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A Spanish Sign Language (LSE) adaptation of the Communicative Development Inventories

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Short Title

Spanish Sign Language adaptation of the CDI

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Abstract

This article presents the adaptation of the MacArthur Communicative Development Inventory (CDI; Fenson et al., 1993, 1994) to Spanish Sign Language (LSE). Data were collected from 55 participants (32 boys and 23 girls; 17 deaf signers, 38 hearing signers) who, evaluated by their caregivers every four months, presented a total of 170 records. The parents reported the signs that the children could understand or produce between 8-36 months. Results suggested that the CDI adapted to the LSE is a valid and reliable instrument. Signing children could understand more signs than they produced at this early developmental stage. There were no significant differences between boys and girls, or between deaf and hearing children. The development of the LSE is similar to that of other sign languages, although with a lower production of signs in the early stages, perhaps due to the bilingualism of most of the children of our study.

A Spanish Sign Language (LSE) adaptation of the Communicative Development Inventories

Spanish Sign Language (LSE) is the language used by the deaf community in Spain (with the exception of Catalonia, which has its own sign language). Like the other sign languages of the world, it is a system of regulated and visual-gestural communication that uses sight for the reception of the message, and movements, space, and facial and corporal expression for its production. However, studies devoted to the development of LSE are scarce (Álvarez et al., 2002; Caamaño, Juncos, Justo, López, & Vilar, 1999; Juncos et al., 1997; Marchesi, Alonso, Paniagua, & Valmaseda, 1995). Whilst research carried out with native children of different sign languages indicates important parallels in the patterns of acquisition of sign and oral languages (Baker & Woll, 2009; Chen Pichler, 2012; Schick, Marschark, & Spencer, 2006), a better understanding of the development of LSE is essential to aid the detection of disorders of language development in the Spanish deaf population.

One of the reasons for the lack of research into LSE is the absence of instruments to address its acquisition and development. This difficulty increases when attempting to assess early development of LSE with normative criteria. The MacArthur-Bates (Fenson et al. 1993, 1994) inventories are often used to measure the early communicative and linguistic development of oral languages. These inventories, also called Communicative Development Inventories (CDIs), were initially developed and published in the USA, but they are currently adapted to more than 50 oral languages. Such adaptations have advanced knowledge of oral communicative and linguistic development of hearing children between 8 and 30 months of age, and they have provided a considerable volume of normative data about their development. This study report the first adaptation of the CDI to LSE.

The CDI consists of checklists to be completed by the child's caregivers, in which the words the child understands or produces are marked. It has been shown that, due to their prolonged contact with the children, parents or habitual caregivers are well acquainted with the communicative and linguistic resources the children use and they provide reliable and representative information about their children's linguistic capacities (López-Ornat et al., 2005). Another advantage is that it is relatively short and easy to apply, and allows the evaluation to be performed in the family context, which is a functional and communicative context that is well-suited for language acquisition. As a result, CDIs have become the benchmark at the global level for the evaluation of communicative and linguistic development in young children.

In Spain, there is an adaptation of the inventories for Spanish oral language carried out by López-Ornat et al. (2005) and with adaptations to Gallician (Pérez & García, 2003), Basque (García, Arratibel, Barreña, & Ezeizabarrena, 2008), and Catalan (Serrat et al., 2005). The Spanish adaptation of the CDI by López-Ornat et al. consists of two scales: Inventory 1, for children from 8 to 15 months, *vocalizations, first words, and gestures*, and Inventory 2, for children from 16 to 30 months, *vocalizations, words, and grammar*. This adaptation has high internal consistency (Cronbach alpha of .70 to .99), high test-retest reliability coefficient (.843 to .987), and adequate content validity (López-Ornat et al., 2005).

With regards to sign languages, CDI versions for American Sign Language (ASL; Anderson and Reilly, 2002), and British Sign Language (BSL; Woolfe, Herman, Roy, & Woll, 2010) are available. In both cases, the age interval tapped by the scales (8-36 months) is higher than that employed to assess oral development (8-30 months). Both scales have provided normative data on deaf children born in deaf, signing families. Using the ASL, parallels have been observed between the acquisition and

development of oral language in hearing people and sign language in signing deaf people: between 12 and 18 months, the latter surpass the former in expressive vocabulary, but this difference gradually disappears, so that at 24 months, vocabulary is similar in both populations (Anderson & Reilly, 2002). The authors suggest there is no evidence of an acceleration in signed vocabulary, but rather a gradual and linear increase.

Regarding BSL, Woolfe et al. (2010) observed great heterogeneity both at the age and rate of the acquisition but, in general, they confirm an increment of signed lexicon similar to that found in hearing children using oral language. This includes an acceleration in the acquisition of vocabulary, which occurs similarly in deaf children who acquire BSL and in hearing children who acquire oral English. In the opinion of Woolfe et al., the discrepancy in the acceleration of vocabulary acquisition that occurred between ASL and BSL may have been due to the different the age ranges established for the data collection (six months in the ASL and four months in the BSL).

With respect to LSE, previous research has documented the development of signed vocabulary in implanted deaf children, collected with a pilot adaptation of the CDI to the LSE (Pérez et al., 2013). The development of 13 implanted deaf children was observed, aged 17 to 62 months – an age interval higher than the one included in the original scale. Results indicated that despite individual variability, the number of signs understood and expressed evolved parallel to the time of exposure to LSE and, as with oral languages, comprehensive vocabulary exceeded productive vocabulary. Signed linguistic development seemed to be affected by the auditory or deaf status of the caregivers, such that the children of deaf parents mastered vocabulary more successfully than the children of hearing parents.

