters interaction in the marking of discourse structure», *Second International Conference on Speech Prosody,* Nara (Japan)*,* pp. 259-62.
http://sprosig.isle.illinois.edu/sp2004/ [25/09/2012]

BALOGH, J. E. (2003): *Pronouns, prosody, and the Discourse Anaphora Weighting Approach,* PhD Dissertation, University of California, San Diego.

BOERSMA, P. and D. WEENINK (2012): *Praat: Doing phonetics by computer (version 5.3.04)* [Computer Software], Amsterdam, Department of Language and Literature, University of Amsterdam.
http://www.praat.org [13/02/2012]

BRENNAN, S. E.; M. W. FRIEDMAN and C. J. POLLARD (1987): «A centering approach to pronouns», *Proceedings of the 25th Annual Meeting of the*

*Association for Computational Linguistics,* Stanford, CA (USA), Association for Computational Linguistics**,** pp. 155-62.
http://www.aclweb.org/anthology-new/P/P87/P87-1000.pdf [25/09/2012]

CORNISH, F. (2005): «Prosody, discourse deixis and anaphora», in C. Auran; R. Bertrand; C. Chanet; A. Colas; A. Di Cristo; C. Portes; A. Reynier and M. Vion (eds)**:** *Proceedings of the International Symposium on Discourse-Prosody Inter-faces,* Aix-en-Provence (France).
http://aune.lpl.univ-aix.fr/~prodige/idp05/idp05_fr.htm [25/09/2012]

DOGIL, G.; J. KUHN; J. MAYER; G. MÖHLER and S. RAPP (1997): «Prosody and discourse structure: Issues and experiments», A. Botinis (ed)**:** *Proceedings of the ESCA Workshop on Intonation: Theory, Models and Applications,* Athens (Greece), International Speech Communication Association, pp. 99-102.

GARRIDO, J. M. (1999): «El reajuste de F0 como marca fonética de límite entre unidades entonativas: Un estudio experimental», E. Martínez Celdrán; S. Planas and J. Romero (eds): *Actes del I Congrés de Fonètica Experimental,* Tarragona (Spain), Universitat Rovira i Virgili and Universitat de Barcelona**,** pp. 223-40.

GROSZ, B. J.; A. K. JOSHI and S. WEINSTEIN (1995): «Centering: A framework for modelling the local coherence of discourse», *Computational Linguistics,* 21, 2, pp. 203-225.

GUSTAFSON-CAPKOVÁ, S. (2000): «The influence of prosodic prominence on the interpretation of ambiguous anaphors in Swedish», in P. Baker; A. Hardy; T. McEnery and A. Siewierska (eds): *Proceedings of the 3rd International Conference on Discourse Anaphora and Anaphor Resolution,* Lancaster (UK).
 http://www.ling.su.se/om-oss/kontakt/presentationer-medarbetare/a-g/sofia-gustafson-capkova-s-publications-1.13690 [25/09/2012]

JASINSKAJA, E.; U. KÖLSCH and J. MAYER (2005): «Global prosodic parameters and anaphora resolution», in C. Auran; R. Bertrand; C. Chanet; A. Colas; A. Di Cristo; C. Portes; A. Reynier and M. Vion (eds): *Proceedings of the International Symposium on Discourse-Prosody Interfaces,* Aix-en-Provence (France).
http://aune.lpl.univ-aix.fr/~prodige/idp05/idp05_fr.htm [25/09/2012]

JASINSKAJA, E.; U. KÖLSCH and J. MAYER (2007): «Nuclear accent placement and other prosodic parameters as cues to pronoun resolution», in A. Branco (ed.): *Proceedings of the 6th Discourse Anaphora and Anaphor Resolution Colloquium,* Berlin-Heidelberg, Springer, pp. 1-14.

LAKOFF, G. (1971): «Presupposition and relative well-formedness», in D. D. Steinberg and L. A. Jakobovits (eds.): *Semantics. An interdisciplinary reader in philosophy, linguistics and psychology,* Cambridge, Cambridge University Press, pp. 329-340.

LAKOFF, G. (1976): «Pronouns and reference», in J. D. McCawley (ed.): *Syntax and semantics 7: Notes from the linguistic underground,* New York, Academic Press, pp. 275-335.

MAYER, J.; E. JASINSKAJA and U. KÖLSCH (2006): «Pitch range and pause duration as markers of discourse hierarchy: Perception experiments», *Proceedings of the 9th International Conference on Spoken Language Processing,* Pittsburgh, PA (USA), International Speech Communication Association**,** pp. 473-6.
http://www.isca-speech.org/archive/interspeech_2006/index.html [25/09/2012]

MITKOV, R. (2002): *Anaphora resolution,* London, Longman.

MITKOV, R. (2010): «Discourse processing», in A. Clark; C. Fox and S. Lappin (eds.): *The handbook of computational linguistics and natural language processing,* Chichester, Wiley-Blackwell, pp. 599-629.

R DEVELOPMENT CORE TEAM (2011): *R: A language and environment for statistical computing* [Computer Software], Vienna, R Foundation for Statistical Computing.
http://www.R-project.org [13/02/2012]

WOLTERS, M. and D. BEAVER (2001): «What does *he* mean?», J. D. Moore and K. Stenning (eds)**:** *Proceedings of the 23rd Annual Conference of the Cognitive Science Society,* Edinburgh, Scotland (UK), Routledge, pp. 1148-53.

WOLTERS, M. and D. K. BYRON (2000): «Prosody and the resolution of pronominal anaphora», P*roceedings of the 18th International Conference on Computational Linguistics,* Saarbrücken (Germany), Morgan Kaufmann**,** pp. 919-25.
http://aclweb.org/anthology-new/C/C00/C00-1000.pdf [25/09/2012]