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Online Article Comprehension in Monolingual Spanish-Speaking Preschoolers with Specific Language Impairment: A Language-Mediated Visual Attention Study

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Abstract

Article production difficulties in Spanish-speaking children with specific language impairment (SLI) are well documented. However, evidence on article comprehension is scarce. In an eye tracking experiment, we compared online comprehension of definite and indefinite articles in monolingual Spanish-speaking children with SLI and children with typical language development (TLD) matched for age. Children listened to simple phrases while inspecting a visual context with four images. The article in the phrase agreed in number and gender with the target image only. Visual target preference was monitored as the phrase unfolded. Eye movements revealed that children with SLI showed a weak preference for the target on indefinite article trials only after hearing the noun, although no significant effects of definiteness were observed. In contrast, children with TLD were able to use the article to anticipate the noun. These findings contribute to reducing the gap between article production and comprehension in children with SLI.

Keywords: Specific language impairment; grammar; articles; comprehension; eye movements

Introduction

Specific Language Impairment (SLI) is defined as a language development disorder, observed in the absence of evident neurological damage, hearing deficit, cognitive impairment or severe environmental deprivation (Ullman & Pierpont, 2005). This disorder can be first identified during childhood and it can extend until adolescence (Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998). Approximately 7% of the child population is affected by SLI (Tomblin, Records, Buckwalter, Zhang, Smith, & O'Brien, 1997). One central aspect of this deficit is the grammatical problems evidenced by these children at both morphological and syntactic level (Aguado, 2007; Leonard, 2014). However, the way in which these difficulties are realised differs across languages (Leonard, 2009; Ullman & Pierpont, 2005). Thus, to understand the underlying grammar problems that characterise the language of children with SLI, it is necessary to investigate this phenomenon in different languages. Yet most of the available studies have been conducted in English-speaking populations, with fewer

studies conducted in other languages, such as Spanish. Existing studies in Spanish-speaking children indicate that grammar difficulties in these children are mostly characterised by problems with plural markers (such as the *s* morpheme), and function words, particularly clitic pronouns (Bedore & Leonard 2001) and determinate articles (Restrepo & Gutiérrez-Clellen 2001).

Articles in Spanish are gender- and number-marked, presenting more challenges for children with SLI relative to their English-speaking peers. In this regard, evidence from spontaneous speech and controlled tasks (e.g. question tasks) has shown that Spanish-speaking children with SLI present difficulties using articles (e.g. Anderson & Souto, 2005; Auza & Morgan, 2013; Coloma, Araya, Quezada, Pavez & Maggiolo, 2016). Particularly, children with SLI tend to omit and substitute articles, making more mistakes than age-matched healthy peers (Anderson & Souto, 2005). Studies using cloze tasks have shown that children with SLI omit articles more than an age-matched control group (Auza & Morgan, 2013; Morgan, Restrepo & Auza, 2013) and they have a similar performance to younger children who are matched for their linguistic profile (Auza & Morgan, 2013). In turn, a study on spontaneous speech (Coloma, et al., 2016), has recently shown that children with SLI tend to make more omissions and substitutions compared to an age-matched control group but also to the control group of younger children matched for mean length utterance (MLU). Altogether, these results suggest that for children with SLI the use of articles in spontaneous context is more difficult than in more controlled situations.

In Spanish, definite articles (i.e., “*el*”, “*la*”, “*los*”, “*las*”; English ‘the’) are always unstressed while indefinite articles (i.e., “*un*”, “*una*”, “*unos*”, “*unas*”; English ‘a’) are predominantly stressed (Alarcos-Llorach, 1994). The surface hypothesis proposed by Leonard (1998), suggest that children with SLI have a limited auditory processing capacity, which affects their analysis of the superficial characteristics of language. Definite articles are always unstressed, which could implicate that they are less salient for listeners, and therefore, more difficult than indefinite articles for SLI children. Based on this hypothesis, it is expected that

Spanish-speaking children with SLI would present more difficulties processing definite articles than indefinite ones.

