Reading and Writing (2023) 36:1201–1226
https://doi.org/10.1007/s11145-022-10335-w

Writing composition ability and spelling competence in deaf subjects: a psycholinguistic analysis of source of difficulties

Francesca Vizzi[1,2] · Paola Angelelli[1,2] · Marika Iaia[1,2] · Anthony H. Risser[3] · Chiara Valeria Marinelli[2,4]

Accepted: 5 July 2022 / Published online: 20 July 2022

Abstract

We studied the compositional written skills and spelling competence of individuals with a severe hearing impairment, examining qualitative and quantitative characteristics of their texts, the psycholinguistic variables modulating their productions, and writing errors following a fine-grained analysis. Sixteen deaf young adults, educated in bilingual settings, were examined and compared to a group of control hearing subjects matched for gender, age, and education. Writing skills were examined through both written composition and written picture-naming tasks. Concerning compositional skills, deaf participants produced shorter and less informative texts, with fewer adjectives and subordinates, and were qualitatively worse with respect to texts produced by hearing controls. Words produced by deaf participants were those acquired earlier and facilitated by a higher lexical neighbourhood. Errors were mainly semantic, morphological, and syntactic errors, reflecting general linguistic weakness. Spelling errors were few, with phonologically nonplausible misspellings relative to controls, and with phonologically plausible ones being quite rare. In the picture-naming task, deaf people had a greater number of all types of errors with respect to their text, including semantic and morphological errors. Their spelling performance featured mainly phonologically nonplausible misspellings, while phonologically plausible ones were relatively few and comparable to controls. Overall, the writing of deaf adults reveal limitations in grammar and lexical-sematic linguistic competence. This was associated with spelling deficits characterized mainly by the poorer use of phonological sublexical spelling procedures. However, in an ecologic context, their spelling deficits appear not so important as has been claimed in the literature.

Keywords Deafness · Writing · Text production · Spelling · Error analysis · Regular orthography

✉ Paola Angelelli
paola.angelelli@unisalento.it

Extended author information available on the last page of the article

Introduction

Deaf individuals generally present with difficulties in reading and writing acquisition as consequences of various factors (e.g., Kyle & Harris, 2011; Musselman, 2000; Perfetti & Sandak, 2000). One of these factors is late exposure to spoken language compared to hearing children (Bertone & Volpato, 2009). In fact, even when the diagnosis of deafness is made early in life, it takes some time before the child learns lip-reading and/or can exploit any acoustic residual information through the use of hearing aids. Moreover, deaf children must undergo a formal learning process to learn spoken language, since this does not happen spontaneously, as in children who can hear. Conditions in which the learning of spoken language take place are very different from those observed in hearing children: the linguistic input can only be offered to the deaf child by a face-to-face interaction (visual input) with the interlocutor, and the language that is used is often simplified both in content and in form.

The perception of phono-acoustic details of language in deaf subjects is poorer and/or distorted with respect to hearing people (Brown & Bacon, 2010; Pisoni et al., 2008; Tomblin et al., 2015). This difficulty in accessing acoustic input may lead to poorer phonological competence (Lyxell et al., 2008; Pisoni et al., 2008) and poorer phonological awareness skills (Sterne & Goswami, 2000), skills that are typically learned through listening. However, there is evidence of a certain degree of phonological coding taking place in deaf people: Sterne and Goswami (2000) reported that some phonemic knowledge was available to their primary school deaf children. Dodd (1987) suggested that the perception of phono-acoustic details of speech does not depend exclusively on the ability to listen, and that deaf people can acquire mental representations of phonemes through lip-reading. Interestingly, some authors affirm that the structure governing orthographic representation for both hearing and deaf subjects could be relatively independent of the peripheral phonological system (Olson & Caramazza, 2004).

The mastering of phonological skills is particularly relevant in regular orthographies (e.g., Serbian, Croatian, Czech, Spanish, Italian), characterized by a high consistency of phoneme-to-grapheme (and vice versa) mappings. In studies conducted in Italian-speaking contexts, a main reliance on phonological (sublexical) procedures has been found to characterize spelling and reading acquisition (i.e., Zoccolotti et al., 2009; for cross-linguistic comparison see Marinelli et al., 2015; for spelling see Notarnicola et al., 2012). Moreover, oral language development has been shown to influence literacy acquisition. In fact, even for hearing children a language delay compromises spelling performance and, in reading, text comprehension (Angelelli et al., 2016; Chilosi et al., 2009). In these studies, dyslexic children with a history of language delay were found to suffer from a more severe spelling deficit, characterized by defective orthographic lexical acquisition together with long-lasting phonological difficulties (Angelelli et al., 2016) and poorer text comprehension compared to children without a history of language delay (Chilosi et al., 2009). In both studies no differences between the two groups were found in severity of the reading deficit, suggesting that spelling more than reading may show concurrent phonological processing deficits and residual oral language difficulties.

As far as the writing skills of those who are deaf, the literature has focused mainly on the analysis of written composition, paying attention to the narrative skills of these individuals and investigating their semantic and syntactic competence. Studies examining their spelling proficiency are rare, at least in languages with regular orthography (see Daigle et al., 2020 for similar evidence on opaque languages). Moreover, the psycholinguistic characteristics (such as word frequency, length, and age of acquisition) of the stimuli spontaneously produced or modulating the performance in a more controlled task have been rarely investigated.

In deaf subjects, poor linguistic competence in the production of written text has often been found when compared to hearing people, matched by age and years of education. Moreover, in most cases, these difficulties persisted after some period of rehabilitation (Bertone & Volpato, 2012). In Italian subjects, several studies (e.g., Caselli et al., 2006; Chesi, 2006) reported peculiar features: the written productions of individuals with hearing impairment were characterized by a poor vocabulary and the formulation of short and telegraphic sentences with a simpler syntactic structure in comparison with productions by those without a hearing impairment. Overall, data indicate that texts produced by deaf people contain generally fewer words, being shorter than those composed by hearing peers, reportedly due to their limited language or literacy knowledge (e.g., Arfé et al., 2016; Gärdenfors et al., 2019; Oliveira et al., 2020). To explore this hypothesis, research has examined the effect of practice on syntactic competence of sentences written by deaf individuals. A few of these studies found that syntactic structure improves with age (Heefner & Shaw, 1996), but the progress is slower for deaf children than for hearing subjects (Yoshinaga-Itano et al., 1996). In particular, Yoshinaga-Itano et al. (1996) emphasized that deaf students showed persisting difficulties with the organization of ideas in writing and that the informativeness of their texts was poor, succeeding in conveying the main concepts but containing few salient and informative details. In addition, significant errors were found in the nominal domain, specifically a systematic omission of indefinite articles, while in the verbal domain, the difficulties were mainly reported in the ordering of subjects and verbs (Franchi & Musola, 2010). In the use of morphology, many errors and omissions were present, specifically, in the use of free morphology (Kelly, 1993), with significant errors regarding prepositions and pronouns (Chesi, 2006). In a relevant study conducted on deaf Italian subjects (Taeschner et al., 1988), students were tested on grammar-structured writing tasks, in which participants had to produce pluralization of nouns, insertions of the correct article for each word, or replacements of noun phrases with clitic pronouns. Errors related to plural formation may consist of the incorrect generalization of the most common morphemes −i (e.g., DITO [finger], as DITI* instead of DITA) and in rendering singular feminine names with a final −e as if they were plurals (MELE [apples] instead of MELA [apple]). Deaf individuals showed no difficulty in performing plural tasks. Instead, the use of articles was very difficult for the deaf group compared to the control group: deaf subjects made many more errors, as they systematically used an article that agreed with the final of the reference name (i.e., le notte, instead of la notte [the night]). The deficit in the use of syntax was not confined to production but was also impaired in solving visually presented syntactic contrasts (such as active–passive, single–plural) in pairing the sentence with the corresponding picture (Bishop, 1983).

Regarding spelling proficiency, most studies have concluded that deaf students suffer from spelling deficits compared to hearing subjects (e.g., for elementary school students: Apel & Masterson, 2015; Kyle & Harris, 2011; Leybaert & Lechat, 2001; Park et al., 2013; Sutcliffe et al., 1999; for high school students: Alamargot et al., 2007; Geers & Hayes, 2011; for adults: Olson & Caramazza, 2004). However, some failed to find a spelling impairment in this population, at least for specific learning conditions (e.g., Leybaert, 2000). Moreover, the profile of spelling difficulties of children with hearing impairment is not clear, and very few studies have examined the efficiency of lexical and sublexical spelling procedures among deaf children learning in regular orthography. A relevant study (Colombo et al., 2012) found that Italian deaf second-to-sixth-grade children make use of phonology when writing single words, but their phonological representations are less robust when compared with those of hearing children with the same level of schooling. The error analysis showed a worse performance of deaf children with a higher prevalence of mixed errors (more than one error for word) and a higher presence of phonologically plausible misspellings than hearing participants. Similarly, studies of deaf children attending primary and secondary school who were learning in opaque orthographies (English and French) have found a not too effective use of phonological coding in spelling (Beech & Harris, 1997; Harris & Beech, 1998; Leybaert & Alegria, 1995). Specifically, in French orthography Leybaert and Alegria (1995) found that only older subjects with deafness and intelligible speech, but not those who were deaf but with unintelligible speech, were able to establish a relationship between the phonological segments and the corresponding graphemes. Only for older and more schooled subjects, a regularity and morphological effect was reported with regular words written more accurately than morphologically complex words and the latter being spelled more accurately than irregular words. The error profile confirmed the results that deaf children with intelligible speech displayed a higher proportion of phonologically plausible misspellings, suggesting a sufficient but delayed acquisition of the alphabetical strategy. The authors suggested that only intelligible and more schooled deaf children would be more efficient in performing a phonological analysis of spoken words segments and to make use of the correspondence between these segments and the representing graphemes. Moreover, Leybaert (2000) reported that deaf children who had been exposed to cued speech (a system which visually delivers phonetically augmented speech-reading [lip-reading]) are phonologically accurate in their spelling of high- as well as low-frequency words.

