EMPIRICAL MANUSCRIPT

Reading Efficiency of Deaf and Hearing People in Spanish

Francisco J. Moreno-Pérez*, David Saldaña, and Isabel R. Rodríguez-Ortiz

Universidad de Sevilla

*Correspondence should be sent to Francisco J. Moreno-Pérez, Departamento de Psicología Evolutiva y de la Educación, Facultad de Psicología, C/Camilo José Cela, s/n. 41018, Sevilla, Spain (e-mail: jmorpe@us.es).

Abstract

Different studies have showed poor reading performance in the deaf compared to the hearing population. This has overshadowed the fact that a minority of deaf children learns to read successfully and reaches levels similar to their hearing peers. We analyze whether deaf people deploy the same cognitive and learning processes in reading as their hearing peers. For this purpose, we analyzed the relation between phonological processing, speechreading, vocabulary, reading speed, and accuracy with reading efficiency in a sample of deaf people and two control groups respectively matched on chronological age and reading level. The results indicate that deaf people's level of reading efficiency is lower than hearing people's of the same age, but that deafness status in itself is not a good predictor of reading level. The results do not support the idea that deaf people's reading is the result of different processes from the hearing population.

Comparing the Efficiency of Deaf and Hearing Readers

Over the years, results have accumulated showing poorer reading performance in the deaf compared to the hearing population. In the classic study by Conrad (1979), levels of reading in people with severe hearing loss reached a maximum level equivalent to fourth grade, with only 15% of the deaf adolescents at that level. Similar results have been found in later studies (Lichtenstein, 1998; Marschark, 2007; Musselman, 2000; Reinwein, Dubuisson, & Bastien, 2001; Wauters, van Bon, & Tellings, 2006; Wauters, van Bon, Tellings, & Leeuwe, 2006). More recently, Qi and Mitchell (2012) carried out a large nationwide study assessing academic achievement in deaf and hard-of-hearing persons. They found that over the past three decades, a wide gap still exists between this population and their hearing peers. In Spanish, recent studies follow this trend. Domínguez and Alegria (2010) explored the level of reading competence in a sample of forty prelingually deaf adults with severe or major loss of hearing (from 91 to 119 dB). The results showed that their reading level was comparable to what would be expected at the end of primary education. This fact is especially relevant if we take into account that this was a selected sample of supposedly “good readers.” Similar results were obtained by Pérez and Domínguez (2006), who concluded that deaf students’ reading level at the end of secondary education is equivalent to primary education fourth graders.

This scenario has overshadowed the fact that a minority of deaf children learn to read successfully and at a similar level to their hearing peers. As shown by Marschark and Harris (1996), these successful deaf readers were already present in the early studies, although they received less attention. Around 10% of successful deaf students acquire a level of reading competence that is comparable to 13-year-olds (Traxler, 2000). Similar percentages are found in longitudinal studies with novice readers, showing that deaf children’s reading acquisition difficulties emerge when they initiating their schooling (Harris & Beech, 1998; Harris & Moreno, 2004) and increase over time compared to their hearing peers (Kyle & Harris, 2010).

A key issue is whether deaf children deploy the same cognitive and learning processes involved in reading as their hearing peers or whether different and distinctive processes derived from the loss of hearing come into play (Easterbrooks et al., 2015). Musselman (2000), when presenting this issue in her review, highlighted three factors that are involved in the acquisition of reading: the way print is encoded, language-specific knowledge, and...
general language knowledge. Goldin-Meadow and Mayberry (2001) also established reduced access to the phonological code and the language captured in print as the two major disadvantages for deaf people in the development of reading. Similarly, Domínguez and Alegria (2010) propose two foci of interest in the study of reading in deaf people: on the one hand, the direct impact of linguistic knowledge at lexical and syntactic levels and on the other, the availability of phonological representations of words in the lexicon. Thus, two distinct levels can be established, one focused on reading decoding, in which phonological skills are very relevant, and the other focused on comprehension, where linguistic skills are more important. These two types of abilities could be conceptualized as specific (reading decoding) and non-specific aspects of reading (linguistic skills) (Alegria & Domínguez, 2009).

One of the most relevant specific elements involved in reading is phonology. The importance of phonological aspects in the development of reading in deaf people is well established in the scientific literature (Alegria, 1998; Marschark & Harris, 1996; Paul, Wang, Trezek, & Luckner, 2005; Perfetti & Sandak, 2000; Wang, Trezek, Luckner, & Paul, 2008), and the data show that phonological skills are better in hearing than in deaf students and, in turn, they are better in deaf students considered good readers than in those who are considered poor readers (Charlier & Leybaert, 2000; Dyer, MacSweeney, Szczerbinski, Green, & Campbell, 2003; Kyle & Harris, 2006; Sterne & Goswami, 2000; Trezek & Wang, 2006). However, other authors (e.g., Allen et al., 2009; Clark, Gilbert, & Anderson, 2011; Miller & Clark, 2011) have questioned the idea that phonology is a necessary prerequisite of decoding in the reading development in prelingual deaf people. In any case, phonological skills seem to have considerable weight in the initial development of reading, when reading decoding mechanisms are being acquired. Kyle and Harris (2006), in a sample of students aged 7–8 years, found a significant correlation between phonological awareness and reading, mediated by the level of hearing loss. Also, some studies suggest that deaf prereaders’ phonological skills predict the level of learning reading skills after 1 year of instruction, analogously to hearing children (Colin, Magnan, Ecalle, & Leybaert, 2007). However, Kyle and Harris (2010) carried out a longitudinal study (3 years) with a sample of deaf students (7–8 years old) and found that learning to read enriches deaf children’s phonological abilities. This result led the authors to conclude that phonological skills in deaf children play a differential role compared to hearing children, in the sense that, for deaf children, they are mainly a consequence of learning to read rather than a forerunner of reading decoding skills, as typically occurs in hearing people. This supports the views of Goldin-Meadow and Mayberry (2001) and Musselman (2000), who proposed a reciprocal relation between phonological skills and reading decoding skills.