The evidence on the differences between definite and indefinite articles processing in monolingual Spanish-speaking children with SLI is scarce. Existing studies in production show that SLI children present more difficulties with definite than indefinite articles, favouring the surface hypothesis (e.g. Auza & Morgan, 2013; Bosch & Serra, 1997; Restrepo & Gutiérrez-Clellen, 2001). For instance, a study using a question task showed that children with SLI have a reduced performance (e.g., omission, substitutions) when using the definite article compared to children with typical language development (TLD) matched for age, as well as younger children matched for MLU. However, the SLI group performed equally to both groups when using indefinite articles (Auza & Morgan, 2013). Similar findings have been reported in spontaneous speech in bilingual Spanish-speaking children with SLI (Aguilar-Mediavilla, Sanz-Torrent & Serra-Raventos, 2007; Bosch & Serra, 1997; Restrepo & Gutiérrez-Clellen, 2001).

The studies discussed so far focus on language production. However, much less is known about the comprehension of articles in children with SLI (Muñoz, Carballo, Fresneda & Mendoza, 2014). Current evidence points out that performance in production and comprehension can be dissociated (e.g. Chondrogianni, Marinis, Edwards & Blom, 2015; Hakansson & Hansson, 2000). For instance, it has been shown that monolingual Greek-speaking children with SLI failed in detecting ungrammatical sentences when clitics were omitted, despite the fact that they had a high level of production (Chondrogianni et al., 2015). Similarly, a study in Canadian French-speaking children with SLI showed that they were able to understand clitic pronouns even though they had problems producing them (Grüter, 2005).

In sum, evidence suggest that children with SLI have difficulties in correctly producing articles. Some studies, however, have identified a clear dissociation between language comprehension and production in this population. Since the number of studies addressing the comprehension of articles in Spanish-speaking children is limited, it remains an open question whether monolingual Spanish-speaking children with SLI have similar difficulties in comprehending articles, as they do for production. In this context, the main aim of this study is to investigate whether online comprehension of articles is impaired in monolingual Spanish-speaking SLI children compared to children with TLD matched for age. In addition, we compared the performance of both groups on definite and indefinite articles to contribute with new evidence testing the surface hypothesis.

In an eye-tracking experiment, children listened to spoken utterances containing definite and indefinite articles while inspecting four images where only one of them agreed in gender and number with the article. We calculated the proportion of looks to the target image after the article was presented. Based on previous evidence in production, we expected slower and less accurate article processing in SLI

children compared with TLD children. This would be reflected by longer latencies (delayed increase in fixation proportion) and a lower overall proportion of fixations to the associated noun in the SLI group relative to the TLD group. Finally, the surface hypothesis would predict that children with SLI would present more difficulties than children with TLD with definite than indefinite articles. If so, this should be reflected by longer latencies and a lower proportion of fixations to the target image.

The Present Study

Participants

A total of 68 participants (30 SLI and 38 children with TLD) were initially evaluated in the study. The data of 10 children from the SLI group was excluded because they did not fulfil the inclusion criteria. The final sample included a group of 20 children with SLI (6 girls, mean age 5.9 years, range 5.1- 6.6 years). For the control group, we selected 20 children with TLD (6 girls, mean age 5.9 years, range 5.1-6.7 years) matched for age and gender. All children in the control group were SLI children's classmates. Parents of participating children were informed about the aim of the study and gave written consent before participation. Participants attended five public schools with "integration programmes" (in Spanish, *Programas de Integración Escolar*, or PIE). These programmes were conceived in Chile to allow children with all sorts of special needs to attend the same schools as children with typical development.

Sample selection

Children with SLI had a diagnosis made by the speech therapists at the school. An independent evaluation was conducted by our research team on each child to confirm their difficulties in grammar (Spanish version of the Clinical Evaluation of Language Fundamentals-4 (CELF-4, Semel, Wiig & Secord, 2003). The diagnosis was confirmed when children presented (1) low grammar skills, reflected by low scores in the Formulated Sentences subtest of the CELF-4. Furthermore, we confirmed that children in the SLI group had (1) normal hearing, assessed by a screening for hearing impairment, (2) nonverbal cognitive skills within a normal rank, measured by Raven's coloured progressive matrices test (Raven, 2005) and (3) no evident neurological or social skills problems, based on teacher's reports. Children in the control group had no history of language difficulties and presented normal hearing and nonverbal cognitive skills measured with the same instruments.