This study presents data on the development of the LSE in native signing children, hearing and deaf, with similar ages (8 – 36 months) to that of the previous adaptations of the CDI to American (Anderson & Reilly, 2002) and British (Woolfe et al., 2010) sign languages. Unlike the study of Pérez et al. (2013), all the participants of this study were children of signing deaf parents. The goal is to observe the developmental trajectories of early vocabulary development and to analyze the possible differences between the children according to their audiological status, after controlling for that of their parents. In general, research on the acquisition of sign language of hearing Children of Deaf Adults (CODA) suggests that this group is not comparable to that of deaf children of deaf parents, because the two groups are likely to receive different input from their parents, with a higher percentage of vocal productions towards the hearing children (Van den Bogaerde & Baker, 2005). On the other hand, the CODAs can be considered bilingual as they have access to the development of both oral and sign language, whereas deaf children cannot (Van den Bogaerde & Baker, 2005). This would lead to different processes and rhythms of acquisition of the sign language for the two populations. In recent years, however, significant changes have occurred in the treatment and management of deafness in children (Knoors & Marschark, 2012). Early detection programs for deafness, the technological development of digital hearing aids, and performing cochlear implants at a very early age allow a large proportion of deaf children of deaf parents to be exposed to bimodal bilingualism (sign language-oral language) from early childhood. For this reason, it is of interest to analyze early development in LSE in the two samples separately. If there are no differences between the two groups, it could be considered that they constitute a single sample of subjects in the adaptation of the CDI to LSE. So, the main goals of this

study are: 1) to assess adaptation of CDI to LSE; 2) to compare deaf children and CODAs with respect to the early acquisition of LSE.

Method

Participants

The sample was comprised of 55 participants (32 boys and 23 girls) who, assessed every four months, provide a total of 170 records. Table 1 summarizes their characteristics, along with the number of records completed in each age range. All participants were native signers, and they were divided into two groups:

- Native Deaf Signers (n = 17; 12 boys and 5 girls), that is, deaf sons and daughters of deaf caregivers that use the LSE as the family communication language. This subgroup contributed a total of 49 records. All of them had congenital bilateral deafness, 11 of them to a profound degree, two to a severe degree, two to a moderate degree, and in the remaining two, the degree of hearing loss was still unknown. Six of the children were wearing cochlear implants (two of them bilaterally), and the implantation age was between 11 and 15 months. Of the remaining non-implanted children, nine were users of bilateral hearing aids, one used a unilateral hearing aid, and the other did not use any technical assistance. Twelve of the children were at least second-generation signers and the rest were first-generation signers (their grandparents were hearers). Three of the children were exposed to another oral language in addition to Spanish: two of the children are exposed to English at their school and one to Euskera in the family.
- Native Hearing Signers (n = 38; 20 boys and 18 girls), namely, hearing sons and daughters of deaf caregivers who use the LSE as the family communication language. This subgroup contributed a total of 121 records. Seven of the

children were at least second-generation signers (their grandparents were deaf signers), and the remainder was first-generation signers (30 of them signed with other deaf relatives, in addition to their parents). Eighteen of the children were exposed to another oral language apart from Spanish: 14 to English at school, and of them, one child was exposed to Russian in the family, two children were exposed to Euskera, and two to Valencian.

For inclusion in either subgroup it was sufficient for at least one of the caregivers to be a signing deaf person. Table 2 shows the characteristics of the family context. Participants presenting some associated disorder that could affect communicative development and/or cognitive development were excluded.

The participants were recruited by contacting the deaf people's associative movement, pediatric and otolaryngology consultants from hospitals and health centers, child education centers, and early care services. Recruitment was carried out throughout the whole of Spain (except for Catalonia, where the Catalan sign language is used instead of the LSE).

The children's participation in the study was preceded by an explanation to the families of the objectives and demands of the project, and written informed consent was obtained from the legal guardians of the minors.

<Table 1 here>

<Table 2 here>

Instruments

Two instruments were employed for data collection: a questionnaire to describe the sample and the CDI adapted to the LSE. The questionnaire was presented in writing, accompanied by explanations in LSE when necessary.

Authorization was obtained from the authors of the original instrument to adapt the CDI MacArthur-Bates to the LSE. The CDI Advisory Board granted us the Level 1 (full authorization) to adapt the inventory.

The adaptation of the original CDI (Fenson et al. 1993, 1994) to LSE was carried out from the inventory adapted to the Spanish oral language (López- Ornat et al., 2005) and from those adapted to ASL and BSL (Anderson & Reilly, 2002; Woolfe et al., 2010). When adapting the two original scales (for children from 8 to 15 months and for children from 16 to 30 months) to LSE, a single inventory was used that extended the age range to cover the period of 8 to 36 months. This was in line with the previous signed versions. In addition, the necessary adjustments were made to make it culturally and linguistically appropriate to the communicative development of Spanish signing children. To achieve this, four native deaf signing professionals, who were specialists in LSE and had experience in early childhood education (Pérez et al., 2013), reviewed the inventory. The result was an inventory made up of a total of 532 signs, divided into 20 categories, and 21 sentences of early comprehension.

After conducting a pilot study with a sample of 12 children in order to check whether the list of contemplated signs were those that are actually observed in signing children of those ages, the inventory was reviewed for this study. The final set included 27 sentences of early comprehension and 569 signs divided into 20 categories: games and routines (28 signs), animals (42), people (29), toys (17), vehicles (14), food and beverages (62), clothing (30), places to go to (21), outdoor objects (24), little things from home (41), furniture and rooms (22), signs of action (96), descriptive signs (64), time (15), pronoun (16), signs for asking (8), prepositions and locatives (17), quantifiers (11), auxiliary verbs (9) and connection signs (3).

The final adaptation of the inventory was published on a website, thanks to the

collaboration with the Fundación CNSE para la Supresión de las Barreras de Comunicación (http://www.fundacioncnse.org/cdi/). The purpose of the publication was to provide families with an accessible instrument to consult the signs included in the inventory. The inventory was to be completed by deaf fathers and mothers, although the majority did not know all the written words that appeared in the written format of the inventory. Hence, and to facilitate the completion of the inventory, the website contained videos in which each one of the words that appeared in the inventory was associated with its corresponding LSE sign.

Procedure

After the families had agreed to participate and had authorized data collection from the children, a researcher from the team (a native signer) visited them and explained how to use the inventory and how to send the results of their observations. The questionnaire describing the sample was also administered during this first visit to the families.