Orthographic depth in particular influences the initial acquisition of reading (Ktori and Pitchford, 2009). When the grapheme-to-phoneme correspondence is more complex and less consistent, readers need a greater control of the alphabetic principle. Languages with a deep orthography, such as English, have many words with irregular spelling in which correct decoding is not fully determined by the written code (e.g., enough). This does not occur in transparentorthographies, such as Spanish, in which the correspondence between oral language and written code is nearly absolute. Numerous results support the idea that phonological awareness is a precursor of reading acquisition in the English language and, by extension, in other languages with deep orthographies (Castles & Coltheart, 2004, for a review). Easterbrooks, Lederberg, Miller, Bergeron, and Connor (2006) compared the acquisition of reading in deaf and hearing children and found that deaf pupils have the potential to learn the phonological structure of English during their preschool years, although their performance is poorer.

However, in Spanish, due to its very transparent orthography, a mutual influence between reading and phonology is well known in hearing children (see Defior, 1994, for a review). Therefore, performance may be similar between deaf and hearing readers, and a different system of relationships between these variables may be found, depending on the depth of the orthography of the language in question. The Universal Phonological Principle, by which a phonological component underlies any reading process, even in languages whose written representation is by nature logographic, seems plausible (Perfetti & Liu, 2006; Perfetti, Zhang, & Berent, 1992), but there may also be substantial variations based on the way the phonology is orthographically represented (Katz & Frost, 1992; Ziegler & Goswami, 2006). In languages of transparent orthography novice, readers handle reading decoding processes sooner (which implies greater accuracy and reading fluency) than in other less transparent languages (Cuetos, 2010; Seymour, Aro, & Erskine, 2003) and this also seems to occur with adult deaf readers. Domínguez and Alegria (2010) found no differences between Spanish-speaking deaf and hearing adults in two out of three phonological tests inspired in the “oddity task” paradigm of Bradley and Bryant (1983). In this task, the participants were presented with three pictures, two of which were phonologically related and one of which was not, and were asked to select the “odd one out.” Along these same lines, Bélanger, Baum, and Mayberry (2012) used masked priming and serial recall tasks in a group of French-speaking deaf adults. In masked priming, a word—the prime—is presented briefly just before or after a series of symbols, such as “####,” which “mask” its visibility. The effects of the presentation of the prime in this fashion on the reading of a target word that appears later are measured. In serial recall tasks, participants have to recall lists of words that have been manipulated phonologically and orthographically. Their data support the idea that the difficulties displayed by deaf adults cannot be linked to problems in phonological processing.

Another specific aspect of reading that has received the attention of researchers in the field of deafness is speechreading and its relation with reading. As mentioned above, there is a close relationship between oral language and reading and therefore, it is logical to expect that they are interconnected. This relation has been found in numerous studies (Catts, Adlof, & Ellis Weismer, 2006; Kelso, Fletcher, & Lee, 2007; Nation, Clarke, Marshall, & Durand, 2004). In this sense, speechreading is positively related to reading performance (Arnold & Köpiesel, 1996; Geers & Moog, 1989; Kyle, Campbell, Mohammed, Coleman, & MacSweeney, 2013; Kyle & Harris, 2006) because it is proposed as the main access to oral speech in the case severely deaf people, regardless of the communicative context in which they are educated. This has been found in deaf adults (Mohammed, MacSweeney, & Campbell, 2003) and in dyslexic readers—who are worse speechreaders than competent readers (Mohammed, Campbell, MacSweeney, Barry, & Coleman, 2006)—but not in typical adult readers.

The main thesis proposed to explain the association between speechreading and reading performance is that speechreading allows access to the phonological elements that are necessary for effective reading (Alegria, 1998; Alegria, Charlier, & Mattys, 1999; Burden & Campbell, 1994; Kyle et al., 2013). However, in the deaf population, alternative hypotheses argue for the existence of an indirect relationship mediated by phonological awareness (Mohammed et al., 2003). On the other hand, Harris and Moreno (2006) propose that speechreading is related to reading independently of phonology. They found it was still a good predictor of reading performance, even
after controlling for phonological skills in deaf readers aged 7–8 years.