However, other studies have reported mixed results. While some studies have confirmed a certain use of the phonological spelling procedure in deaf students, where the presence of phonologically plausible misspellings is proportionally lower with respect to hearing students (e.g., Arfè et al., 2014; Geers & Hayes, 2011; Leybaert, 2000), others have reported a prevalence of phonological nonplausible misspellings (mainly transpositions and deletions causing a change in the phonemic make-up of a word), suggesting greater spelling difficulties along the phonological sublexical procedure (Hayes et al., 2011; Olson & Caramazza, 2004; Sutcliffe et al., 1999). Also, in a recent study of deaf primary school subjects learning in a French context, the error analysis of their written text revealed fairly good orthographic representations (90% of graphemes adhered to the orthographic standards), despite their general writing deficits (Daigle et al., 2020). In fact, their lexical success rate (i.e., number of correctly written words) was comparable to hearing students. In sum, in some studies a sort of superiority in deaf orthographic knowledge, as opposed to phonological knowledge, has been hypothesized (Harris & Moreno, 2004).

The greater interindividual differences within the deaf population in speech ability, oral language learning, degree of deafness, and the ability to exploit residual hearing through hearing aids contribute to making the results of different studies exploring the use of the phoneme-to-grapheme mapping controversial in nature. The analysis of psycholinguistic variables modulating the spelling performance of deaf subjects might contribute to exploring the functioning of their lexical and sublexical spelling procedures. Unfortunately, these studies are lacking.

The aim of the present study is to analyse the writing skills of deaf individuals by means of tasks that would minimize the methodological limitations created by deafness by making use of a written description of a picture and of a written picture-naming task. Our goals are multiple: (a) to study the writing composition skills of deaf individuals, paying attention to text quality and psycholinguistic characteristics of their written productions in order to assess their lexical and grammatical written competence; (b) to examine spelling proficiency as a function of lexical and sublexical psycholinguistic variables, through both ecologic (i.e., text production) and more controlled (i.e., written picture-naming) tasks; and (c) to analyse the types of errors following a fine-grained grid for both samples of written production, to better understand the sources of any writing difficulties. In particular, we consider semantic, morphological, and syntactic errors (reflecting general linguistic weakness) and sublexical and lexical-orthographic misspellings (tapping the efficiency of the two spelling procedures). Due to the regular orthography, characterized by a high consistency of sound-to-print mappings, we hypothesized that deaf subjects, similar to hearing controls, may rely mainly on a phoneme-to-grapheme procedure, to be mastered with a certain degree of competence. However, the different way of oral language acquisition and the delay in language development may lead to defective development of the phonological system, with long-lasting phonological spelling difficulties. As far as lexical procedure development, studies of typically developing Italian children have showed an early use of the lexical spelling processes too: in first-graders, regular words were spelled more accurately than ambiguous words, and a facilitation in the spelling of ambiguous words acquired emerged earlier (Notarnicola et al., 2012). In Italian, as in most regular orthographies, there is a certain degree of ambiguity in the oral-to-written direction, and there are instances of ambiguous/unpredictable spellings (when a given phonological string has more than one possible orthographic solution, though only one is correct). For instance, the phonemic group [kw] may be transcribed by the orthographic sequences QU, CU, or CQU (e.g., the Italian word [kwota, rate], is written QUOTA and not *CUOTA); no definite rule by which to establish the correct sequence and reference to a lexical entry is required. Moreover, typically developing Italian children in third grade have showed successful use of lexical units like morphemes (more manageable lexical units with respect to the whole stimulus), benefitting from the presence of morphological structure in spelling newly encountered stimuli, even with regular transcription (Angelelli et al., 2014). Following the authors, exposure to these frequently occurring chunks of sound and meaning in speech and their corresponding orthographic patterns in writing could allow morphemes to become relatively independent spelling units. This would enable children, especially those less skilled (because of their young age or those with reading problems) to process them correctly, avoiding the error-prone phoneme-to-grapheme analysis (for results about children suffering from dyslexia, see Angelelli et al., 2017).

Therefore, the second aim of this study is to understand to what extent deaf people learning in Italian rely on the lexical-orthographic procedure in spelling, considering that typically developing children exploit very early lexical-orthographic information in spelling and that visual exposure to orthographic material is not impaired and may be the same as those without hearing impairment. The possibility that deaf subjects use visual strategies, helping establish good orthographic representations, has already been postulated (Daigle et al., 2020). A main reliance on the lexical-orthographic spelling procedure was also reported in a single case study of a dyslexic Italian child suffering from a long-lasting phonological deficit (Marinelli et al., 2017). Despite obvious differences, a similar compensation strategy might be considered for those who are deaf.

Method

Participants

Participants were 16 deaf subjects (9M, 7F, mean age = 36.2 years) with prelingual deafness and 16 matched control subjects.

The following inclusion criteria were used to select the sample of deaf individuals:

- Diagnosis of deafness (hearing impairment ≥ 70 dB; with severe-to-profound hearing loss).
- Normal performance on a nonverbal intelligence test (mean = 45.13; SD = 4.53) on Raven's Standard Progressive Matrices (Raven, 2008).
- Absence of other sensory, psychiatric, or neurological deficits, except deafness, following an ad hoc structured anamnestic questionnaire (see also Marinelli et al., 2019).

The participants were resident in Puglia, in the area of Lecce or Brindisi. All participants had a high educational qualification, with a mean education level of 12.88 years (range 10–16 years; see Table 1). In the deaf group, seven subjects out of 16 (44%) were engaged in a regular work activity (mainly employees and workers); in the control group, 11 participants out of 16 (68%) were engaged in various types of work.

Eleven individuals had hearing parents, while both parents were deaf for five individuals. Participants with hearing parents used the Italian oral language

Table 1 Some demographic information concerning deaf and control participants

	Deaf participants		Control participants		t	*p*
	Mean	SD	Mean	SD		
Age	36.32	9.12	35.51	7.95	0.27	n.s
Years of education	12.88	1.09	12.88	0.50	0.00	n.s

within the family, but also had good knowledge of Italian Sign Language (LIS—Lingua Italiana dei Segni). Participants with deaf parents early on acquired LIS, and also had good lip-reading skills. As for type of deafness, 62.5% of participants had congenital deafness and 37.5% acquired, with an average age of diagnosis of 21 months (SD = 15.6). None of the subjects had cochlear implants. As for the use of hearing aids, 50% of the sample stated that they did not use them due to physical discomforts of various kinds; 44% of the subjects stated that they used hearing aids assiduously; the remaining 6% stated that they used the aids sporadically.

The performance of the deaf subjects was compared to the performance of a group of 16 hearing control subjects, matched one by one with the deaf individuals for gender (nine males and seven females), age, and educational level. All statistical comparisons between deaf and control participants were not significant (all $t < 1$; see Table 1).

Deaf and control participants of the present study were studied comprehensively for their reading abilities. A full portrait of their reading skills is reported in a previous publication (see Marinelli et al., 2019).

Materials and procedure

Written text production

To assess composition skills, we used a written text production test. This test examines the ability to produce a descriptive text in a picture-driven situation within a 5-min time limit. We administered image B of the Advanced MT-Testing-3-Clinic test (Cornoldi et al., 2017), which illustrates people in a marketplace. We gave each subject a colour image and a protocol sheet, then asked them to describe the image.

The assignment of the task was presented both in written form and explained to the deaf participants using the LIS and is as follows: *"You have 5 min and a maximum of 10 lines to describe the scene you see in the picture so that people who have not seen the picture may be able to imagine the content."* At the end of the 5 min, we picked up the sheet.

The written productions were analysed in different ways. Firstly, following the scoring guidelines of the test manual (Cornoldi et al., 2017), expressive competence was evaluated through qualitative and quantitative indices.

The qualitative evaluation (a text quality score), scored on a 5-point scale from 1 (completely unsatisfactory) to 5 (fully satisfactory), was performed on the following parameters:

- *Global impression:* evaluation based on an overall first impression.
- *Adherence to deliveries:* adherence to the delivery of the task.
- *Structure of the text:* the quantity of details described and the spatial and hierarchical relationship between them.
- *Punctuation:* punctuation marks (punctuation), brackets, division into paragraphs.
- *Vocabulary:* the quantity of different words used, the property in relation to the vocabulary and context, how many different words are produced.
- *Morphosyntax:* the concordance of gender and number for adjectives, verbs, and names, the concordance of times, and the use of the subjunctive.
- *Quality of handwriting:* readability and prototypicality of handwriting.