Parents recorded their children's receptive and expressive vocabulary by marking on a list which signs the children were capable of understanding or expressing.

Multiple observations of the children's communicative development was collected, following a procedure similar to that applied by Anderson and Reilly (2002) in their adaptation of the CDI to ASL, and by Woolfe et al. (2010) in their adaptation to BSL. Thus, each child was assessed every four months until the age of 36 months. When the child reached the age of 18 months, the parents were sent a copy of the questionnaire of the previous section (12-15 months), so that they could enter the data in it, as recommended in the data collection of the original CDI. The procedure of evaluating the children every four months has allowed us to carry out an analysis of the cross-sectional (by age groups) and longitudinal data (by development of each age

group). The records of each child in each age range assessed are shown in Table 3. Each record corresponds to the evaluation of the receptive and expressive vocabulary made by the parents on the sign language that their own child was acquiring with a periodicity of four months since the beginning of their participation in the study.

Following the same procedure as Woolfe et al. (2010), the complete data set was reviewed in order to eliminate any items that had been chosen two or less times by the whole sample. However, no items were eliminated because all had been selected at least twice by within expressive and receptive vocabulary.

<Table 3 here>

Results

Reliability and Validity

The reliability and validity of the data was investigated following the procedure employed by Anderson and Reilly (2002) and Woolfe et al. (2010). A subgroup of the participants (22%; 12 boys, three of them deaf), covering all the age intervals, was recorded in a situation of playful interaction (using an image book and playing with an interactive table and a game of stacking objects). The signs produced by the children were recorded and subsequently coded separately by a native signer and a non-native signer with fluent knowledge of the LSE. Inter-rater reliability on the data by the two coders was high (r = .996 for expressive vocabulary; r = .975 for receptive vocabulary).

To analyze test-retest reliability, the correlation was calculated between the measurement of vocabulary development obtained by the CDI-LSE questionnaire at a certain time and the measure obtained by the same questionnaire and evaluator one month or a month and a half later. This procedure was applied to 20% of the children of the sample (11 boys, two of them deaf), covering all the age intervals. Test-retest

reliability was high for receptive (r = .935; individual scores range: .748 - .975) and expressive vocabulary (r = .980; individual scores range: .715 - .997). This reliability rate was comparable with that reported for the oral version of the Spanish CDI (r range: .838 - .987, for Inventory 1; and r range: .883 - .986, for Inventory 2), suggesting that parents are highly consistent in their reporting of their child's sign language production (Anderson & Reilly, 2002).

Two analyses were carried out to assess validity. First, the signs marked by the parents on the questionnaire the day before the recording were correlated with the signs observed during the play interaction. Significant correlations were found for total scores (r = .815 for expressive vocabulary; r = .969 for receptive vocabulary).

Second, following the validation procedure of Anderson and Reilly (2002), the relationship between the scores obtained in the questionnaire and in the recording was analyzed, by counting the signs that were in common between the videotape session and the LSE-CDI reported by the parents. A ratio between the two scores was then calculated: a first score was provided by the number of signs produced by the child during the videotape and endorsed by the parent on the LSE-CDI, and a second score was obtained from the total number of signs produced by the child that the parent may have either endorsed or not on the LSE-CDI. In the case of sign production, an external validity score of .87 (range: .67 - 1.00) was obtained, and for comprehension, an average score of .88 (range: .60 - 1.00) was recorded. In both cases, the data indicated valid reporting of the children's use of LSE by parents as in the CDI adaptations to other sign languages (Anderson & Reilly, 2002; Woolfe et al., 2010).

LSE scores distribution

Table 3 presents the overall results, and expressive and comprehension vocabulary by age and sex. There was considerable individual variation across the

initial period of the evaluation. The mean number of signs produced in the youngest age bracket was very low: between the ages of 8 and 11 months, the evaluated children produced between 0 and 5 signs. From 8 - 11 months to 12 - 15 months, and from this interval to 16 - 19 months, there was a significant advance in the average number of produced signs, which resembles the acceleration of vocabulary described in oral languages. Children understood more signs than they produced at all ages: at 8 - 11 months, $z(16) = 3.52$, $p < .001$, $\eta^2 = 12.686$; at 12 - 15 months, $z(19) = 3.73$, $p <$,001, $\eta^2 = 12.594$; at 16 - 19 months, $z\ (27) = 4.54$, $p < .001$, $\eta^2 = 12.365$; at 20 - 23 months, $z(21) = 4.02$, $p < .001$, $\eta^2 = 12.493$; at 24 - 27 months, $z(26) = 4.54$, $p < .001$, $\eta^2 = 12.385$; at 28 - 31 months, $z(30) = 4.70$, $p < .001$, $\eta^2 = 12.32$; and at 32 - 36 months, $z(31) = 4.83$, $p < .001$, $\eta^2 = 12.309$. The development that the comprehensive vocabulary followed was similar to that of the expressive vocabulary, as shown in Figure 1. In fact, both measures correlate at all age ranges: at 8 - 11 months, $r(16) = .64$, $p = .008$; at 12 - 15 months, $r\ (19) = .68$, $p = .001$; at 16 - 19 months, $r(27) = .72$, $p < .001$; at 20-23 months, $r(21) = .58$, $p = .006$; at 24 - 27 months, $r(26) = .86$, $p < .001$; at 28 - 31 month, $r(30) = .89$, $p < .001$; and at 32 - 36 months, $r(31) = .81$, $p < .001$.

Sex differences in expressive and comprehensive vocabulary were examined within each age group. Bonferroni corrections for multiple comparisons were applied, reducing the alpha level to .007. The analyses carried out found no significant differences between boys and girls in any of the age ranges, either in expressive or comprehensive vocabulary. No significant differences were found between boys and girls when the sample was split into Native Deaf Signers and Native Hearing Signers. Table 3 presents boys' and girls' scores.