In addition, speechreading could be positively influenced by the use of systems such as Cued-Speech or Visual Phonics. Their aim is to provide visual information that complements oral language and aids in speechreading, via the combination of hand configurations and positions around different parts of the face. These systems could contribute to enhance phonological awareness and reading development. This has been found to be the case for Cued-Speech in French (Colin et al., 2007; Leybaert & Charlier, 1996) and in Spanish (Santana & Torres, 2000). Marschark (2007) has indicated that there is not the same amount of evidence in the case of English, which is a less transparent orthography than both French and Spanish. The use of Visual Phonics has also been associated to improvements in decoding and reading comprehension (Trezek & Wang, 2006; Trezek, Wang, Woods, Gampp, & Paul, 2007).

There are other factors of a lexical nature that also influence reading accuracy, fluency, and semantic access (Perfetti, 2007). Deaf people’s lower level of reading comprehension may be due to inadequate access to word meaning, in addition to incorrect word decoding (Verhoeven & Perfetti, 2011). Vocabulary has proven to be an influential aspect in the reading comprehension of the hearing population (Ouellette, 2006; Perfetti & Hart, 2002) and in children with loss of hearing (Hermans, Knoors, Ormel, & Verhoeven, 2008; Verhoeven & van Leeuwe, 2008). The extension and depth of the vocabulary of deaf people generally tend to be more limited than their hearing peers (Pittman, Lewis, Hoover, & Stelmachowicz, 2005).

Coppens, Tellings, Schreuder, and Verhoeven (2013) with a sample 64 hearing and 60 deaf third-grade children found a close relationship between decoding and lexical decision and their predictive value for reading comprehension. This led the authors to propose vocabulary limitations as the main cause of reading comprehension problems in children with loss of hearing. Systematic reviews and meta-analyses on the research in this field during the past 40 years, such as the one by Luckner, Sebald, Cooney, Young, and Muir (2005), found that delay in vocabulary was one of the five factors most cited as a cause of reading difficulties, along with their problems to access the phonological code and an unspecific difficulty, or one related to early schooling experience.

With a few exceptions (e.g., Augusto, Adrián, Alegría, & Antoñana, 2002; Domínguez & Alegria, 2010; Domínguez & Soriano, 2009), most of the studies were carried out with English-language participants. English orthography may be the most opaque of the alphabetical languages studied in the literature on reading acquisition, and the system of relations among the factors we have mentioned may be different. On the other hand, there are no studies with deaf Spanish speakers that address this issue and contemplate the inclusion of two control groups in their design: one matched in chronological age and the other in reading age. This kind of design allows the differential analysis of specific and non-specific aspects involved in reading in subjects who have, on the one hand, comparable pre-reading abilities and, on the other hand, the vital background provided by age. Therefore, within this context, we have two research goals:

- To determine the levels of reading efficiency in adult deaf readers in comparison with hearing readers of the same chronological age.
- To assess the factors that may predict levels of reading efficiency in deaf persons in comparison with hearing readers of the same chronological age and of the same level of reading efficiency.

### Method

#### Participants

The sample was composed of 80 individuals distributed into three groups: a group (n = 27) of severe to profound (more than 70 dB of hearing loss) prelinguistically deaf people (Deaf group) with a mean age of 14.41 years (SD = 3.65, range = 9.54–25.66, 17 boys and 10 girls); a second group of 27 hearing people matched on chronological age with the first group (CA-matched group) (M = 16.29, SD = 3.75, range = 11.76–27.17, 14 boys and 13 girls); and a third group of 26 hearing people matched on reading age with the group of deaf people (RA-matched group) (M = 11.62, SD = 2.46, range = 8.37–16.31, 13 boys and 13 girls).

All three groups were matched on gender, χ^2(2) = 1.06, p = .588, and the Deaf group and RA group were matched on reading acquisition, (50.96) = 0.34, p = .736, as measured with the Reading Efficiency Test of Carrillo and Marín (1997) (see below).

All participants had a normal nonverbal IQ, measured with the Wechsler Intelligence Scales for Children (WISC-IV) or Adults (WAIS-III) (Wechsler, 2001, 2005), and did not have any associated disorder, other than deafness in the Deaf group. The two control groups were composed of children and adolescents who were normal hearing readers, as determined with the TALE-2000 Test (Toro, Cervera, & Urio, 2000) (see Instruments and Procedure section).

The group of deaf people and the CA-control group were matched on educational level, χ^2(3) = 3.88, p = .243, with most of them having reached secondary education (see Table 1).

Nine subjects of the Deaf group had received a cochlear implant, at a late age in all cases (>4 years of age), except for one who was implanted at an early age (1 year old). We analyzed the equivalence of both subgroups (implanted vs. nonimplanted), finding no significant differences on any of the variables included in the present study. They all communicated orally and

### Table 1. Sample characteristics

<table>
<thead>
<tr>
<th>Sample characteristics</th>
<th>Deaf group (n = 27)</th>
<th>CA group (n = 27)</th>
<th>RA group (n = 26)</th>
<th>Comparison p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, M (SD)</td>
<td>14.41 (3.65)</td>
<td>16.29 (3.75)</td>
<td>11.62 (2.46)</td>
<td>D = CA &gt; RA**</td>
</tr>
<tr>
<td>Nonverbal IQ, M (SD)</td>
<td>92.74 (10.99)</td>
<td>101.26 (9.63)</td>
<td>103.73 (12.49)</td>
<td>D = CA = RA</td>
</tr>
<tr>
<td>Gender</td>
<td>17/10</td>
<td>14/13</td>
<td>13/13</td>
<td>NS</td>
</tr>
<tr>
<td>Degree of education</td>
<td>8/14/5</td>
<td>6/14 7</td>
<td>16/9/1</td>
<td>NS</td>
</tr>
</tbody>
</table>


**p < .01.
were attending mainstream schools where oral Spanish speech is used as the means of communication. However, the speech perception abilities of the Deaf group were very low, in spite of using hearing aids.