The quantitative indices considered were the following:

- *Number of words:* number of words in the written production.
- *Number of phrases:* number of phrases in the written production.
- *Number of subordinate sentences:* number of sentences that are grammatically dependent on another sentence (principal sentence) and related percentage (*number of subordinate sentences/total sentences* * 100).
- *Number of repetitions:* number of content words written more than once within the same written text and related percentage (*number of repetitions/total words* * 100).
- *Number of full lexical pauses*[1]*:* inappropriate words that represent interruption in the flow of written production and related percentage (*number of full lexical pauses//total words* * 100).
- *Percentage of lexical informativity (relevant words/total words**100): percentage of lexical information in the written text.

There are no reliability/validity values for the above-mentioned indices; however, the evaluation of expressive competence thus conducted was shown to be sensitive to detect developmental changes as a function of schooling, to discriminate the writing performance of different populations of struggling writers (e.g., children suffering from specific learning disabilities and children with ADHD) from controls (Tressoldi et al., 2013), and to reveal changes resulting from appropriate intervention programs (Re et al., 2007).

To analyse participants' errors, as well as the psycholinguistic characteristics of words used in their texts, individual productions were tabulated word by word. Errors were coded, reflecting both general linguistic weakness and spelling errors.

Linguistic errors were coded as follows:

[1] This index was derived by Marini et al. (2015).

- *Morphosyntactic errors:* errors in the agreement between noun and adjective, noun and article, and in the choice of person, mode, and verb (e.g., PERSONE SEDUTI instead of PERSONE SEDUTE [people sitting]; GRANDI MERCATO instead of GRANDE MERCATO [big market]).
- *Semantic errors:* naming errors resulting in the production of semantically related words (e.g., DIVANO [sofa] instead of PANCHINA [bench]).
- *Neologisms*: new stimuli coined by the subject, far from the recognizable target words.

Considering the different length of texts produced by each participant, all errors were transformed into percentages on total words (*number of each type of error/total words* * 100).

Misspellings were classified (as adapted from Angelelli et al., 2004, 2010, 2016) as follows:

- *Phonologically nonplausible errors* (inaccurate spelling via the sublexical procedure): errors causing a change in phonemic make-up of a word reflecting difficulties in phonemic segmentation, phoneme-to-grapheme encoding, or a phonological/graphemic buffer disorder. Errors were insertions, substitutions, deletions, or transpositions of one or more letters (e.g., GURDA instead of GUARDA, [looks]; METROPOLITONA instead of METROPOLITANA [underground]).
- *Phonologically plausible errors* (impaired spelling along the lexical procedure): spelling errors that can be pronounced to sound like target words; these errors arise from over-reliance on phoneme-to-grapheme conversion routines and the failure to rely on lexical spelling. The category included both word separation/blending (e.g., NELL'A* instead of NELLA [in]) and lexical errors in single words (e.g., GRATTACELO instead of GRATTACIELO [skyscraper]).
- *Stress errors:* erroneous omission or insertion of the stress due to inaccuracy of the phonetic analysis or the application of written conventions.

The written productions were also studied through a psycholinguistic analysis of words (nouns, verbs, and adjectives) used. We computed various psycholinguistic indices such as word frequency and N-size (i.e., number of orthographic neighbours) (both according to CoLFIS database, 2005), familiarity, age of acquisition (AoA), and concreteness. The three latter variables were calculated according to the results of an independent rating of 35 university students: three questionnaires were given to these university students, who were asked to estimate, on a 7-point Likert scale, the familiarity, AoA, and concreteness of each word contained in the database (following the procedure described by Barca et al., 2002).

For both the expressive competence measures and the error analysis, an interrater-agreement analysis was done. Both FV and MI evaluated the expressive competence of written productions and coded errors. For the expressive competence measures, interrater agreement between evaluators was 0.86–0.75; for the error analysis, interrater agreement between evaluators was 1–0.84.

Picture-naming test

A written picture-naming test was used to assess the ability to write target words, minimizing the effect of sensory deficit on a dictated word, via a figure representing the object to be written. This experimental paradigm has the limitation of relying on the evaluation of concrete-stimuli spelling (words that can be represented by images), but it is the only way to evaluate responses with material equal and controlled (in which specific variables are manipulated) and partialling out difficulties deriving from the acoustic deficit.

In this study, 78 figures were selected from the image database of Lotto and colleagues (2001). Figures were selected to correspond to words representing the various sources of spelling difficulties in the Italian orthography: (a) regular words with complete one-sound-to-one-letter correspondence (e.g., ASINO [donkey]); (b) regular words requiring the application of context-sensitive rules (e.g., CHITARRA [guitar]); and (c) words with ambiguous transcription along the phonological-to-orthographic conversion routine (e.g., AQUILA [eagle]). Moreover, regular words contained different sources of phonetic-to-phonological complexity (different length, presence/absence of consonant clusters or doublets). For each word, we computed various psycholinguistic variables, including word frequency, name agreement, and H index (i.e., the agreement on the name produced, by assigning an explicit weighting to the number of names alternatives produced by the sample examined by Lotto et al., 2001). Familiarity, AoA, and concreteness values also were computed following the same procedure described above (Barca et al., 2002). The entire set of stimuli is presented in "Appendix".

To better study the effect of regularity of stimuli transcription, we selected from the entire list of words a sublist of 30 long words (7.8 letters on average, SD = 1.44; range 6–9) of low frequency (mean = 1.87, SD = 0.50) with the following characteristics: 10 regular words with one-sound-to-one-letter correspondence, 10 regular context-sensitive words, and 10 ambiguous words (words with two or more possible transcriptions along the phonological-to-orthographic conversion procedure). There were no stressed words. The three sets of words were balanced for the main psycholinguistic variables such as length, frequency, AoA, familiarity, orthosyllabic difficulty (i.e., presence of double consonants and cluster of consonants), and for the H index. No statistical difference between the three sets of items emerged. In "Appendix" an asterisk marks the words entered in this second analysis.

The images were randomly represented on a sheet of paper, and participants were asked to write down the name of each visual stimulus presented, without any time limit.

Similarly to what was done for text productions, linguistic errors were coded as follows:

- *Morphological errors:* errors regarding inflectional morphology, such as the use of plurals or gender markers (e.g., VESTITI [dresses] instead of VESTITO [dress]; PISELLO [pea] instead of PISELLI [peas]).

- *Semantic errors:* naming errors resulting in the production of semantically related words (e.g., PICCHIO [woodpecker] instead of PAPPAGALLO [parrot]; PULMINO [minibus] instead of AMBULANZA [ambulance]).
- *Word substitutions*: naming errors resulting in the production of words not semantically related to the target word (e.g., RAME [copper] instead of PORRO [leek]; ANTE [doors] instead of TENDA [curtain]).
- *Neologisms:* new stimuli coined by the subject, far from the recognizable target words.

Rarely, subjects committed other kinds of productions, such as these:

- *Morphological variant:* words derived from nouns and adjectives, or words formed with the same suffixes as the diminutives, especially -ino, -étto, -ùccio, and -éllo (e.g., SCATOLINA [little box] instead of SCATOLA [box])
- *Synonyms:* the production of a synonym of the target word (e.g., MAIS instead of PANNOCCHIA [corncob])
- *Picture misperception:* word substitutions due to a misperception of the picture (e.g., TRONCO [trunk] instead of PORRO [leek]).

These latter productions were not considered and were not statistically analysed.

Misspellings were coded as a function of the phonological plausibility, in two categories:

- *Phonologically nonplausible errors:* spelling errors not respecting phoneme-to-grapheme correspondences and that cause a change in phonemic make-up of a word (e.g., ANGURO instead of CANGURO [kangaroo]). Among these, errors on double consonants were also computed (e.g., RAMME instead of RAME [copper]).
- *Phonologically plausible errors*: spelling errors that can be pronounced to sound like target words (e.g., GRATTACELO instead of GRATTACIELO [skyscraper]); ACQUILA instead of AQUILA [eagle]).

If the same stimulus presented more than one error (but the stimulus target was recognizable), each error was coded (e.g., UCELLO* [bird] instead of PICCHIO [woodpecker] was classified as both a semantic error and a phonological error).

Also in this case, errors were transformed in percentages of total words (*number of each type of error/total words* * 100).

Interrater agreement between evaluators (FV and MI) was performed and found to be 1–0.85.

Results

Written text production

Text quality and psycholinguistic characteristics of written production, as well as the number of each error type of the two groups, were compared with t-tests for

Table 2 Evaluation of text quality

	Deaf participants		Control participants		t	*p*
	Mean	SD	Mean	SD		
Global impression	1.69	1.01	4.19	0.75	6.67	0.001
Adherence to deliveries	2.63	1.36	4.69	0.60	4.99	0.001
Structure of the text	1.50	0.82	4.19	0.91	7.21	0.001
Punctuation	1.25	0.45	4.19	0.91	8.82	0.001
Vocabulary	1.44	0.81	4.50	0.63	8.98	0.001
Morphosyntax	1.50	0.63	4.63	0.72	9.58	0.001
Quality of handwriting	2.88	1.15	3.44	1.09	1.40	n.s

Table 3 Occurrence of adjectives, verbs, and nouns in texts written by deaf and control participants

	Deaf participants		Control participants		X^2	*p*
	n	%	n	%		
Adjectives	79	20.47	169	27.13	5.70	0.05
Verbs	127	32.90	181	29.05	1.66	n.s
Nouns	180	46.63	273	43.82	0.76	n.s
Total words	386		623			

independent samples. The frequency of adjectives, verbs, and nouns on the total words produced by the two groups was compared through chi-square analyses.