Table 4 shows the comparison between the signs produced in each of the age ranges in LSE and those produced in the same intervals in ASL and BSL. Between 8

and 15 months, the LSE signers produced fewer signs than their peers in the other two sign languages. As of 16 months, the production figures between the three languages converge, with more similarities between the LSE and the BSL. Within each language enormous individual variability was evident between the users of sign languages.

<Figure 1 here>

<Table 4 here>

Results according to audiological status

Table 5 presents the data of expressive and comprehensive vocabulary of the sample divided into the two subgroups: Native Deaf Signers and Native Hearing Signers. There were no significant differences between hearing and deaf children in any age bracket, nor were there significant differences when the groups were split by sex. However, the small sample size should be considered when drawing conclusions.

<Table 5 here>

Developmental data

In 40 children (12 deaf children and 28 hearing children), more than one questionnaire on the use of the LSE was collected, providing developmental data the majority of participants. By selecting only those for whom three or more full developmental periods, was collected this sample was reduced to 29 children (7 deaf children and 22 hearing). Of these, 11 were missing a consecutive questionnaire (see Table 1). To replace this missing datum, the average of the signs produced in the age range before and after the missed questionnaire was taken. Figures 2 and 3 show the evolutionary trajectories of the deaf and hearing children evaluated in terms of their signed production and with reference to the averages observed in their group.

In the group of Native Deaf Signers, all participants maintained a development of signed production, and there were no children with two standard deviations above or

below the mean of the signed production of their group in each age range. Of the Native Hearing Signers, no child's signed production was two standard deviations below the mean of the children of their group at each age range, although there were four participants (305, 311, 317, and 329) who, between 12 and 23 months of age, presented a signed production that was two standard deviations above the mean of their group.

<Figure 2 here>

<Figure 3 here>

Factors associated with early vocabulary development

In line with the oral Spanish adaptation of the CDI (López-Ornat et al., 2005), the relationship between maternal (and, in the current study, paternal) education and birth order with early vocabulary level was analyzed. Separate analyses were conducted for each age range to avoid the same participant being entered into an analysis multiple times.

The educational level included seven categories: 1) No studies; 2) Primary education; 3) Graduated from Compulsory Secondary Education (CSE); 4) High school; 5) Medium-degree vocational training; 6) Higher degree vocational training; 7) University Degree/Diploma/Graduate. No parent did not study at all, so to facilitate the analyses, the levels in were regrouped into: 1) Primary education, CSE; 2) High school or medium or higher degree vocational training; and 3) University studies. No differences were found due to the fathers' or mothers' educational level in the children's expressive or comprehensive vocabulary at the age intervals 8-11, 12-15, 16-19, 20-23, and 24-27 months. In the interval of 28-31 months, only the educational level of the father was associated both with comprehensive vocabulary, $H(2) = 6.31$, $p < .05$, and expressive vocabulary, $H(2) = 8.25$, $p < .05$. However, after post-hoc analyses,

applying the Bonferroni correction, the differences only manifested in the expressive vocabulary of children whose parents had primary studies versus those whose parents had attended high school or equivalent studies (M = 165.90 vs. M = 318.13; $U(25)$ = 29.00, $p < .01$, $\eta^2 = .278$). The same result was obtained with the children in the age range of 32-36 months. The educational level of the father was related to the level of expressive vocabulary, $H(2) = 9.18$, $p < .05$: the children whose parents had a High school education or equivalent presented more signed vocabulary than those with Primary studies (M = 441.76 vs. M = 326.22; ($U(25) = 25.00$, $p < .01$, $\eta^2 = .323$).

Regarding the birth order, in the intervals of 8-11, 12-15, 16-19, and 20-23 months, no differences were observed between children that were first-born and children that were not first-born. However, at the age of 24-27 months, significant differences were observed according to the birth order, The first-born outperformed those that were not first-born in comprehensive vocabulary (M = 374.94 vs. M = 225.50; $U(25) = 31.00$, $p = .05$, $\eta^2 = .257$), and in expressive vocabulary (M = 267.56 vs. M = 135.40; $U(25) = 20.50$, $p = .05$, $\eta^2 = .378$). The same was observed at the age of 28-31 months regarding the birth order, both in comprehensive vocabulary (M = 423.60 vs. M = 180.60; $U(29) = 51.00$, $p = .05$, $\eta^2 = .217$) and in expressive vocabulary (M = 343.20 vs. M = 180.60; $U(29) = 36.00$, $p = .05$, $\eta^2 = .336$). The effect was also apparent at the age of 32-36 months in comprehensive vocabulary (M = 468.75 vs. M = 365.60; $U(30) = 59.50$, $p = .05$, $\eta^2 = .184$) and expressive vocabulary (M = 392.50 vs. M = 226.20; $U(30) = 43.00$, $p = .05$, $\eta^2 = .299$).

In line with Woolfe et al. (2010), a second set of analyses was conducted using only expressive vocabulary scores, which are considered more reliable and valid than the scores in comprehensive vocabulary (Law & Roy, 2008). Only participants with more than two consecutive questionnaires were included in the analysis (n = 29; 7 deaf

children). Three measures were analyzed: rate of vocabulary learning (number of items/month) and onset age for vocabulary learning (months), both based on the slope of the regression line (the unstandardized coefficient, B) and on the intercept (constant/A) (Woolfe et al., 2010). The third measure was vocabulary size at 32-36 months, which was the age range with the highest number of completed questionnaires (n = 31). In the case of Woolfe et al., 2010, the 20 - 23 month interval was employed.

The estimated mean rate of expressive vocabulary learning was 13.96 signs/month (SD = 7.24, range: 2.30 – 32.32 signs/month), figures very similar to those found in BSL (13.5 signs/month, SD = 7.49, range: 2.58 – 32.44). The mean age that vocabulary learning began was 13.24 months (SD = 3.96, range: 4.50 – 23.21 months), a little higher than BSL (11.61 months, SD = 2.35, range: 5.07 –16.12 months). The mean vocabulary in the range of 32-36 months was 312.03 signs (SD = 149.42, range: 68 – 547 signs), similar to that obtained in BSL (M = 348.13, SD = 114.88; range: 124 – 517 signs). As expected, this measure correlated with the rate of learning, $r(22) = .756$, $p < .001$, so that the children who learned more words per month reached a higher level of vocabulary as they approached three years of age.