This study complied with all ethical standards, ethical approval was sought and obtained, and informed consent was obtained from the families or adult participants.

Instruments and Procedure

The following instruments were used:

- Reading efficiency was measured with the Test de Eficiencia Lectora (Reading Efficiency Test, TECLE; Carrillo & Marín, 1999) which combines comprehension and speed and provides a global reading efficiency level for each student. It includes 64 incomplete phrases that are missing the last word. Below each phrase, four response options are presented: a correct word, a word that is orthographically similar but semantically or syntactically inadequate, a pseudoword that is orthographically similar to the correct choice, and a pseudoword that is phonologically similar to the correct option. As the test progresses, the sentences become longer and more morphosyntactically complex, and the response item words less familiar. The raw score is the number of correctly completed phrases in the stipulated time (5min). This test has amply demonstrated its efficacy in measuring the reading level (Carrillo, Alegría, Miranda, & Sánchez, 2011; Cuadro & Marín, 2007; Ferreres, Abusamra, Casajús, & China, 2011), in Spanish and Latin-American population (Abusamra, Ferreres, Raiter, De Beni, & Cornoldi, 2010; Bravo, Villalón, & Orellana, 2004). It has also been used as an instrument of global competence in other studies of deaf population in Spanish (Dominguez & Alegria, 2010). It has a high test-retest reliability, r(376) = .88, p < .001, and high internal reliability (Cronbach’s α = .96) (Cuadro, Costa, Trías, & Ponce de León, 2009).

- The Spanish Peabody’s Picture Vocabulary Test (TVIP; L. L. Dunn, L. M. Dunn, & Arribas, 2006) was used for the assessment of vocabulary in Spanish. It is considered a valid and reliable measure of vocabulary and overall linguistic competence (Campbell, Bell, & Keith, 2001; Williams, 1999).

- To assess reading accuracy and speed (reading words and pseudowords), we used the Escalas Magallanes de Lectura y Escritura (Magellan Scale of Reading and Writing, TALE 2000; Toro et al., 2000). This is a standardized test for the assessment of reading-writing skills widely used in Spanish. It includes a word reading subtest of 24 long words (3–4 syllables) of relatively frequent use, which include many of the combinations of consonants and vowels used in Spanish. The pseudoword reading subtest is made of 33 short words (2–3 syllables) with no meaning, but which follow the phonetic rules of Spanish for the construction of syllables. The reading speed subtest measures the number of words read per minute in a series of texts included in the test.

- Phonological Awareness Test (Dominguez, Alonso, & Rodriguez, 2003). This test has a total of 60 items distributed in four subtests: Syllable Identification, Phoneme Identification, Omission of Syllables, and Omission of Phonemes. In all of them, the level of phonological knowledge is measured (at the syllable and phoneme levels) in three situations according to the position they occupy within the word: onset, rhyme, and middle (Alonso, Rodriguez, & Dominguez, 2007). Correct responses are calculated for syllable and phoneme identification and omission, up to a maximum score of 60. This test is especially useful in deaf people because its application relies on photographic and not on hearing stimuli.

- Test de Lectura Labiofacial (Speechreading Test; Rodríguez, Moreno, & Saldaña, 2011). This test explores speechreading of all Spanish phonemes at three levels (phonemes, words, and phrases), manipulating changes in onset and rhyme in the case of phonemes and words, and in all cases, presenting distractors more or less related to the target. The computerized instrument presents a video of the face of a person pronouncing the word or phrase and four pictures as response items. Each stimulus is repeated twice and is presented without any sound. The instrument provides a maximum total raw score for all levels of 106. It has shown satisfactory reliability (Cronbach’s α = .91) and a high correlation, r(27) = .61, p = .001, with the Utley test, a classic speechreading task (Utley, 1946). The response forms, including the stimuli, can be consulted in the Supplementary Material associated with this article at http://jdsde.oxfordjournals.org/.

- Data collection was conducted in individual sessions of approximately 1 hr duration and took place in the schools of the participants or in deaf people’s associations.

The evaluators were psychologists with experience as research technicians, who also received specific training for the application of the tests by the authors. The environmental conditions in which assessment took place were adequate, and the order of task administration was counterbalanced. In all sessions, two evaluators were present and agreement was practically total.

Results

The analyses were carried out with the SPSS 20 statistical package, applying parametric tests after previously verifying that their application criteria were met. In all cases, we used the raw scores of the instruments to perform the analyses. The level of significance was set at .05, and the effect size statistic was Cohen’s d.

Comparative Group Analysis

To analyze possible group differences in the variables of the study, we applied a one-factor analysis of variance. The descriptive statistics of the groups and the result of the contrasts can be seen in Table 2.

The results yielded no significant group differences in the levels of competence in reading accuracy (either in words or pseudowords) or in phonological awareness. The performance levels of the three groups in these tasks were very high, practically reaching a ceiling effect. Therefore, both tasks were excluded from the rest of comparative analyses.