The expressive competence evaluation (see Table 2) showed that the written productions of deaf subjects were worse than those of hearing ones in each of the examined parameters (i.e., in the global impression, adherence to the deliveries, structure of the text, punctuation, vocabulary, and morphosyntax), except for quality of handwriting.

Additionally, texts written by the deaf subjects were significantly shorter in terms of words (mean number of words 41.31 ± 24.52 vs. 63.63 ± 16.22 in deaf vs. controls respectively; $t_{(31).} = 2.91$, $p < 0.01$) and number of sentences (mean number of phrases 4.50 ± 2.45 vs. 7.00 ± 1.97 in deaf vs. controls respectively; $t_{(31)} = 1.87$, $p < 0.01$). Productions by deaf subjects contained a significantly lower percentage of adjectives with respect to controls, while the percentages of verbs and nouns were comparable between groups (see Table 3). Text produced by deaf subjects also contained a lower percentage of subordinates, but higher percentages of repetitions and full lexical pauses with respect to controls (see Table 4). Overall, their texts were then also less informative with respect to controls.

The psycholinguistic analysis of words produced highlighted that deaf participants mainly used words acquired early (with low AoA) and words with higher N-size with respect to control participants (see Table 5). The familiarity of words led to very similar mean values between groups, although the difference was significant in favour of controls, probably for the low variability of the measure.

Table 4 Morphosyntactic characteristics and lexical informativity in texts written by deaf and control participants

	Deaf participants		Control participants		t	*p*
	Mean %	SD	Mean %	SD		
Repetitions	0.03	0.03	0.01	0.02	2.30	0.05
Subordinates	0.28	0.21	0.51	0.10	3.65	0.001
Full lexical pauses	0.03	0.03	0.01	0.01	2.37	0.05
Lexical informativity	0.36	0.21	0.95	0.04	8.43	0.001

Data are mean percentages on total words (for repetitions, full lexical pauses and lexical informativity) and total sentences (for subordinates)

The analysis of errors (see Fig. 1) showed that deaf people committed a significantly higher number of morphosyntactic and semantic errors relative to controls. In 20% of cases, semantic errors consisted of the easier lexical access to superordinate terms. These individuals committed few phonologically nonplausible misspellings but significantly more of them than controls. Interestingly, phonologically plausible errors were relatively rare in both groups, similarly to stress errors and neologisms.

Summary of results

The written text productions of deaf participants were shorter and characterized by a lower text quality and a scarcity of adjectives. Words produced by deaf participants were influenced by the same psycholinguistic variables influencing hearing controls, though deaf participants chose words acquired earlier in life and with higher lexical neighbourhoods compared to control participants. The error analysis highlighted a prevalence of morphosyntactic and semantic errors, while phonologically nonplausible misspellings were few, although over threshold with respect to controls, and phonologically plausible misspellings were quite rare.

In sum, when deaf subjects can choose the words to be written (in text production), they demonstrate, similarly to controls, a sensitivity to various psycholinguistic variables such as length, word frequency, concreteness, and familiarity, accessing lexical items with a higher lexical activation and/or those earlier acquired more so than controls. In text production, both sublexical and lexical spelling procedures were negatively affected in deaf participants. However, these participants were found to exhibit more severe difficulties with morphosyntactic competence and lexical-semantic limitations, rendering their texts poor.

Written picture naming

Both deaf and control participants wrote most of the stimuli administered (86.16% and 98.42%, for deaf and controls respectively), showing good adherence to the task; however, missing responses were higher for deaf participants with respect to controls (13.84% vs. 1.58%, respectively: $t_{(31)} = 3.54$, $p < 0.01$). Total accuracy was lower for deaf participants with respect to controls (62.34% ± 22.18 vs.

Table 5 Psycholinguistic characteristics of words produced by deaf and control participants in the written text task

	Deaf participants		Control participants		t	*p*
	Mean	SD	Mean	SD		
Length	6.99	2.33	7.16	1.97	1.22	n.s
Word frequency	47.01	137.19	39.20	73.18	1.20	n.s
N-size	5.90	7.07	4.78	4.85	2.99	0.01
Familiarity	6.61	0.18	6.66	0.25	3.34	0.001
AoA	2.71	0.63	2.95	0.55	5.97	0.0001
Concreteness	4.47	1.23	4.50	1.06	0.49	n.s

AoA age of acquisition

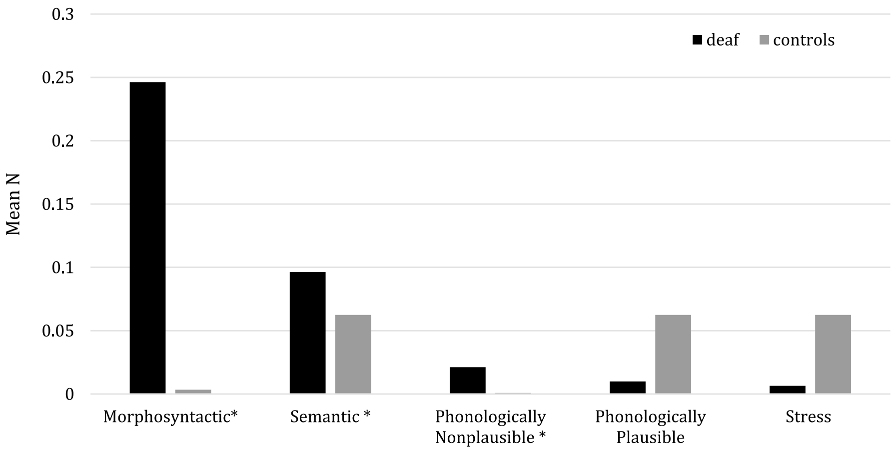

Fig. 1 Analysis of errors committed by deaf and control participants in the written text task. Data are mean percentages of types of errors on total words. The asterisk (*) indicates a significant difference between groups ($p<0.01$ for morphosyntactic errors and phonologically nonplausible errors and $p<0.05$ for semantic errors)

93.43% ± 2.66, respectively; $t_{(31)}=5.81$, $p<0.0001$). A logistic mixed-effect model was performed on participants' accuracy in spelling each stimulus of the whole data set. Group (deaf vs. controls), length (number of letters), word frequency (according to CoLFIS, 2005), familiarity, age of acquisition, and H index were entered in the model as fixed factors. Items and participants were entered in the model as random factors.

The results showed the significance of the effect of group ($F_{(1,2516)}=11.09$, $p<0.001$), word frequency ($F_{(1,2516)}=22.53$, $p<0.0001$), age of acquisition ($F_{(1,2516)}=10.34$, $p<0.001$), and H index ($F_{(1,2516)}=24.13$, $p<0.0001$), while familiarity trended toward significance ($F_{(1,2516)}=3.44$, $p=0.06$). In fact, there was a decrease in the probability of making errors in hearing controls relative to deaf participants ($\beta=-4.63$, $t=-3.33$, $p<0.001$) and on high-frequency words

Table 6 Analysis of errors committed by deaf and control participants in the written picture-naming task (entire list)

	Deaf participants		Control participants		t	*p*
	Mean %	SD	Mean %	SD		
Accurate words	62.34	22.18	93.43	2.66	5.81	0.001
Morphological errors	4.03	2.58	0.24	0.51	6.03	0.001
Semantic errors	14.87	8.42	4.51	2.36	4.90	0.001
Word substitution	0.79	1.21	0.00	0.00	2.64	0.01
Neologisms	0.40	1.58	0.00	0.00	1.00	n.s
Phonological Nonplausible errors	6.17	5.33	0.24	0.69	4.55	0.001
Phonologically plausible errors	0.16	0.43	0.08	0.32	0.59	n.s

Data are mean percentages of accurate words and types of errors on total words

($\beta = -0.72$, $t = -6.12$ $p < 0.0001$); and errors increased in spelling words acquired later ($\beta = 0.21$, $t = 2.99$, $p < 0.01$) or with high H index ($\beta = 0.55$, $t = 2.76$, $p < 0.01$). The significant interactions were group × familiarity ($F_{(1,2516)} = 5.88$, $p < 0.01$) and group x index H ($F_{(1,2516)} = 3.88$, $p < 0.05$): the facilitating effect of familiarity was more marked in deaf than in control participants ($\beta = 0.32$, $t = 2.43$, $p < 0.01$), while the high index H impaired performance mainly in control subjects ($\beta = 0.74$, $t = 1.97$, $p < 0.05$). Random factors (participants and items) were both not significant ($Z < 1$).

The error analysis (see Table 6 and Fig. 2) revealed higher percentages of semantic errors and morphological ones, while word substitutions (unrelated productions) were few in deaf participants and absent in controls (all comparisons with controls were significant). Neologisms were generally few in both groups. Deaf participants also showed a dominance of phonologically nonplausible misspellings relative to phonologically plausible ones, the latter being generally small in both groups. However, it is worth noting that this type of error could be elicited only on 10 stimuli, while the other errors may potentially appear in all the administered stimuli. Figure 2 shows the percentage of the various types of errors in both groups.