In contrast to Woolfe et al. (2010) reporting on BSL, the age of onset did not correlate with the vocabulary reached at three years. However, in line with BSL, the age of onset did not correlate with the learning rate. Table 6 shows the correlation between these three measures of expressive development of sign language and chronological age, the age of acquisition of the LSE and the educational qualifications of the mothers and fathers. The only significant correlation was evident between the educational level of the father and the level of expressive vocabulary reached at 32-36 months.

<Table 6 here>

Percentile scores for receptive and expressive sign language

Table 7 presents the percentiles (10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th}) equivalent to the scores obtained in expressive and comprehensive vocabulary of the whole sample of participants. As no significant differences were observed between the boys and girls or between the group of deaf and hearing participants, these calculations were made with the complete sample.

<Table 7 here>

Discussion

The adaptation of the MacArthur CDI to the LSE has provided a valid instrument to evaluate early signed communicative development in children aged 8-36 months. We propose that it is capable of detecting possible delays in the acquisition of LSE with similar validity and reliability as adaptations of the instrument to other oral (Fenson et al., 1993, 1994; García et al., 2008; López-Ornat et al., 2005; Pérez & García, 2003) and sign languages (Anderson & Reilly, 2002; Woolfe et al., 2010).

The pattern of growth of early vocabulary in the LSE resembled that found in other sign languages that were evaluated with the same instrument (Anderson & Reilly, 2002; Woolfe et al., 2010): first, at all age intervals, more signs are understood than are produced; second, individual variation was very high in all the age ranges evaluated, particularly in expressive vocabulary in the younger children, in which the standard deviation is higher than the mean. This data may be reflecting the influence of key factors in language development, such as the quality of linguistic input the children receive.

The average number of signs produced in the first observed age interval (8 - 11 months) was very low, so, in this study, precociousness in deaf children's early lexical acquisition of sign language compared to that described for hearing children who acquire an oral tongue was not observed. This precociousness in the production of signs

has also been questioned in other recent investigations with deaf children (Rinaldi, Caselli, Di Renzo, Gulli & Volterra, 2014).

Here, results suggest that between 8 and 15 months, LSE signers produce fewer signs than their peers in two other sign languages (BSL and ASL). This lower production of signs in Spanish children may be accounted for by the greater incidence of bilingualism in this sample (some participants were hearing signers, and some participants were deaf children wearing cochlear implants, hearing aids, and/or have some hearing residuals). It is also likely that the input received by bimodal bilingual children from their deaf parents will contain an increase in oral productions. Research indicates that deaf parents include more oral productions when they sign to their hearing children and we cannot disregard the fact that this accommodation to the audiological conditions of the child also occurs when deaf children wear a cochlear implant. Traditionally, in Spain, an oral approach has prevailed in the education of deaf people, so it is not surprising that deaf adult signers educated in this context include a greater number of oral lexical elements in their interactions with their deaf children. This means that children who are native signers acquire their lexicon in both oral and sign language and that, as with children in contexts of oral bilingualism, the acquisition of two languages can give rise to a slower process of lexical incorporation (Hoff & Core, 2013). Thus, in order to determine the actual vocabulary of bilingual children, the lexicon they develop in both languages should be taken into consideration (Hoff et al., 2012; Marchman & Martínez-Sussmann, 2002; Pearson, Fernandez & Oller, 1993).

However, the estimated mean rate of expressive vocabulary learning is very similar between LSE and BSL. At 16 months, the production figures between the three languages approach each other, with closer similarities between LSE and BSL than between these two languages and ASL. In this case, the reasons for the differences may

be found in cultural aspects. For example, there may be a greater exposure to sign language in the early care services in the USA than in other countries. Also, factors relating to the passing of time: the CDI in ASL was developed almost 20 years ago, and the treatment of deafness has recently undergone major changes providing children with greater and better possibilities of learning oral language. This means the deaf population is increasingly exposed to bimodal bilingualism from an early age (Knoors & Marschark, 2012).

An abrupt increase of vocabulary around 16-19 months was observed in the current study, which mirrors the acceleration of the vocabulary that is typical of oral languages. This acceleration was observed in BSL, but not in ASL, a difference attributed by Woolfe et al. (2010) to the different size of age intervals employed: four months in the case of BSL and six months in the case of ASL. Here, as four-month age intervals were used, the same phenomenon of acceleration of vocabulary was observed as in BSL.

In terms of gender differences, boys and girls exhibited similar receptive and expressive vocabulary. Woolfe et al. (2010) did not find any differences between boys and girls in BSL. In the Spanish adaptation of López-Ornat et al. (2005), there were no differences between boys and girls at the age of 8 to 11 months in terms of comprehension and production of words, but at 25 months a difference was observed which the authors attributed to an anomalous decrease in their data of the vocabulary development.

With regard to the variables associated with early development of sign languages, Woolfe et al. (2010) found that parental educational level and training in BSL was significantly related to the development of the children's vocabulary. Anderson and Reilly (2002) did not offer information on the educational or professional

level of the parents of the sample of children in their study. In the oral CDI, the mother's educational level was related to the comprehension of words only in children from 12 to 15 months; children of mothers with primary studies or without schooling scored higher than those with secondary studies and those with university studies. These data coincide with the Mexican and American normative studies regarding the higher averages presented by children of mothers with lower educational levels, which was interpreted as the mothers' possible bias towards a more favorable view of the development of the child's comprehension (López-Ornat et al., 2005). However, in expressive vocabulary, no relationship was found with the mother's educational level in either of the two inventories (8 - 15 and 16 - 30 months). In LSE, only the father's educational level was related to expressive vocabulary from 28 months. Why the father's educational level has this relationship with the acquisition of sign language is unclear, but it could reflect the evolution that society has experienced in recent decades with a greater involvement of the father in the children's education. This may explain why this relationship emerges now and not in previous studies. Also, the correlation might be because the father's education level is related to the family's income, which, in turn, may imply more resources for better education.