However, statistically significant group differences were found in the rest of the variables: reading efficiency, F(2, 80) = 5.13, p = .008, vocabulary, F(2, 80) = 24.07, p = .000, reading speed, F(2, 80) = 21.41, p = .000, and speechreading, F(2, 80) = 11.89, p = .000. Tukey’s post hoc honestly significant difference (HSD) analysis showed that the level of reading efficiency displayed by the Deaf group was significantly lower than the CA group (HSD_{deaf-CA group} = −9.33, p = .031, d = 0.74), and, as expected, the mean score of the RA group was significantly lower than the CA group (HSD_{RA-CA group} = 10.67, p = .012, d = 0.87).

The Deaf group also had a lower level of competence in the vocabulary test compared to the other groups, both the CA group (HSD_{deaf-CA group} = −45.63, p = .000, d = 1.77) and the RA group (HSD_{deaf-RA group} = −18.61, p = .018, d = 0.69). A similar profile was
found in the results obtained concerning reading speed. The reading speed of both control groups was significantly higher than in the Deaf group (HSD_{Deaf-CA group} = −55.61, p = .000, d = 1.74, HSD_{Deaf-RA group} = −26.57, p = .008, d = 0.88).

However, with regard to speechreading, no significant differences were observed between the Deaf group and the CA group (HSD_{Deaf-CA group} = 2.32, p = .155). Both groups displayed a similar level of competence in this variable. However, the RA group differed significantly from the other groups, showing a worse performance (HSD_{Deaf-RA group} = 6.06, p < .001, d = 1.37, HSD_{CA-RA group} = 3.74, p = .010, d = 0.77).

Table 3 shows the correlations of each of the variables for each group. Well-differentiated profiles can be seen of the different groups with regard to the correlations between the variables and their relation with reading efficiency. In the Deaf group, speechreading correlated significantly both with reading efficiency, \( r(27) = .660, p < .001 \), vocabulary level, \( r(27) = .579, p = .002 \), and reading speed, \( r(27) = .701, p < .001 \). However, in the other groups, no significant relation was found between speechreading and the other variables.

However, reading speed correlated very significantly with reading efficiency in all three groups, with a very strong association in the RA group, \( r(26) = .903, p < .001 \), and somewhat more moderate in the Deaf group, \( r(27) = .731, p = .000 \), and the CA group, \( r(27) = .694, p < .001 \). No statistically significant differences were found between the correlations of the Deaf group and the control groups, although the two control groups correlated (\( z = −2.168, p = .030 \)).

On the other hand, there was no relation between vocabulary level and reading efficiency in the more expert readers (CA group), but there was a relation in the less-skilled readers (RA group), \( r(26) = .764, p < .001 \), and the deaf readers, \( r(27) = .807, p < .001 \), although there were no significant differences between the correlations of these two groups.

Thus, as a result of the system of relations between variables, the profile of each group seems to indicate that the deaf people and the RA control group behave more similarly to each other than to the CA-control group, because in the first two, the same variables (vocabulary and reading speed) are associated with reading efficiency. However, the two control groups are more similar to each other in the lack of an association between speechreading and reading efficiency, in contrast to the group of deaf people.

### Concurrent Predictors of Reading Efficiency in Spanish-Speaking Deaf People

The next step in our analysis is to examine which factors of those described in the preceding section predict the level of reading efficiency in deaf Spanish speakers. With this goal in mind, we selected the subjects from the group of deaf people and the CA-controls and performed a stepwise hierarchical linear regression analysis. The RA group was excluded from this analysis because the dependent variable was experimentally blocked. Therefore, all the variables that had a relation with reading efficiency were included, and we incorporated “deafness” as a dummy categorical variable (coded as 1 for deafness and 0 for hearing). Table 4 shows the correlation matrix of the different variables.

The total score in reading efficiency correlated positively with age, \( r(54) = .471, p < .001 \), vocabulary \( r(54) = .693, p < .001 \), reading speed, \( r(54) = .725, p < .001 \), reading accuracy (words), \( r(54) = .328, p = .015 \), phonological awareness, \( r(54) = .352, p = .009 \), and the condition of “being deaf”, \( r(54) = −.345, p = .011 \). In this sense, the condition of being deaf was related to other variables, in addition to the dependent variable. Specifically, it correlated with nonverbal IQ, \( r(54) = −.387, p = .004 \), vocabulary, \( r(54) = −.667, p < .001 \), and reading speed, \( r(54) = −.661, p < .001 \).

On the other hand, we also found significant correlations between independent variables in our study. Thus, reading speed correlated with vocabulary, \( r(54) = .766, p < .001 \), and with reading accuracy, both in nonwords, \( r(54) = .280, p = .040 \), and in words, \( r(54) = .402, p = .003 \), and the level of phonological awareness correlated significantly with the level of vocabulary, \( r(54) = .284, p = .038 \), and with speechreading, \( r(54) = .368, p = .006 \).

Lastly, age also correlated significantly with other independent variables of our study, such as the level of vocabulary, \( r(54) = .598, p < .001 \), reading speed, \( r(54) = .471, p < .001 \), or speechreading, \( r(54) = .275, p = .044 \). This also occurred between nonverbal IQ and level of vocabulary, \( r(54) = .473, p < .001 \).