A second analysis was performed on the sublist of stimuli examining the effect of regularity of transcription. Missing responses were very low but still superior in deaf participants relative to control participants (13.96% vs. 3.33% deaf and controls respectively: $t_{(31)} = 2.73$, $p < 0.01$). Missing responses in deaf participants were equally present in the three stimulus subsets (about 10% in context-sensitive and ambiguous words and 18% in the subset of regular words; $t < 1$). Also, data were analysed with logistic mixed-effect models, with the group (deaf vs. controls) and the stimulus type (regular words, words requiring the application of context-sensitive rules, ambiguous words) as fixed factors, while items and participants entered as random factors.

Results highlighted the significance of the main effects of group ($F_{(1,954)} = 110.95$, $p < 0.0001$) and stimulus type ($F_{(1,954)} = 2.44$, $p < 0.05$), as well as of the interaction group x stimulus type ($F_{(1,954)} = 3.37$, $p < 0.05$). As can be seen from Fig. 2, the interaction showed that, while controls spelled with similar rates of errors for the three types of stimuli, deaf subjects had worse performances in writing ambiguous

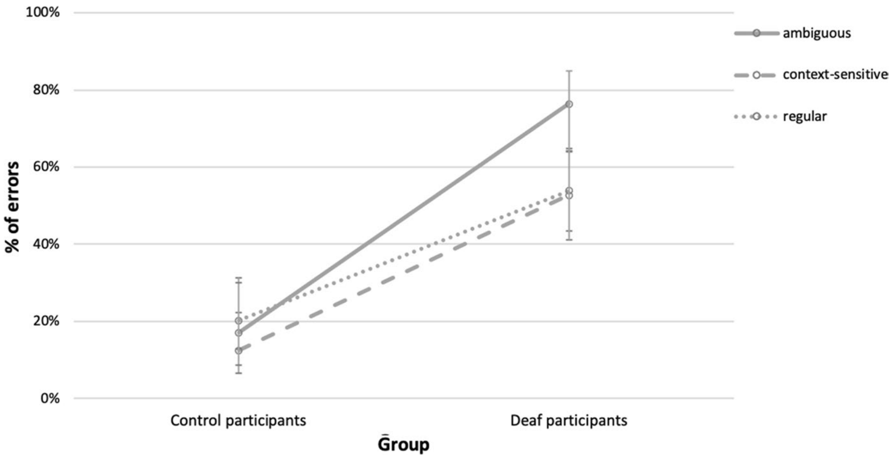

Fig. 2 Percentages of errors committed on regular, context-sensitive, and ambiguous words by deaf and control participants

words with respect to regular words with and without contextual rules ($p < 0.0001$). Regular words with and without contextual rules were spelled comparably. Deaf participants always underperformed relative to hearing participants ($p < 0.0001$), even if the difference was greater in the case of ambiguous words (difference = 0.59) relative to regular words with contextual rules (difference = 0.40) and without contextual rules (difference = 0.34). The random factors of participant and item were not significant ($Z < 1$).

Also, for this matched subset of stimuli, the error analysis (see Table 7) confirmed higher percentages of semantic and morphological errors in deaf compared to control participants. Also, word substitutions were few in deaf participants, but absent in controls.

Phonologically nonplausible misspellings were suprathreshold with respect to controls; phonologically plausible spelling errors were few in deaf and not statistically different from control participants. Note that also in writing ambiguous words, deaf people committed more phonologically nonplausible misspellings with respect to phonologically plausible ones (2.50% vs. 1.25%, respectively), while controls committed only phonologically plausible errors (0.63%).

Summary of results

The analysis of performance on the written picture-naming task highlighted the written difficulties of deaf participants. Firstly, deaf people increased their rate of all types of errors in text production, probably due to the nature of the picture-naming task, in which stimuli are not chosen by subjects and a strict comparison between groups may be done. As far as the characterization of errors, deaf participants showed a prevalence of semantic errors, word substitutions, and morphological errors, suggesting a poor lexical-sematic competence and a deficit in the use of grammar.

Table 7 Analysis of errors committed by deaf and control participants in the written picture-naming task (30 item sublist)

	Deaf participants		Control participants		t	*p*
	Mean %	SD	Mean %	SD		
Morphological errors	5.00	1.21	0.42	0.34	4.35	0.001
Semantic errors	17.08	2.28	4.38	1.25	5.83	0.001
Word substitutions	0.63	0.40	0.00	0.00	1.86	n.s
Phonologically nonplausible errors	3.75	1.67	0.00	0.00	2.69	0.01
Phonologically plausible errors	0.42	0.34	0.21	0.25	0.59	n.s

Error data are mean percentages of types of errors on total words

Concerning their spelling skills, the performance of deaf subjects also showed a significant number of phonologically nonplausible misspellings. This pattern of results remained when the number of regular and ambiguous words was matched. So, even if a regularity effect emerged, with regular words written more accurately that ambiguous words, the error analysis still confirmed a prevalence of phonologically nonplausible misspellings irrespective of the type of stimulus. Overall, the pattern of results is compatible with a not skilful use of the phonological spelling procedure and a certain support for the lexical-orthographic procedure.

Discussion

The analysis of written text productions clearly shows a worse trend in the use of many linguistic aspects of written language by deaf participants, not only in the use of morphosyntactic rules but also in the ineffective use of an informative lexicon. Texts written by deaf participants were shorter than those produced by hearing controls (for comparable results on Italian subjects see Arfé et al., 2016; see also Daigle et al., 2020); they included a less informative lexicon, consistent with other studies focusing on the content and the communicative function of written texts (Gormley & Sarachan-Deilly, 1987; Wolbers et al., 2015). Overall, the description of skills in the performance of deaf subjects relative to the control group showed the following: reduced informational content, reduced length and richness of text, a poorer global impression of text content, lowered adherence to deliveries, impaired structure of the text, and a reduced level of correctness in both morphosyntax and punctuation. Consistently, the analysis of the psycholinguistic characteristics of the words written highlighted the linguistic poverty of the deaf group. In fact, deaf participants were shown to choose words acquired early in life and with a higher lexical neighbourhood relative to the control group. The choice to write words with high orthographic neighbourhood content could be due to easier access to this type of stimulus in the output lexicon. Moreover, the error analysis revealed the presence of semantic (inaccurate naming) and morphosyntactic errors. This impoverished vocabulary was confirmed by analysis of grammatical class and structure of the texts, which were shorter and contained fewer adjectives, in line with other evidence reported in the literature (see also Moores & Sweet, 1990; Yoshinaga-Itano et al., 1996). The significant rate of morphosyntactic errors is consistent with results obtained from other studies examining other Italian deaf adults (Fabbretti et al., 1998; Volterra & Bates, 1989) which highlighted that deaf subjects produced more writing errors in free morphology than hearing subjects for each type of test used. The Italian language requires knowledge of the morphosyntactic structure of words, which is also related to knowledge of the phonemic analysis of the oral language.

Overall, the psycholinguistic analysis of texts supports the hypothesis of a poor and undeveloped vocabulary (Arfè et al., 2015; Convertino et al., 2014) and morphosyntactically poor competence in individuals who are deaf, reflecting lower language proficiency. Different factors may be considered. First, it should be noted that the language to which deaf people are exposed is often limited, simplified, and restricted to face-to-face interaction with the interlocutor. Moreover, difficulties in the use of morphosyntactic rules may reflect the differences between Italian Sign Language (LIS) and oral language. In fact, all of the deaf participants were bilingual (LIS and Italian oral language), and this could considerably facilitate their communication, but it also could lead to an interference of the different grammars of the two languages. In addition, it appears that it is more difficult to acquire grammatical morphology after the critical period for language acquisition has ended (Newpart & Supalla, 1992). However, it is interesting to note that there are studies that disconfirm a detrimental role of sign language on writing acquisition and support the hypothesis that deaf writing difficulties are best explained by deafness itself (Fabbretti et al., 1998). Finally, the presence of morphological errors could be explained by the fact that morphological relations require the achievement of a high level of linguistic competence, which is clearly poorer in subjects with prelingual deafness. Results of the present study highlight that morphosyntactic difficulties of deaf children tend to persist throughout adulthood, despite years of schooling (for similar results see Fabbretti et al., 1998). This evidence is in line with the claim that acoustic perception plays a fundamental role in the use of grammatical morphology (Caselli et al., 1994).

It seems reasonable that the peculiarities that emerged from the analysis of the written text productions of the deaf participants seem to be the expression of a generalized problem with verbal language acquisition, resulting from hearing loss and consequent delayed exposure to oral language, differences in the acquisition mode, and limited literary knowledge. However, other factors may modulate their written composition skills. A detrimental role of an inefficient working memory has been proposed by various authors. Verbal rehearsal skills have been shown to be significantly compromised in deaf children (Arfé et al., 2015; Harris et al., 2013; Pisoni & Cleary, 2003), as well as the executive component of verbal working memory (Alamargot et al., 2007; Arfè et al., 2015). Working memory difficulties may interfere with the organization, completeness, and coherence of text compositions, as well as sentence-level quality (microstructural and macrostructural dimensions, following Arfè et al., 2015).