Materials and design

Apparatus Eye movements were sampled monocularly at 500 Hz using the Remote Mode of the EyeLink 1000 Plus eye tracker system (SR Research, Ontario, Canada). To operate the system in the remote mode, a small target sticker was placed on the participants' forehead. Pictures were displayed using a high definition 24-inch widescreen display (BenQ

XL2430) at 1024 x 768 pixels at a refresh rate of 144 Hz viewed from a distance of 57 cm.

Stimuli We created 32 short phrases in Spanish composed of two single words (article + noun). All phrases were preceded by an imperative verb ('Look!') to draw the participant's attention to the screen. Half of them contained a definite article and the other half contained indefinite articles with the same gender and number distribution. The auditory stimuli were recorded by a Spanish native female speaker uttered in infant-directed speech (IDS). The mean length of the articles was 1431 ms (definite articles 1368 ms; indefinite articles 1495 ms). The visual stimuli included 32 images, illustrating four familiar objects within four different categories (vegetables, animals, toys and common house objects) on the four quadrants of the screen: A target (e.g. '*manzana*', apple), a number competitor which shared the number morpheme with the target (e.g. '*plátano*', banana), a gender-lexical competitor which shared both the gender and the lexeme morphemes with the target (e.g. '*manzanas*', apples) and a distractor which did not share either lexical or morphological information with the target (e.g. '*plátanos*', bananas). Objects corresponding to targets and competitors in the same trial belonged to the same category (see Figure 1). Using a Latin square design, we created four experimental lists that rotated the target object for each of the visual displays. Thus, each object in the display appeared as the target an equal number of times across the lists. The position of each type of object (based on their number and gender agreement) was counterbalanced across items.

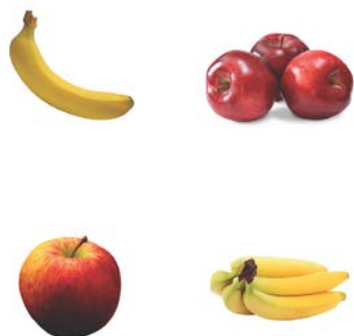


Figure 1. Visual display example for an experimental trial example.

Procedure

All participants were seated comfortably in the front of the computer screen in an isolated room at their school. Before the experiment started, a 5-point calibration was implemented. On each trial a centred fixation point was initially presented (drift check). The trial was manually triggered by the experimenter and a visual display (four objects) appeared in the screen. After 2750 ms, participants heard the verb '*Mira*' (look). Then, the article was played at 4000 ms after picture onset followed by the target noun at

5250 ms after picture onset. The image remained on the screen for 3000 ms after noun onset. Participants' eye movements were recorded during the whole experiment. The experiment lasted approximately 5 minutes, still a short break was taken, if necessary. The study was approved by the Ethics Committee of the Faculty.

Data analysis

We created four square areas of interest (AOI) surrounding each object displayed in the visual context, and a fixation report containing with the fixation's order, duration and locations using the Data Viewer software (SR Research). Subsequently, the R Project software (R Core Team, 2018), was used to examine every trial per participant and AOI on every millisecond. Then, fixation proportion to each AOI was calculated as the percentage of looks for each trial and across time, considering participants' fixations outside of the areas of interest as looks to the background.

Our analysis relied on a complementary approach based on confidence intervals for quantifiable effect size in terms of the magnitude and timing of preferential fixation proportion (see Cumming, 2014; Huettig & Guerra, 2019; Huettig & Janse, 2016), as well as a linear mixed effects regression (LMER, with the lme4 package, Bates, Maechler, Bolker, Walker, 2015) on the log ratio of the proportion of fixations between the target and the gender-lexical competitor (Arai, Van Gompel, & Scheepers, 2007) aggregated in three critical time windows.