In view of the relations between the variables, we performed a hierarchical regression analysis (Block Design) in three steps...
to determine the relative contribution of deafness to the level of reading efficiency with regard to the remaining variables. Age and nonverbal IQ were introduced in the first step as control variables; in the second step, the condition of being deaf was entered; and in the third step, the other independent variables were entered.

As seen in Table 5, the control variables significantly explain 20.8% of the variance (\(R^2 = .208, p = .003\)), just like the remaining variables, which explain approximately 42% of the variance (\(R^2 = .421, p < .001\)). However, the condition of being deaf was not a significant predictor of the level of reading efficiency, and only explained 3.9% of the variance.

If deafness is not relevant to predict the level of reading efficiency, we must determine which of the remaining variables can be relevant predictors, contributing to explaining deaf people’s poorer reading performance. To answer this question, we carried out a linear regression analysis, similar to the one described above, in the Deaf and RA groups but this time, we entered the control variables (age and nonverbal IQ) in the first step, and in the second step, as an alternative to determine the best predictors, the rest of the variables that had shown an association with reading efficiency in the Deaf group and the RA group (see Table 6). These results clearly contrast with the previously presented results for the CA group, in that there was only a significant correlation with one variable (reading speed), so it was therefore not possible to replicate the regression analysis described for the Deaf group.

As can be observed in Table 7, in the Deaf group, all the factors significantly explained the variance, but not the control variables entered in Step 1. Thus, the best predictor of reading efficiency in the Deaf group was vocabulary, which explained 55.6% of the variance (\(R^2 = .556, p < .001\)), followed by reading speed with 37.5% of explained variance (\(R^2 = .375, p < .001\)), and phonological awareness (\(R^2 = .252, p = .004\)), and speechreading (\(R^2 = .257, p = .004\)).

These data differ from those obtained in the RA group, where the control variables very significantly account for the highest percentage of variance (\(R^2 = .539, p < .001\)), followed by reading speed (\(R^2 = .297, p < .001\)), and vocabulary (\(R^2 = .121, p = .010\)).

**Discussion**

In our study, we proposed two goals: on the one hand, to determine the levels of reading efficiency of adult deaf readers in comparison with hearing readers matched on chronological and reading age, and, on the other hand, to assess the factors that predict levels of reading efficiency in the different groups.

Regarding the first goal, the results obtained in our study on Spanish deaf people’s global level of reading are similar to those of other recent studies in English (e.g., Marschark, 2007; Musselman, 2000; Wauters, van Bon, & Tellings, 2006; Wauters, van Bon, Tellings, & van Leeuwe, 2006) and in Spanish (Alegría & Domínguez, 2009; Domínguez & Alegría, 2010). In this sense, deaf people’s level of reading efficiency is significantly below the control group of the same chronological age. In addition, this discrepancy is not a result of poorer phonological or orthographic skills, factors that are closely intertwined in the process of reading decoding, because all three groups reach a ceiling in this type of skills (reading accuracy—words and pseudoword—and phonological awareness). Thus, the data indicate that, following the dual-route model (Coltheart, 1980), deaf people can be efficient in the use of both routes (lexical and sublexical) and this is probably because, in Spanish, decoding (accuracy) is

### Table 4. Correlations (raw scores) between measures in Deaf and CA groups (n = 54)

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Nonverbal IQ</th>
<th>Level of education</th>
<th>Reading efficiency</th>
<th>Vocabulary</th>
<th>Reading speed</th>
<th>Reading accuracy (words)</th>
<th>Phonological awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of education</td>
<td>.418**</td>
<td>.158</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading efficiency</td>
<td>.422**</td>
<td>.264</td>
<td>.213</td>
<td></td>
<td>.693**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>.598**</td>
<td>.473**</td>
<td>.413**</td>
<td></td>
<td>.725**</td>
<td>.766**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading speed</td>
<td>.471**</td>
<td>.306</td>
<td>.313**</td>
<td></td>
<td>.185</td>
<td>.227</td>
<td>.280*</td>
<td></td>
</tr>
<tr>
<td>Reading accuracy (words)</td>
<td>.134</td>
<td>.250</td>
<td>.045</td>
<td>.328*</td>
<td>.352**</td>
<td>.284*</td>
<td>.199</td>
<td>.050</td>
</tr>
<tr>
<td>Phonological awareness</td>
<td>.257</td>
<td>.011</td>
<td>.181</td>
<td></td>
<td>.352**</td>
<td>.284*</td>
<td>.199</td>
<td>.050</td>
</tr>
<tr>
<td>Speechreading</td>
<td>.275*</td>
<td>.203</td>
<td>.175</td>
<td></td>
<td>.213</td>
<td>.045</td>
<td>.059</td>
<td>.007</td>
</tr>
<tr>
<td>“Being deaf”</td>
<td>−.250</td>
<td>−.387**</td>
<td>−.048</td>
<td>−.345*</td>
<td>−.667**</td>
<td>−.661**</td>
<td>−.222</td>
<td>.031</td>
</tr>
</tbody>
</table>

Note: Only the combinations of variables with significant correlations are shown in the Table. CA = a group of chronological age–matched hearing people. *p < .05. **p < .01.