Birth order was also significantly related to vocabulary attainment in LSE. In the Spanish oral CDI, differences were found in favor of the first-born in the production of words from 16 to 20, and 21 to 25 months (López-Ornat et al., 2005). Here, results replicated this finding, although in a later age bracket. The first-born had an advantage in signed comprehensive and expressive vocabulary from 24 months, perhaps due to receiving more adult sign language input than the second child.

In conclusion, we propose that the adaptation of the CDI to LSE provides a valid evaluation instrument to measure early linguistic development of signing children.

Results can be compared to those achieved by the oral versions of the CDI. By employing this instrument, future studies will be able to shed light on the differences between native and non-native signers in relation to the development of signed vocabulary in the LSE, as well as on the relationship between the development of vocabulary in sign language and in oral language found in bimodal bilingual children. This instrument will also aid the development of detection of possible delays and early intervention in the implementation of the LSE of native signing children. Also, monitoring and evaluating the progress of non-native deaf children whose exposure to the LSE is delayed.

Despite these findings, a number of limitations to the present study must be acknowledged. The sample size was relatively small, due to the low prevalence of auditory problems in the population, the reduced percentage of deaf signing parents and the difficulty gaining access to these families. This gave rise to the other limitation of the study: the inclusion of hearing participants, who were not included in the other CDI adaptations to sign languages. However, the deaf population has evolved in recent decades in terms of access to oral language, thanks to cochlear implants, digital hearing aids, and universal auditory screening, all of which is allowing deaf children to have more opportunities to be bimodal bilingual in the same way as their hearing peers born in signing deaf families. Therefore, whilst the inclusion of these children represents a discrepancy between this study and previous adaptations of the CDI, we propose that it was a necessary development to reflect the changing situation of deaf individuals. This also paves the way for future studies researching bimodal bilingualism.

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Table 1. *Participants and datasets corresponding to each age range*

Code	Deaf	Gender	Age range (months)							
			8-11	12-15	16-19	20-23	24-27	28-31	32-36	Total
100	Yes	Female	1	1	1		1	1	1	6
101	Yes	Male	1	1	1	1	1	1	1	7
102	Yes	Female						1	1	2
103	Yes	Male	1	1	1			1	1	5
104	Yes	Male					1	1		2
105	Yes	Female			1	1	1	1	1	5
106	Yes	Male			1					1
107	Yes	Male				1	1	1	1	4
108	Yes	Male						1	1	2
109	Yes	Male					1	1		2
110	Yes	Female			1		1	1	1	4
113	Yes	Male				1	1		1	3
114	Yes	Male	1							1
115	Yes	Male	1	1						2
116	Yes	Male			1					1
117	Yes	Male		1						1
118	Yes	Female			1					1
300	No	Female		1	1					2
301	No	Male		1	1		1	1	1	5

302	No	Male					1	1		2
303	No	Male					1	1	1	3
304	No	Female	1	1	1	1		1	1	6
305	No	Female				1	1	1	1	4
306	No	Female			1	1	1	1	1	5
307	No	Male			1	1	1	1	1	5
308	No	Female					1	1	1	3
309	No	Female			1					1
310	No	Male	1	1	1	1		1	1	6
311	No	Female	1	1	1	1		1	1	6
312	No	Male					1			1
313	No	Male	1	1	1	1	1	1	1	7
314	No	Female							1	1
315	No	Male	1	1	1	1				4
316	No	Female	1	1	1	1	1	1		6
317	No	Male				1	1	1	1	4
318	No	Female			1					1
320	No	Male							1	1
321	No	Male							1	1
322	No	Female					1	1	1	3
323	No	Female					1		1	2
324	No	Male						1	1	2
325	No	Male							1	1
326	No	Female		1	1	1		1	1	5

327	No	Male					1	1	1	3
328	No	Male			1	1	1	1	1	5
329	No	Female	1	1	1	1				4
330	No	Female	1		1	1	1			4
331	No	Male						1	1	2
332	No	Female		1		1		1		3
333	No	Female		1	1	1	1			4
334	No	Male	1	1	1	1				4
335	No	Male		1	1					2
336	No	Male					1			1
337	No	Female	1							1
338	No	Male	1							1
Total number of datasets per age range			16	19	27	21	26	30	31	170
Age mean of each dataset (months) (SD)			8.8 (0.9	13.1 (1.2)	17.6 (1.2)	21.6 (1.1)	25.3 (1.3)	29.4 (1.3)	33.4 (1.3)	

Table 2. *Family context*

	Deaf Native Signers (n = 17)	Hearing Native Signers (n = 38)
Deaf fathers / LSE users	16 / 17	34 / 37
Deaf mothers / LSE users	16 /17	32 / 38
Fathers' age	*M* = 37.48 (*SD* = 7.79) ; 26.58 – 52.29	*M* = 35.89 (*SD* = 5.61) ; 21.23 – 46.18
Mothers' age	*M* = 32.55 (*SD* = 3.36) ; 27.72 – 39.13	*M* = 34.42 (*SD* = 4.62) ; 21.27 – 43.34
Fathers' level of education	Primary studies: 2 Compulsory secondary education: 3 High school degree: 2 Vocational training degree: 7 University degree: 3	Primary studies: 7 Compulsory secondary education: 6 High school degree: 1 Vocational training degree: 17 University degree: 3
Mothers' level of education	Primary studies: 2 Compulsory secondary education: 4 High school degree: 2 Vocational training degree: 6 University degree: 3	Primary studies: 5 Compulsory secondary education: 4 High school degree: 3 Vocational training degree: 19 University degree: 6

Note: No family data could be obtained for one of the hearing children (code 300) except that her parents were deaf signers. We also did not obtain data on the level of education of three fathers in the Hearing Native Signers group.