To calculate confidence intervals, the proportion of fixation was aggregated into time windows of 250 ms, by participant and AOI. LMER models included the maximal random structure justified by the design but excluded the random correlations from the model to facilitate converge, keeping the within-unit intercepts (Barr, Levy, Scheepers, & Tily, 2013). Consequently, the regression analysis included the aggregated log ratio as a dependent variable, type of article (i.e., "Definite", "Indefinite"), children's group (i.e., SLI, TLD), and time window (i.e., article, noun, and silent window) as predictors. Article type and group were centred using a zero-sum contrast, which compares predictor level means to each other. To observe the changes in time, we used a sliding contrast (Venables & Ripley, 2002) in the time window predictor.

Results

First, we present the results of our confidence intervals analysis, which provides a detailed visual description of the fixation proportion pattern across time. Then, we compared online comprehension of articles in children with SLI and children with TLD through a LMER model on the log ratio across time windows.

Confidence Intervals results Figure 2 shows participants' gaze pattern over time divided by children's group with (within-subject) 95% confidence intervals as shaded areas around the full lines. In the upper panel, the proportion of fixation to each of the four images in the visual context is

depicted. The confidence intervals analysis shows that children with SLI exhibit no preference for the target between the onset of the article and the onset of the noun. After the noun onset, SLI children show a strong preference both for the target and the gender-lexical competitor, discarding the number competitor and the distractor. Results show a small preference for the target at 1600 ms after the noun onset which lasts for about 800 ms. By contrast, children with TLD show a preference for the target even before they heard the noun, and this preference further increases for the rest of the trial.

With regards to the effect of article type on the gaze pattern of children with SLI, confidence intervals show no preference for the target object before the onset of the noun, either when children heard either a definite or an indefinite article. Figure 3 shows the mean log ratio between target and gender-lexical competitor by group and by article type. This analysis reveals that the small, late preference for the target exhibited by children with SLI seems to be driven by the indefinite article. Children with TLD, in contrast, show a preference for the target before the onset of the noun. The graph also shows that preferential looks towards the target object start earlier for indefinite articles.

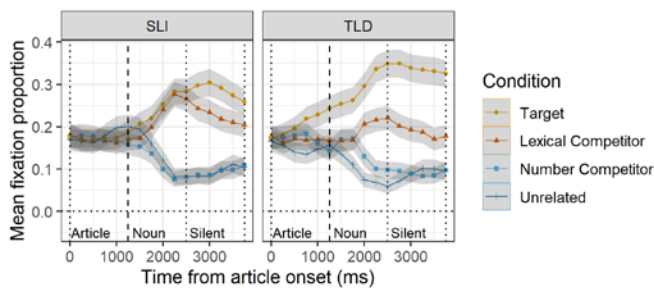


Figure 2. Mean fixation proportion and log ratio as a function of children’s group in time steps of 250 ms.

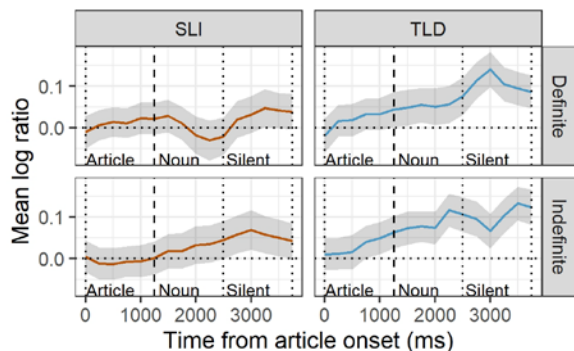


Figure 3. Mean log ratio as a function of children’s group and article type in time steps of 250 ms.