Other goals of the present study were to investigate the mastering of transcoding spelling skills, with a focus on the efficiency of both lexical and sublexical procedures, and to characterize the type and prevalence of the variuos spelling errors. Both tasks highlighted lower spelling competence, although not so defective, in deaf participants with respect to controls, with a high rate of phonologically nonplausible errors. A high proportion of phonologically nonplausible errors have been reported by other studies (e.g., Harris & Moreno, 2004; Hayes et al., 2011; Olson & Caramazza, 2004). Phonologically nonplausible errors probably reflect inaccurate phonological representations (Hanson et al., 1983), more so than inaccuracy in the phoneme-to-grapheme associations. These data agree with several studies showing that deaf people's phonological representations are sufficiently incomplete and inaccurate to allow them to extract regularities between phonological and orthographic units (Aaron et al., 1998; Burden & Campbell, 1994). Other work has also found that few of the errors produced in writing by the deaf can be considered phonologically plausible (Aaron et al., 1998; Burden & Campbell, 1994). Despite their difficulties along the phonological sublexical procedure, deaf participants seem to benefit from the support of the lexical spelling procedure and its facilitated effects for high-frequency words with respect to low-frequency ones (consistent with another study, Sutcliffe et al., 1999). Our data are also consistent with a study previously conducted showing that deaf people can achieve reasonably high levels of word decoding, even though they are slower and less accurate than hearing controls (Marinelli et al., 2019). However, caution is needed, as the present results are based on deaf adults with a high level of schooling and educated in a bilingual context. Therefore, our results may not generalize to the entire deaf population.

Moreover, our study may be affected by the small sample size, which impacts the statistical power of results. Furthermore, given the impossibility of dictating targeted stimuli and having resorted to a picture-naming spelling task, we cannot exclude the possibility that some errors may reflect difficulties/inefficiencies other than those attributed (e.g., morphological errors may reflect weaknesses in morphological knowledge, or the presence of unspecified orthographic representations but also fragilities in the semantic system).

In sum, a real disability of the deaf individual is in limits to their language acquisition, which can become an obstacle to integration into society and social interaction. The achievement of a good level of reading and writing skills is essential to be able to integrate into a highly developed society such as the one in which we live. Only adequate study with the tools of modern linguistics can create the structures for effective interventions and education for people who are required to access all parts of speech through the visual channel.

Appendix

The asterisk marks the words entered in the analysis conducted to study the effect of regularity of stimuli transcription.

Word		Stimulus typology	No. of letters	Word frequency	Familiarity	AoA	H index	N-size
AQUILA*	EAGLE	Ambiguous	6	2.27	4.06	4.06	0.71	1
CASTAGNA*	CHESTNUT	Ambiguous	8	1.53	5.93	3.26	0.55	3
CERNIERA*	ZIPPER	Ambiguous	8	1.54	5.93	4	0.73	1
CIGNO*	SWAN	Ambiguous	5	1.7	5.46	3.53	0.27	3
CONIGLIO*	RABBIT	Ambiguous	8	2.07	6.13	2.8	0	0
FOGLIA*	LEAF	Ambiguous	6	2.16	6.26	1.93	0.27	8
GRATTACIELO*	SKYSCRAPER	Ambiguous	11	1.66	3.66	4.93	0	1
MAGLIONE*	SWEATER	Ambiguous	8	1.62	6.66	2.6	0	2
PUGNALE*	DAGGER	Ambiguous	7	1.57	1.46	4.2	0.37	1
TENAGLIA*	PINCERS	Ambiguous	8	1.34	3.66	5.66	0.53	2
AMBULANZA*	AMBULANCE	Regular	9	1.6	5.26	5.13	0	1
ARMADIO*	WARDROBE	Regular	7	2.13	6.46	2.93	0.22	4
ELEFANTE*	ELEPHANT	Regular	8	1.84	4.2	2.66	0	2
PANTALONI*	PANTS	Regular	9	2.38	6.8	2.26	0.22	1
PENTOLA*	POT	Regular	7	1.94	7	2.73	0	5
POLTRONA*	ARMCHAIR	Regular	8	2.57	6.26	2.66	0.43	1
TAMBURO*	DRUM	Regular	7	1.85	4.33	3.33	0	1
TENDA*	TENT	Regular	5	1.94	3.46	3.4	0.22	8
VESTITO*	DRESS	Regular	7	2.4	3.53	2	0.4	5
BOTTE	BARREL	Regular	5	1.83	3.8	3.86	0	15
GATTO	CAT	Regular	5	2.57	6.46	2	0	11
LETTO	BED	Regular	5	3	6.73	1.8	0	18
MAPPA	MAP	Regular	5	2.18	3.93	5.73	0.4	7
GALLO	ROOSTER	Regular	5	2.29	6.4	2.46	0.27	13
GONNA	SKIRT	Regular	5	2.17	4	2.53	0	7
PORRO	LEEK	Regular	5	1.46	3.6	6.53	1.49	11
TORRE	TOWER	Regular	5	2.57	3.93	3.86	0.27	10
BATTERIA	DRUMS	Regular	8	1.72	5.13	5.06	0	4
MANETTE	HANDCUFFS	Regular	7	1.57	2.13	5.06	0	4
RUBINETTO	FAUCET	Regular	9	1.79	6.66	3.13	0	1
ZATTERA	RAFT	Regular	7	1.23	2.80	4.8	0	2

Word		Stimulus typology	No. of letters	Word fre-quency	Familiar-ity	AoA	H index	N-size
BIRILLO	SKITTLE	Regular	7	0.77	3.13	2.86	0	2
BUSSOLA	COMPASS	Regular	7	1.67	3.6	5.33	0.22	2
PISELLI	PEAS	Regular	7	1.81	6.2	3.33	0.76	4
SASSOFONO	SAXO-PHONE	Regular	9	0.84	4.53	5.93	0.66	0
AEREO	AIRPLANE	Regular	5	2.86	5.73	3.46	0	7
ASINO	DONKEY	Regular	5	1.84	5.46	2.53	0.74	7
EDERA	IVY	Regular	5	1.6	5.66	4.87	0.58	3
LEONE	LION	Regular	5	2.61	4.33	2.4	0	4
RADIO	RADIO	Regular	5	2.98	6.86	3.26	0	2
SEDIA	CHAIR	Regular	5	2.4	6.8	2	0	4
VIOLA	VIOLET	Regular	5	1.75	4.6	3.57	1.02	5
ZAINO	KNAPSACK	Regular	5	1.92	4.8	4.53	0	1
AUTOMOBILE	CAR	Regular	10	2.6	7	2.8	1.34	1
PAPAVERO	POPPY	Regular	8	1.11	5.60	4.07	0.71	1
PEPERONE	PEPPER	Regular	8	1.55	6.40	4.33	0	2
PIANETA	PLANET	Regular	7	2.42	3.46	5.86	0.96	1
PIRAMIDE	PYRAMID	Regular	8	2.06	2.60	4.73	0	1
POMODORO	TOMATO	Regular	8	2.24	6.66	2.66	0	1
TULIPANO	TULIP	Regular	8	0.84	6.13	4.6	0.48	1
VIOLINO	VIOLIN	Regular	7	2.15	4.53	4.46	0.33	4
CAPPELLO	HAT	Regular	8	2.58	2.8	2.46	0	3
CARROZZA	CARRIAGE	Regular	8	2.33	2.66	3.66	0	2
CASTELLO	CASTLE	Regular	8	2.71	3.93	2.93	0.22	6
CAVALLO	HORSE	Regular	7	2.94	5.66	2.6	0	4
COLTELLO	KNIFE	Regular	8	2.39	6.86	2.33	0	3
PISCINA	SWIMMING POOL	Regular	7	2.35	4.6	3.4	0	2
SCATOLA	BOX	Regular	7	2.45	5.33	2.13	0	3
SCRIVANIA	DESK	Regular	9	2.47	6.2	3.86	0.33	1
ASPARAGO	ASPARA-GUS	Regular	8	0.69	5.66	5.13	0.58	1
CALZINO	SOCK	Regular	7	0.84	5.93	2.87	0	4
CANGURO	KANGA-ROO	Regular	7	0.95	3.73	3.86	0	1
CLESSIDRA	SAND-GLASS	Regular	9	0.77	3.4	6.13	0	0
CORNAMUSA	BAGPIPE	Regular	9	0.3	2.93	5.6	0.37	1
GIRAFFA	GIRAFFE	Regular	7	1	4	2.86	0	1
MAPPA-MONDO	GLOBE	Regular	10	0.95	5.73	4.93	0	0
MELOGRANO	POME-GRANATE	Regular	9	0.69	4.4	4.66	0.27	1

Word		Stimulus typology	No. of letters	Word frequency	Familiarity	AoA	H index	N-size
RASTRELLO	RAKE	Regular	9	0.95	3.46	3.93	0	1
BICCHIERE*	GLASS	Context sensitive	9	2.53	7	1.8	0	4
CHIESA*	CHURCH	Context sensitive	6	3.22	5.2	2.86	0	5
CHITARRA*	GUITAR	Context sensitive	8	2.04	6	4.26	0	1
COPERCHIO*	LID	Context sensitive	9	1.84	6.66	3	0.27	0
CUCCHIAIO*	SPOON	Context sensitive	9	2.02	6.8	2	0	0
FORCHETTA*	FORK	Context sensitive	9	1.67	6.8	1.8	0	1
MARGHERITA*	DAISY	Context sensitive	10	2.17	6.4	2.8	0.4	1
PANNOCCHIA*	CORN	Context sensitive	10	1.07	5.42	4.4	0.47	0
PICCHIO*	WOODPECKER	Context sensitive	7	0.69	4.26	4.33	0.48	3
SECCHIO*	BUCKET	Context sensitive	7	1.47	4.8	2.8	0	2

Acknowledgements We would like to thank the Research and Editing Consulting Program (RECP) of the International Neuropsychological Society for editorial assistance.