Table 3. *Expressive and receptive scores in LSE according to age range (months) and gender*

Age range	*N*	Total expressive				Total receptive			
		Mean	*SD*	Min.	Max.	Mean	*SD*	Min.	Max.
Total									
8-11	16	1.56	1.81	0	5	16.19	24.77	1	102
12-15	19	13.68	12.59	0	47	49.21	41.12	3	156
16-19	27	70.67	41.95	9	187	167.41	81.64	22	328
20-23	21	145.81	98.89	40	336	261.19	118.2	73	467
24-27	26	216.73	123.95	17	486	317.46	142.89	39	534
28-31	30	261.90	142.68	16	526	356.83	145.72	48	566
32-36	31	312.03	149.42	68	547	418.84	122.32	127	564
Boys									
8-11	9	1.56	2.19	0	5	21.89	31.69	1	102
12-15	10	9.50	8.77	0	29	52.90	45.27	3	156
16-19	12	60.83	25.96	12	112	159.75	63.82	85	328
20-23	10	145.90	84.53	63	327	272.10	113.85	114	467
24-27	15	223.73	111.01	50	410	318.20	117.8	102	507
28-31	17	258.41	129.9	16	462	372.24	131.37	135	535
32-36	18	288.32	142.24	86	517	416.28	114.99	173	564
Girls									
8-11	7	1.57	1.51	0	4	8.86	9.14	1	27
12-15	9	18.33	14.97	4	47	45.11	38.25	15	136
16-19	15	78.53	50.88	9	187	173.53	95.33	22	303

20-23	11	145.73	114.57	40	336	251.27	126.90	73	423
24-27	11	207.18	144.85	17	486	316.45	177.81	39	534
28-31	13	266.46	163.28	23	526	336.69	165.93	48	566
32-36	13	344.77	158.6	68	547	422.38	136.58	127	564

Table 4. *Descriptive statistics of expressive vocabulary (signs) in LSE, ASL, and BSL*

Age range (months)	LSE	ASL (Anderson & Reilly, 2002)	BSL (Woolfe et al., 2010)
	M (*SD*)	*M* (*SD*)	*M* (*SD*)
8 - 11	1.56 (1.81) Range: 0 - 5	5 (5.90) Range: 2 – 17	3.76 (7.3) Range: 0 - 30
12 - 15	13.68 (12.59) Range: 0 - 47	55.45 (35.88) Range: 4 – 107	15.83 (22.58) Range: 0 - 100
16 - 19	70.67 (41.95) Range: 9 - 187	141.7 (90.44) Range: 18 – 295	59.29 (58.61) Range: 2 - 239
20 - 23	145.81 (98.89) Range: 40 - 336	187.4 (122.85) Range: 83 – 454	126.89 (93.88) Range: 7 - 338
24 - 27	216.73 (123.95) Range: 17 - 496	252.33 (105.90) Range: 35 – 454	203.6 (145.07) Range: 28 - 501
28 - 31	261.90 (142.68) Range: 16 - 526	317.64 (115.76) Range: 122 - 499	268.33 (106.78) Range: 97 - 480
32 - 36	312.03 (149.42) Range: 68 - 547	359.94 (100.28) Range: 166 - 519	348.13 (114.88) Range: 124 - 517

Table 5. *Descriptive statistics of sign vocabularies in LSE of deaf and hearing children.*

		Total expressive vocabulary				Total receptive vocabulary			
Age (months)	*N*	*M*	*SD*	Min.	Max.	*M*	*SD*	Min.	Max.
Deaf children									
8-11	5	1.80	2.17	0	5	10.20	6.05	2	19
12-15	5	7.40	7.02	0	19	30.20	11.12	15	43
16-19	8	86.5	55.55	9	187	173.13	93.55	22	303
20-23	4	214.25	102.68	92	336	293.75	146.31	114	416
24-27	8	231.63	137.43	17	440	318.38	159.71	39	507
28-31	10	280	129.44	23	480	338.90	156.86	48	518
32-36	9	342.11	145.97	68	508	391.56	163.50	127	539
Hearing children									
8-11	11	1.45	1.81	0	5	18.91	29.66	1	102
12-15	14	15.93	13.56	3	47	56	45.98	3	156
16-19	19	64	34.4	12	135	165	78.76	60	328
20-23	17	129.71	93.80	40	332	253.53	114.56	73	467
24-27	18	210.11	121.1	50	486	317.06	139.73	102	534
28-31	20	252.85	151.25	16	526	365.80	143.19	135	566
32-36	22	299.73	152.42	86	547	430	103.65	228	564

Table 6. *Correlations between three measures of children's expressive vocabulary development and mothers' and fathers' age, mothers' and fathers' age of acquisition of LSE, and mothers' and fathers' educational aptitudes*

Children's expressive vocabulary	Age		Age of LSE acquisition		Educational aptitudes	
	Mothers	Fathers	Mothers	Fathers	Mothers	Fathers
Rate of learning (n = 29)	r = .043 p = .825	r = .121 p = .531	r = -.253 p = .185	r = -.234 p = .231	r = -.022 p = .910	r = .094 p = .640
Start age of vocabulary learning (months) (n = 29)	r = .350 p = .563	r = .108 p = .576	r = .066 p = .734	r = .181 p = .356	r = -.317 p = .093	r = -.194 p = .322
Vocabulary size (32-36 months) (n = 31)	r = -.307 p = .093	r = .001 p = .997	r = -.035 p =. 852	r = -.205 p = .287	r = .169 p =.363	r = .541 p = .002

Table 7. *Percentile scores for receptive and expressive sign language at different age intervals (months)*

	Percentiles									
	Expressive Sign Language					Receptive Sign Language				
Age	10	25	50	75	90	10	25	50	75	90
8-11	0	0	1	3	5	1	3	7	19	61
12-15	3	5	9	23	33	14	22	37	70	138
16-19	29	43	64	95	139	74	106	162	238	295
20-23	57	68	111	215	331	111	173	235	394	422
24-27	86	140	193	295	422	134	193	334	432	516
28-31	115	156	234	374	480	151	228	391	490	535
32-36	134	193	387	433	517	233	345	443	531	558