Linear mixed regression results The results of the LMER model on log ratio shows a main effect of children’s group ($\beta = 0.024$, $se = 0.007$, $t = 3.53$, $p < 0.01$, see Table 1). Overall, the proportion of looks to the target (relative to the lexical competitor) across time windows was higher for children with TLD than for children with SLI (see Figure 2). In

addition, we found an increase in the preference for the target over time, as evidenced by the significant difference between time window contrasts; overall, a larger preference for the target object was observed during the noun time window compared to the article time window ($\beta = 0.028$, $se = 0.012$, $t = 2.35$, $p < 0.05$), as well as in the silent time window relative to the noun time window ($\beta = 0.033$, $se = 0.012$, $t = 2.68$, $p = 0.01$, see Figure 2). No main effect of article type, or reliable interaction effects were observed (all t -values $< |2|$). Table 1 shows the summary of the LMER model on log ratio and Figure 4 illustrates the main effects identified in the LMER model.

Discussion

In the present study we compared the online comprehension of articles in monolingual Spanish-speaking children with SLI to a control group of children with TLD matched for age. Furthermore, we examined the performance of both groups on definite and indefinite articles to contribute to the surface hypotheses discussion. The results showed that children with SLI exhibit an impaired online comprehension of articles. Regarding the type of article, we observed that both groups of children performed similarly in definite and indefinite articles suggesting that the difficulties observed in children with SLI cannot be completely explained by the surface hypothesis.

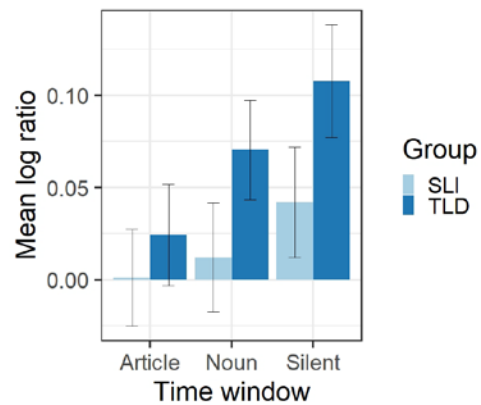


Figure 4. Mean log ratio as a function of children’s group and window of interest in time steps of 1250 ms.

Specifically, we observed that children with SLI did not look more at the noun referred to by the article before it was named, suggesting the lack of use of the gender or number information of articles to anticipate the noun. After the onset of the noun, children with SLI looked longer both at the corresponding noun (e.g. *manzana*/apple) and its gender-lexical competitor (e.g. *manzanas*/apples) discarding the competitors that had a different lexeme (e.g. *plátano*/banana and *plátanos*/bananas). These results indicate that visual attention in children with SLI was guided by the lexical information of the noun but not by the morphological information of the article. Conversely, children with TLD tended to look more to the corresponding noun even before it

was produced and this preference continue to increase after the noun onset. This reveals that children with TLD were able to predict the noun based on the morphological information of the article.

The time course curves also showed that after the noun (silent window), children with SLI presented a slight preference for the referred image. This slight tendency does not allow us to establish with certainty that the children with SLI were processing morphological information. However, it suggests that, at some level, they might integrate the morphological information provided by the article with the morphological information provided by the noun (i.e., the presence or absence of the morpheme *s*) to disambiguate the competition between the corresponding noun (e.g. *la manzana*/the apple) and its gender-lexical competitor (e.g. *las manzanas*/the apples).

Previous evidence in Spanish has shown that online comprehension of articles is preserved in older children with SLI (Christou et al., 2019). This previous study showed that bilingual (Catalan-Spanish) children with SLI (mean age 7.8 years) behaved similarly to their peers matched for age. Specifically, both groups looked longer at the target image after hearing the article, even before the referred noun was presented. When they split the SLI group into older (mean 9.07 years-old) and younger (mean 6.0 years-old) participants, the time-curves showed that both age groups tended to look more to the referred noun. However, children in the older group showed a significantly larger magnitude of the effect than the younger children. In our study, children with SLI were similar in age (5.8 years-old) to the younger group of Christou et al. Yet we did not find any clear effect of article processing.