### Table 5. Hierarchical regression analysis predicting reading efficiency (Deaf and CA groups)

<table>
<thead>
<tr>
<th>Step</th>
<th>Variables</th>
<th>% R² Change</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age – nonverbal IQ</td>
<td>20.78</td>
<td>6.69</td>
<td>.003</td>
</tr>
<tr>
<td>2</td>
<td>“Being deaf”</td>
<td>3.94</td>
<td>2.62</td>
<td>.112</td>
</tr>
<tr>
<td>3</td>
<td>Vocabulary reading speed</td>
<td>42.07</td>
<td>14.57</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>reading accuracy (words)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>phonological awareness</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. CA = a group of chronological age–matched hearing people.

### Table 6. Partial correlations (raw scores) between measures in Deaf and RA groups controlling for age and nonverbal IQ

<table>
<thead>
<tr>
<th>Group</th>
<th>Variable</th>
<th>Reading efficiency</th>
<th>Vocabulary</th>
<th>Reading speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaf</td>
<td>Vocabulary</td>
<td>.834**</td>
<td>.657**</td>
<td>.296</td>
</tr>
<tr>
<td>(n=27)</td>
<td>Reading Speed</td>
<td>.685**</td>
<td>.589**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phonological</td>
<td>.561**</td>
<td>.513*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Awareness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Speechreading</td>
<td>.567**</td>
<td>.414*</td>
<td>.653**</td>
</tr>
<tr>
<td>RA</td>
<td>Vocabulary</td>
<td>.513*</td>
<td>.536**</td>
<td></td>
</tr>
<tr>
<td>(n=26)</td>
<td>Reading Speed</td>
<td>.803*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Only the combinations of variables with significant correlations are shown in the table. RA = a group of reading age–matched hearing people. *p < .05. **p < .01.
acquired relatively early, sooner than in other less transparent languages, and ceases to be relevant for reading efficiency. For example, Storch & Whitehurst (2002) carried out a longitudinal study with over 600 English-speaking students in which they followed reading accuracy and comprehension from kindergarten to fourth grade. They found that in the first years, decoding and comprehension were closely related and did not behave as relatively independent abilities until fourth grade. Phonological and orthographic representations that develop during reading acquisition could be sustained at two different levels: an implicit or epi-linguistic level and an explicit or meta-linguistic level, which allows knowledge and manipulation of the sublexical elements of the language and that is more easily learned in more transparent languages (Seymour et al., 2003). In this sense, Spanish is one of the most transparent European languages and greatly facilitates the acquisition of reading, whereas English is one of the languages that provides the least resources (Seymour, 2005).

In contrast to reading accuracy, the results in the Deaf group reveal a lower reading speed than that shown by the control groups, very significantly and with large effect sizes. If we relate the results obtained in reading accuracy and speed, we can make an interpretation tending toward the idea that deaf readers use the sublexical route more than the lexical one, although both paths to reading may be functional. This interpretation is consistent with other works carried out with deaf readers comparable to the participants in our work (Martinez & Augusto, 2002). Generally, the combination of both accuracy and speed has been conceptualized, both in classic and current studies, under the term of reading fluency and it has been applied to isolated word and pseudoword reading and to reading texts (Crosson & Lesaux, 2010). However, the relative contribution of reading accuracy and reading speed to reading fluency changes with reading age. At the initial moments of learning, decoding mechanisms involved in word reading have more impact. Only when sufficient proficiency has been acquired in word reading, sufficient cognitive resources are freed to be able to acquire reading fluency at the level of text reading. As noted by Wolf and Katzir-Cohen (2001), reading fluency of words and reading fluency of texts should be understood as different constructs in which high-level linguistic skills (vocabulary, syntactic knowledge, and comprehension) are more linked to reading texts than to reading words. It should be taken into account that our data correspond to reading fluency at the word level and, in this sense, they support the idea that the group of deaf people behaved like “novice readers” in this variable, clearly contrasting with the results obtained in the other groups. However, this poorer performance in reading fluency at the word level should not be taken as a direct explanation, in absolute terms, of the low levels of reading efficiency presented by the deaf people in our study. There is increasing empirical evidence that reading fluency at the word level is a worse predictor of levels of reading comprehension than fluency in reading texts (Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003a,b), and that the relation between word reading fluency and reading comprehension becomes weaker with age (Yovanoff, Duesbery, Alonzo, & Tindal, 2005). In spite of this, reading speed correlated significantly with reading efficiency in all three groups and, in the CA group, it was the only variable that did so, probably due to the timed nature of the reading efficiency task.

With regard to the vocabulary level, our data indicate that the group of deaf people has a significantly limited vocabulary compared to the control groups. The difference with the CA group was greater than with the RA group, and vocabulary correlated with reading efficiency in the Deaf group and in the RA group, but not in the CA group. These results are consistent with those of other recent studies in English (Coppens et al., 2013; Pittman et al., 2005) and also in Spanish (Augusto et al., 2002). Deaf students’ development is usually slower than their hearing peers’ and they usually respond to well-planned instructional situations, without there being any periods of rapid extension (Alegría & Domínguez, 2009).