Funding Open access funding provided by Università del Salento within the CRUI-CARE Agreement.

References

Aaron, P. G., Keetay, V., Boyd, M., Palmatier, S., & Wacks, J. (1998). Spelling without phonology: A study of deaf and hearing children. *Reading and Writing: An International Journal, 10*, 1–22. https://doi.org/10.1016/j.ridd.2014.10.012

Alamargot, D., Lambert, E., Thebault, C., & Dansac, C. (2007). Text composition by deaf and hearing middle-school students: The role of working memory. *Reading and Writing: An International Journal, 20*, 333–360. https://doi.org/10.1007/s11145-006-9033-y

Angelelli, P., Judica, A., Spinelli, D., Zoccolotti, P., & Luzzatti, C. (2004). Characteristics of writing disorders in Italian dyslexic children. *Cognitive and Behavioral Neurology, 17*(1), 18–31. https://doi.org/10.1097/00146965-200403000-00003

Angelelli, P., Marinelli, C. V., & Burani, C. (2014). The effect of morphology on spelling and reading accuracy: A study on Italian children. *Frontiers in Psychology, 5*, 1–10. https://doi.org/10.3389/fpsyg.2014.01373

Angelelli, P., Marinelli, C. V., De Salvatore, M., & Burani, C. (2017). Morpheme-based reading and spelling in Italian children with developmental dyslexia and dysgraphia. *Dyslexia: An International Journal of Research and Practice*. https://doi.org/10.1002/dys.1554

Angelelli, P., Notarnicola, A., Judica, A., Zoccolotti, P., & Luzzatti, C. (2010). Spelling impairment in Italian dyslexic children: Does the phenomenology change with age? *Cortex, 46*, 1299–1311. https://doi.org/10.1016/j.cortex.2010.06.015

Angelelli, P., Putzolu, A., Iaia, M., Marinelli, C. V., Gasperini, F., Chilosi, A. M., & Brizzolara, D. (2016). Spelling impairments in Italian dyslexic children with and without a history of early language delay. Are there any differences? *Frontiers in Psychology—Educational Psychology, 7*, 527. https://doi.org/10.3389/fpsyg.2016.00527

Apel, K., & Masterson, J. J. (2015). Comparing the spelling and reading abilities of students with cochlear implants and students with typical hearing. *Journal of Deaf Studies and Deaf Education, 20*, 125–135. https://doi.org/10.1093/deafed/env002

Arfé, B., Ghiselli, S., & Montino, S. (2016). The written language of children with cochlear implant. *Hearing, Balance and Communication, 14*(3), 103–110. https://doi.org/10.1080/21695717.2016.1197619

Arfé, B., Nicolini, F., Pozzebon, E., Dockrell, J., & Berninger, W. V. (2014). The influence of verbal working memory on writing skills in children with hearing loss. In *Writing development in children with hearing loss, dyslexia or oral language problems: Implications for assessment and instruction* (pp. 85–99). https://doi.org/10.1093/deafed/env005.

Arfé, B., Rossi, C., & Sicoli, S. (2015). The contribution of verbal working memory to deaf children's oral and written production. *Journal of Deaf Studies and Deaf Education, 20*(3), 203–214.

Barca, L., Burani, C., & Arduino, S. L. (2002). Word naming times and psycholinguistic norms for Italian nouns. *Behaviour Research Methods, Instruments, & Computers, 34*, 424–434. https://doi.org/10.3758/bf03195471

Beech, J. R., & Harris, M. (1997). The prelingually deaf young reader: A case of reliance on direct lexical access? *Journal of Research in Reading, 20*, 105–121. https://doi.org/10.1111/1467-9817.00024

Bertinetto, P. M., Burani, C., Laudanna, A., Marconi, L., Ratti, D., Rolando, C., & Thornton, A. M. (2005). *Corpus e Lessico di Frequenza dell'Italiano Scritto (CoLFIS)*. http://linguistica.sns.it/CoLFIS/Home.htm.

Bertone, C., & Volpato, F. (2009). Oral language and sign language: Possible approaches for deaf people's language development. *Cadernos De Saúde, 2*, 51–62. https://doi.org/10.34632/cadernosdesaude.2009.2976

Bertone, C., & Volpato, F. (2012). Le conseguenze della sordità nell'accessibilità alla lingua e ai suoi codici. *Educazione Linguistica Language Education, 1*, 549–580.

Bishop, D. V. M. (1983). Comprehension of English syntax by profoundly deaf children. *Journal of Child Psychology and Psychiatry, 24*, 415–434. https://doi.org/10.1111/j.1469-7610.1983.tb00118.x

Brown, C. A., & Bacon, S. P. (2010). Fundamental frequency and speech intelligibility in background noise. *Hearing Research, 266*, 52–59. https://doi.org/10.1016/j.heares.2009.08.011

Burden, V., & Campbell, R. (1994). The development of word-coding skills in the born deaf: An experimental study of deaf school-leavers. *British Journal of Developmental Psychology, 12*(3), 331–349. https://doi.org/10.1111/j.2044-835X.1994.tb00638.x

Caselli, M. C., Maragna, S., Pagliari Rampelli, L., & Volterra, V. (1994). *Linguaggio e Sordità*. La Nuova Italia.

Caselli, M. C., Maragna, S., & Volterra, V. (2006). *Linguaggio e Sordità. Gesti. Segni e parole nello sviluppo e nell'educazione*. Il Mulino.

Chesi, C. (2006). *Il linguaggio verbale non standard dei bambini sordi*. Edizioni Universitarie Romane.

Chilosi, A. M., Brizzolara, D., Lami, L., Pizzoli, C., Gasperini, F., Pecini, C., Cipriani, P., & Zoccolotti, P. (2009). Reading and spelling disabilities in children with and without a history of early language delay: A neuropsychological and linguistic study. *Child Neuropsychology, 15*(6), 582–604. https://doi.org/10.1080/09297040902927614

Colombo, L., Arfé, B., & Bronte, T. (2012). The influence of phonological mechanisms in written spelling of profoundly deaf children. *Reading and Writing, 25*(8), 2021–2038. https://doi.org/10.1007/s11145-011-9343-6

Convertino, C., Borgna, G., Marschark, M., & Durkin, A. (2014). Word and world knowledge among deaf learners with and without cochlear implants. *Journal of Deaf Studies and Deaf Education, 19*(4), 471–483. https://doi.org/10.1093/deafed/enu024

Cornoldi, C., Pra Baldi, A., & Giofrè, D. (2017). *Prove MT Avanzate-3-Clinica. La valutazione delle abilità di Lettura, Comprensione, Scrittura e Matematica per il biennio della Scuola Secondaria di II Grado*. Erikson.

Daigle, D., Berthiaume, R., Costerg, A., & Plisson, A. (2020). What do spelling errors tell us about deaf learners of French? *The Journal of Deaf Studies and Deaf Education, 25*(3), 365–376. https://doi.org/10.1093/deafed/enz049

Dodd, B. (1987). Lip-reading, phonological coding and deafness. In B. Dodd & R. Campbell (Eds.), *Hearing by eye: The psychology of lip-reading* (pp. 177–189). Lawrence Erlbaum Associates Inc.

Fabbretti, D., Volterra, V., & Pontecorvo, C. (1998). Written language abilities in deaf Italians. *The Journal of Deaf Studies and Deaf Education, 3*, 231–244. https://doi.org/10.1093/oxfordjournals.deafed.a014353

Franchi, E., & Musola, D. (2010). *Acquisizione dell'italiano e sordità. Omaggio a Bruna Radelli*. Libreria Editrice Cafoscarina.

Gärdenfors, M., Johansson, V., & Schönström, K. (2019). Spelling in deaf, hard of hearing and hearing children with sign language knowledge. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2019.02463

Geers, A. E., & Hayes, H. (2011). Reading, writing, and phonological processing skills of adolescents with 10 or more years of cochlear implant experience. *Ear and Hearing, 32*, 49S-59S. https://doi.org/10.1097/aud.0b013e3181fa41

Gormley, K., & Sarachan-Deily, B. (1987). Evaluating hearing-impaired students' writing: A practical approach. *Volta Review, 89*(3), 157–166.

Hanson, V. L., Shankweiler, D., & Fischer, F. W. (1983). Determinants of spelling ability in deaf and hearing adults: Access to linguistic structure. *Cognition, 14*(3), 323–344. https://doi.org/10.1016/0010-0277(83)90009-4

Harris, M., & Beech, J. R. (1998). Implicit phonological awareness and early reading development in prelingually deaf children. *Journal of Deaf Studies and Deaf Education, 3*, 205–216. https://doi.org/10.1093/oxfordjournals.deafed.a014351

Harris, M., & Moreno, C. (2004). Deaf children's use of phonological coding: Evidence from reading, spelling, and working memory. *The Journal of Deaf Studies and Deaf Education, 9*(3), 253–268. https://doi.org/10.1093/deafed/enh016

Harris, M. S., Kronenberger, W. G., Gao, S., Hoen, H. M., Miyamoto, R. T., & Pisoni, D. B. (2013). Verbal short-term memory development and spoken language outcomes in deaf children with cochlear implants. *Ear and Hearing, 34*, 179–192. https://doi.org/10.1097/AUD.0b013e318269ce50

Hayes, H., Kessler, B., & Treiman, R. (2011). Spelling of deaf children who use cochlear implants. *Scientific Studies of Reading, 15*(6), 522–540. https://doi.org/10.1080/10888438.2010.528480

Heefner, D. L., & Shaw, P. C. (1996). Assessing the written narratives of deaf students using the six-trait analytical scale. *Volta Review, 98*(1), 147–168.