Differences in difficulty between these two studies might be related to the distinct results. In Christou et al., semantic keys were given by the verb in some of the trials (e.g. “*la niña tira una piedra*”/‘the girl throws a stone’). These trials had a lexical competitor (e.g. *pedras*/stones) and two distractors (*cocina*/stove and *molino*/windmill). Thus, two of the distractors (stove and windmill) could be discarded before the onset of the article based on verbal semantic information. In contrast, in our experiment, no previous semantic information was given. This difference makes our task more demanding for younger children with SLI, revealing their article comprehension difficulties. Taken together, the results from Christou et al. and those from the present study suggest a developmental path in article comprehension, in which article comprehension tends to improve with age in Spanish-speaking children with SLI.

These findings are in line with previous results in the production of articles in monolingual Spanish-speaking children showing that young children (5.5 years of age; Morgan et al., 2013; 6.6 years of age; Coloma et al., 2016) present difficulties using articles. Altogether, evidence based on production and comprehension indicates that children with SLI present a slower development rate in article acquisition than children with TLD. However, there is no evidence in article production in Spanish-speaking children

older than 7 years of age. Thus, it is possible that comprehension and production reach a typical performance at different ages. Further studies, comparing comprehension and production in monolingual Spanish-speaking children with SLI at different ages are needed to understand better the developmental path of article acquisition.

Regarding the type of article, children with SLI performed worse than children with TLD in both types of article. Furthermore, we did not find differences in the magnitude of the response between article type (i.e., definite or indefinite) in any group. Nonetheless, we observed a tendency in the TLD group to look to the referred noun faster in indefinite than definite articles. Likewise, the tendency observed in the SLI group to look more to the referred noun after it was named was driven again by indefinite articles. The surface hypothesis (Leonard, 1998) predicts that indefinite articles are easier than definite articles since they are acoustically more salient. Thus, this tendency in favour of indefinite articles can be explained by this hypothesis. However, this tendency did not reach significant levels. In addition, our results showed that children have problems with indefinite articles which cannot be explained by the surface hypothesis. These suggest that acquisition of articles relies more on other levels of processing such as cognitive or linguistic levels.

There are not many studies addressing the surface hypothesis of children with SLI in languages other than English. Evidence in English-speaking children with SLI in favour of this hypothesis has shown that English-speaking children with SLI have problems with morphemes that are short in duration and unstressed such as the past tense -ed and third person singular -s (Leonard, 2014). In Spanish, evidence in production of articles by children with SLI shows that they make more mistakes with definite than indefinite articles (Restrepo & Gutierrez-Clellen, 2001). Similar results have been observed in bilingual children (Catalan-Spanish). Aguilar-Mediavilla, Sanz-Torrent and Serra-Reventos (2007) found that bilingual children with SLI omitted more articles compared to an age-control group, in particularly for definite articles (Aguilar-Mediavilla, Sanz-Torrent & Serra-Reventos, 2007).

Our findings cannot be fully accounted for by the surface hypothesis, since the comparison between the definite and indefinite articles revealed no significant effects of article type. This is in line with a comprehension study in Greek-speaking children with SLI, suggesting that the surface hypothesis is not sufficient to explain the grammar problem in this population (Chondrogianni et al., 2015). Specifically, the study showed that definite articles are less impaired than clitics pronouns even though both functional words have similar levels of acoustic saliency. More evidence from both comprehension and production research that contrast salient and non-salient functional words in Spanish is needed to define the extent to which this hypothesis explains the grammar problems of Spanish-speaking children with SLI.

To our knowledge this is the first study in monolingual Spanish-speaking children addressing the online comprehension of articles, contributing to decrease the gap of

knowledge about comprehension in Spanish-speaking children with SLI. The findings presented here indicate that children with SLI, unlike children with TLD at the same age, do not use morphological information of articles to predict their referred noun, indicating that they have difficulties in the comprehension of articles. Additionally, the differences in acoustic characteristics between definite and indefinite articles has a weak influence on the performances of participants, suggesting that the surface hypothesis is not central in explaining the difficulties in children with SLI.

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