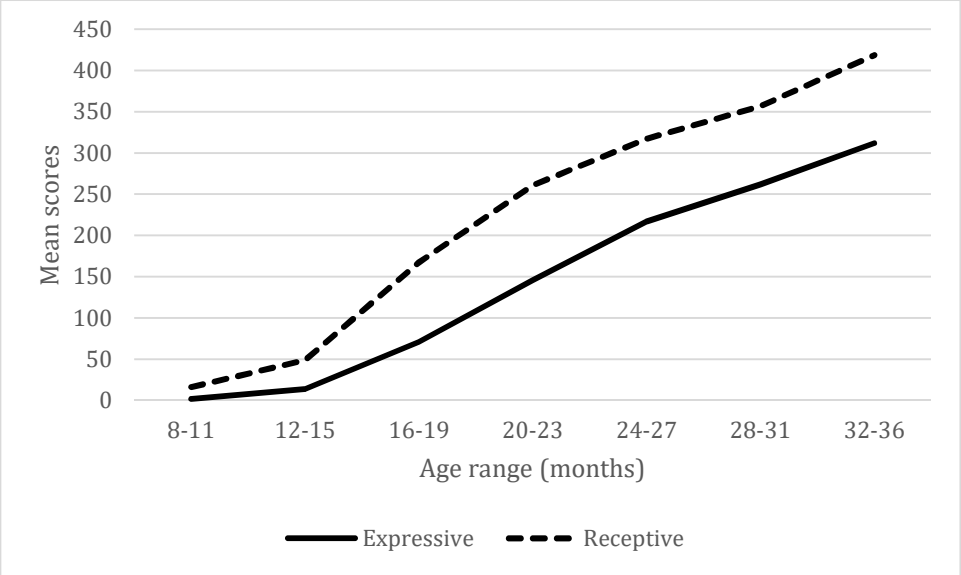

Figure 1. Expressive and receptive scores by age range.

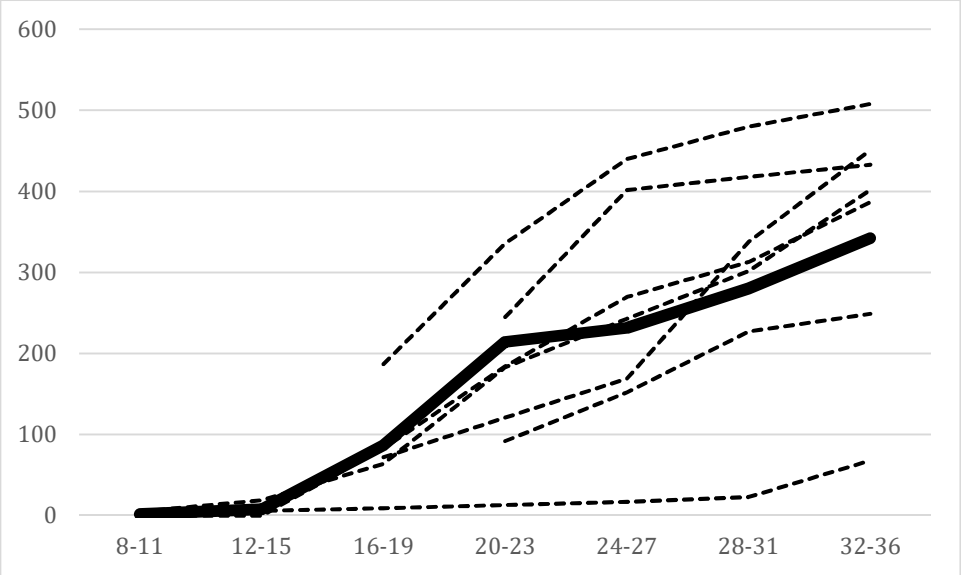

Figure 2. Individual growth trajectories of deaf children (n = 7) for mean expressive scores across the age ranges.
Note.- The thickest line corresponds to the mean of expressive vocabulary of all deaf children in each age range.

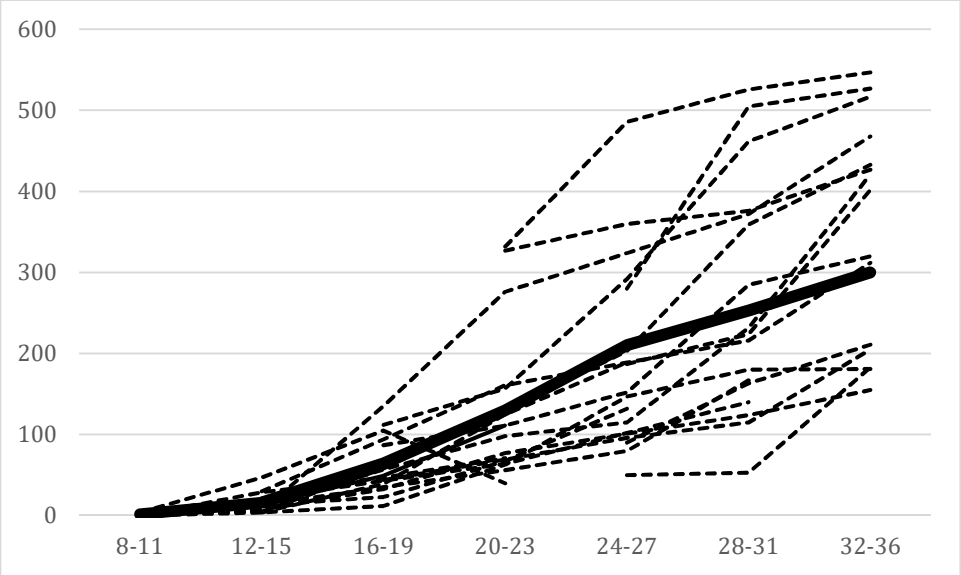

Figure 3. Individual growth trajectories of hearing children (n = 22) for mean expressive scores across the age ranges.
Note.- The thickest line corresponds to the mean of expressive vocabulary of all hearing children in each age range.