However, with respect to speechreading, the Deaf group is comparable to the CA group, and both obtain significantly higher scores than the RA group. Similar scores in speechreading in hearing and deaf adolescents and adults is also found in English (Arnold & Köpse1, 1996; Kyle et al., 2013). This is particularly interesting, to the extent that, in addition to age, our groups were matched on educational level, a variable that has been proposed as an explanation of why deaf people are not better speechreaders than their hearing peers (Ellis, MacSweeney, Dodd, & Campbell, 2001). Age seems to be a very influential factor for the level of speechreading, like in other languages (Andersson, Lyxell, Rönberg, & Spens, 2001; Kyle et al., 2013; Tye-Murray, Sommers, & Spehar, 2007): hearing children are worse speechreaders than older people, either deaf or hearing. A possible explanation is that age involves greater linguistic development and experiential background, and these factors may be positively influencing the level of speechreading. However, in view of our data, vocabulary does not seem to be an essential factor in this respect, so other factors must be contributing with more weight to the development of speechreading. In this sense, only in the Deaf group does speechreading correlate significantly with reading efficiency.

When examining the correlational analysis, it can be seen that in the Deaf group, the profile of variables that are significantly associated with reading efficiency is more similar to that of the RA group than the CA group. Except for speechreading, both groups have positive and very significant correlations of vocabulary level and reading speed with reading efficiency. In addition, the correlations between the two groups are not statistically different. The hierarchical linear regression between the matched chronological age groups shows that being deaf explains very little variance (9.9%) compared with the other variables (62.9%). These results indicate that loss of hearing in itself is not an explanatory factor of deaf people’s reading difficulties, and that hearing impairment has a negative effect on reading development through a system of relationships mediated by factors involved in the reading process.

The next regression analysis was performed with the goal of determining the best predictors of reading efficiency in the

### Table 7. Hierarchical regression analyses predicting reading efficiency (Deaf and RA groups)

<table>
<thead>
<tr>
<th>Group</th>
<th>Step</th>
<th>Variables</th>
<th>% R² Change</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaf group</td>
<td>1</td>
<td>Age – nonverbal IQ</td>
<td>20</td>
<td>1.917</td>
<td>.155</td>
</tr>
<tr>
<td>(n = 27)</td>
<td>2</td>
<td>Vocabulary</td>
<td>55.6</td>
<td>50.168</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Reading speed</td>
<td>37.5</td>
<td>19.403</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Phonological awareness</td>
<td>25.2</td>
<td>10.088</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Speechreading</td>
<td>25.7</td>
<td>10.401</td>
<td>.004</td>
</tr>
<tr>
<td>RA group</td>
<td>1</td>
<td>Age – nonverbal IQ</td>
<td>53.9</td>
<td>13.448</td>
<td>.000</td>
</tr>
<tr>
<td>(n = 26)</td>
<td>2</td>
<td>Vocabulary</td>
<td>12.1</td>
<td>7.843</td>
<td>.010</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Reading speed</td>
<td>29.7</td>
<td>4.04</td>
<td>.000</td>
</tr>
</tbody>
</table>

Note: RA = a group of reading age–matched hearing people.
Conclusions

In deaf individuals in our study, reading speed and efficiency are poorer than in their hearing peers. These differences are not due to worse phonological or orthographical skills. Their vocabulary is also at a lower level than their chronological age-matched controls, but also than reading age-matched controls, and impacts greatly on their reading efficiency. However, vocabulary does not seem to impact on speechreading, which appears to be more influenced by other linguistic factors.

Another important finding is that hearing loss in itself is not sufficient to predict reading difficulties in deaf persons. Variables that are related to reading in typically-developing individuals are also relevant in their case. In this sense, our data show that deaf people have a profile that is closer to early readers.

Some suggestions for educational intervention might in future be obtained from these results if they are replicated. First, at least in transparent orthographies, early reading intervention should probably focus more on aspects similar to those found in general enrichment programs, and less on deafness as a specific deficit for reading. Second, at least in Spanish, intervention centered on phonology and orthography has a limited impact on the development of reading comprehension once a certain level has been reached. It should be applied until an adequate level of decoding is acquired, but perhaps no further.

Supplementary Data

Supplementary material is available at http://jdsde.oxfordjournals.org/.

Funding

Consejería de Innovación, Ciencia y Empresa, Junta de Andalucía (Spain), via its Excellent Research Projects (P07-SEJ-02574).

Acknowledgments

The authors also wish to thank all the people who participated in this study for their time and collaboration.

Conflicts of Interest

No conflicts of interest were reported.

References


Limitations

In the interpretation of these results, some limitations of the study should be kept in mind. First, the participants of the Deaf group are predominantly deaf people who are not users of cochlear implants or hearing aids. Although nine users had been implanted, all of them except for one had received the cochlear implant at a late age. In this sense, our sample may not be representative of the deaf population implanted at an early age and who received adequate rehabilitation, and therefore with a much higher level of oral competence than our participants. Also, although our instruments were very finely tuned to the specific needs and profile of deaf readers, and evaluators trained by the authors of the instruments themselves, administration fidelity was not specifically assessed and could add some additional measurement error. Finally, due to our goals, some of the conclusions of this work may applicable only to Spanish, and, reasonably, to other languages with a similar degree of orthographic transparency, but not to other more opaque languages. It should be taken into account that the factors inherent to the orthographic dimension of each language may involve different considerations leading to the overestimation or underestimation of the importance of certain factors (Miles, 2000).