Kelly, L. P. (1993). Recall of English function words and inflections by skilled and average deaf readers. *American Annals of the Deaf, 138*(3), 288–296. https://doi.org/10.1353/aad.2012.0481

Kyle, F. E., & Harris, M. (2011). Longitudinal patterns of emerging literacy in beginning deaf and hearing readers. *Journal of Deaf Studies and Deaf Education, 16*, 289–304. https://doi.org/10.1093/deafed/enq069

Leybaert, J. (2000). Phonology acquired through the eyes and spelling in deaf children. *Journal of Experimental Child Psychology, 75*(4), 291–318. https://doi.org/10.1006/jecp.1999.2539

Leybaert, J., & Alegria, J. (1995). Spelling development in deaf and hearing children: Evidence for use of morpho-phonological regularities in French. *Reading and Writing: An International Journal, 7*, 89–109. https://doi.org/10.1007/BF01026949

Leybaert, J., & Lechat, J. (2001). Variability in deaf children's spelling: The effect of language experience. *Journal of Educational Psychology, 93*, 554–562. https://doi.org/10.1037//0022-0663.93.3.554

Lotto, L., Dell'Acqua, R., & Job, R. (2001). Le figure PD/DPSS. Misure di accordo sul nome, tipicità, familiarità, età di acquisizione e tempi di denominazione per 266 figure. *Giornale Italiano Di Psicologia. Rivista Trimestrale, 1*, 193–210.

Lyxell, B., Sahlén, B., Wass, M., Ibertsson, T., Larsby, B., Hällgren, M., & Mäki-Torkko, E. (2008). Cognitive development in children with cochlear implants: Relations to reading and communication. *International Journal of Audiology, 47*, 47–52. https://doi.org/10.1080/14992020802307370

Marinelli, C. V., Cellini, P., Zoccolotti, P., & Angelelli, P. (2017). Lexical processing and distributional knowledge in sound–spelling mapping in a consistent orthography: A longitudinal study of reading and spelling in dyslexic and typically developing children. In B. Rapp & M. McCloskey (Eds.), *Developmental dysgraphia.* Routledge. https://doi.org/10.1080/02643294.2017.1386168

Marinelli, C. V., Romani, C., Burani, C., & Zoccolotti, P. (2015). Spelling acquisition in English and Italian: A cross-linguistic study. *Frontiers in Psychology, 6*, 1843. https://doi.org/10.3389/fpsyg.2015.01843

Marinelli, C. V., Vizzi, F., & Zoccolotti, P. (2019). Reading skills in deaf subjects: Role of psycholinguistic factors and global influences in affecting reading performance. *Psychology, 10*, 1754–1775. https://doi.org/10.4236/psych.2019.1012115

Marini, A., Marotta, L., Bulgheroni, S., & Fabbro, F. (2015). *Batteria per la valutazione del linguaggio in bambini dai 4 ai 12 anni*. Giunti OS.

Moores, D. F., & Sweet, C. (1990). Factors predictive of school achievement. In *Educational and developmental aspects of deafness* (pp. 154–201).

Musselman, C. (2000). How do children who can't hear learn to read an alphabetic script? A review of the literature on reading and deafness. *Journal of Deaf Studies and Deaf Education, 5*, 11–31. https://doi.org/10.1093/deafed/5.1.9

Newport, E. L., & Supalla, T. (1992). *Critical period effects in the acquisition of a primary language: I. The influence of maturational state on the acquisition of complex morphology in American Sign Language*. University of Rochester.

Notarnicola, A., Angelelli, P., Judica, A., & Zoccolotti, P. (2012). The development of spelling skills in a shallow orthography: The case of the Italian language. *Reading and Writing: An International Journal, 25*, 1171–1194. https://doi.org/10.1007/s11145-011-9312-0

Oliveira, K. L. S. D., Feitosa, A. L. F., Depolli, G. T., & Pedruzzi, C. M. (2020). Reading and writing performance in cochlear implant users: Integrative review. *Audiology-Communication Research*. https://doi.org/10.1590/2317-6431-2020-2298

Olson, A. C., & Caramazza, A. (2004). Orthographic structure and deaf spelling errors: Syllables, letter frequency, and speech. *The Quarterly Journal of Experimental Psychology Section A, 57*(3), 385–417. https://doi.org/10.1080/02724980343000396

Park, J., Lombardino, L. J., & Ritter, M. J. (2013). Phonology matters: A comprehensive investigation of reading and spelling skills of school-age children with mild to moderate sensorineural hearing loss. *American Annals of the Deaf, 158*, 20–40. https://doi.org/10.1353/aad.2013.0013

Perfetti, C. A., & Sandak, R. (2000). Reading optimally builds on spoken language: Implications for deaf readers. *Journal of Deaf Studies and Deaf Education, 5*, 32–50. https://doi.org/10.1093/deafed/5.1.32

Pisoni, D. B., & Cleary, M. (2003). Measures of working memory span and verbal rehearsal speed in deaf children after cochlear implantation. *Ear and Hearing, 24*, 106S-120S. https://doi.org/10.1097/01.AUD.0000051692.05140.8E

Pisoni, D. B., Kronenberger, W., Conway, C. M., Horn, D. L., Karpicke, J., & Henning, S. (2008). Efficacy and effectiveness of cochlear implants in deaf children. In M. Marschark & P. Hauser (Eds.),

Deaf cognition: Foundations and outcomes. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195368673.003.0003
Raven, C. J. (2008). *Standard progressive matrices*. Giunti OS.
Re, A. M., Pedron, M., & Cornoldi, C. (2007). Expressive writing difficulties in children described as exhibiting ADHD symptoms. *Journal of Learning Disabilities, 40*(3), 244–255. https://doi.org/10.1177/00222194070400030501
Sterne, A., & Goswami, U. (2000). Phonological awareness of syllables, rhymes, and phonemes in deaf children. *The Journal of Child Psychology and Psychiatry and Allied Disciplines, 41*(5), 609–625. https://doi.org/10.1111/1469-7610.00648
Sutcliffe, A., Dowker, A., & Campbell, R. (1999). Deaf children's spelling: Does it show sensitivity to phonology? *Journal of Deaf Studies and Deaf Education, 4*, 111–123. https://doi.org/10.1093/deafed/4.2.111
Taeschner, T., Devescovi, A., & Volterra, V. (1988). Affixes and function words in the written language of deaf children. *Applied Psycholinguistics, 9*(4), 385–401. https://doi.org/10.1017/S0142716400008079
Tomblin, B. J., Harrison, M., Ambrose, S. E., Walker, E. A., Oleson, J. J., & Moeller, M. P. (2015). Language outcomes in young children with mild to severe hearing loss. *Ear and Hearing, 36*, 76S-91S. https://doi.org/10.1097/aud.0000000000000219
Tressoldi, P. E., Cornoldi, C., & Re, A. M. (2013). *BVSCO-2 batteria per la valutazione della scrittura e della competenza ortografica-2*. Giunti O.S.
Volterra, V., & Bates, E. (1989). Selective impairment of Italian grammatical morphology in the congenitally deaf: A case study. *Cognitive Neuropsychology, 6*, 273–308. https://doi.org/10.1080/02643298908253421
Wolbers, K. A., Dostal, H. M., Graham, S., Cihak, D., Kilpatricl, J. R., & Saulsberry, R. (2015). The writing performance of elementary students receiving strategic and interactive writing instruction. *Journal of Deaf Studies and Deaf Education, 20*, 385–398. https://doi.org/10.1093/deafed/env022
Yoshinaga-Itano, C., Snyder, L. S., & Mayberry, R. (1996). How deaf and normally hearing students convey meaning within and between written sentences. *Volta Review, 98*, 9–38.
Zoccolotti, P., De Luca, M., Di Filippo, G., Judica, A., & Martelli, M. (2009). Reading development in an orthographically regular language: Effects of length, frequency, lexicality and global processing ability. *Reading and Writing: An International Journal, 22*, 1053–1079. https://doi.org/10.1007/s11145-008-9144-8

Authors and Affiliations

Francesca Vizzi[1,2] · **Paola Angelelli**[1,2] · **Marika Iaia**[1,2] · **Anthony H. Risser**[3] · **Chiara Valeria Marinelli**[2,4]

[1] Department of Human and Social Sciences, University of Salento, Lecce, Italy

[2] Lab of Applied Psychology and Intervention, Department of Human and Social Sciences, University of Salento, Studium 2000, Edificio 5, V.le San Nicola, Lecce, Italy

[3] Department of Clinical Psychology, Adler University, Chicago, USA

[4] Department of Clinical and Experimental Medicine, University of Foggia, Foggia, Italy