Cognition 168 (2017) 27–33

Contents lists available at ScienceDirect

Cognition

journal homepage: www.elsevier.com/locate/COGNIT

Original Articles

Phonological and orthographic coding in deaf skilled readers

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ARTICLE INFO

Article history:
Received 4 April 2016
Revised 14 June 2017
Accepted 15 June 2017
Available online 21 June 2017

Keywords:
Reading
Lexical decision
Deaf skilled readers
Phonological coding
Orthographic coding

ABSTRACT

Written language is very important in daily life. However, most deaf people do not achieve good reading levels compared to their hearing peers. Previous research has mainly focused on their difficulties when reading in a language with an opaque orthography such as English. In the present study, we investigated visual word recognition of deaf adult skilled readers while reading in Spanish, a language with a transparent orthography, for which obligatory phonological mediation has been claimed. Experiment 1 showed a pseudohomophone inhibitory effect in hearing but not in deaf people. Experiment 2 showed similar orthographic sensitivity, as measured by the transposed-letter effect, for both groups. These results suggest that deaf skilled readers do not rely on phonological mediation, while maintaining the same level of orthographic sensitivity as hearing readers, thus suggesting that the use of phonological coding is not required to access the lexicon and meaning in a language with a transparent orthography.

1. Introduction

Written language is an important channel for daily communication and for cultural transmission. Learning to read changes our brain (Carreiras, Seghier, Baquero, Estévez, Lozano, Devlin, & Price, 2009), influences our cognitive machinery, including spoken language processing (Frost & Katz, 1989; Frost, Repp, & Katz, 1988; Ziegler & Ferrand, 1998), and opens a new world of opportunities. However, most deaf people never achieve a good reading level and lag behind their hearing peers (Conrad, 1979; Traxler, 2000). Various authors have suggested that reduced access to speech phonology is the main underlying cause of their reading difficulties and the high percentage of deaf people who make a great effort to learn to read (Hanson & Fowler, 1987; Perfetti & Sandak, 2000). Even so, it is unclear whether, for example, explicit training of phonological awareness helps deaf individuals to achieve high reading proficiency (Campbell & Wright, 1988; Izzo, 2002; Nielsen & Luetke-Stahlman, 2002). Regardless of the difficulties in the development and acquisition of reading for deaf individuals and the role of phonology in this process, there are deaf adults who have achieved a high level of reading, equivalent to hearing peers. While most previous research has focused on the difficulties of deaf readers in relation to phonological processing (Colin, Magnan, Ecalle, & Leybaert, 2007; Kelly & Barac-Cikoja, 2007), in the present study we adopt a different perspective by focusing on deaf highly skilled readers and investigating their use of phonological and orthographic codes during reading in comparison to hearing readers.

Many studies have highlighted the importance of phonological coding and awareness for reading skills in deaf individuals (Hanson & Fowler, 1987; Perfetti & Sandak, 2000). The majority of studies that investigate the role of phonology in the deaf population do so through meta-phonological tasks and phonological awareness, which require explicit phonological judgments (Aparicio, Gounot, Demont, & Metz-Lutz, 2007; Campbell & Wright, 1988; Dyer, MacSweeney, Szczerbinski, Green, & Campbell, 2003; Transler, Leybaert, & Gombert, 1999; Waters & Doehring, 1990). In addition, many of these studies focus on deaf children, where reading is still in the development phase. Our interest, on the other hand, is in studies that investigate the role of phonology in more implicit reading tasks, such as lexical decision between words and nonwords, and reading with deaf adult readers. Studies that use this paradigm, such as Transler and Reitsma (2005), show evidence for phonological coding in visual word recognition in deaf Dutch readers, but in this case the population studied was children. In contrast, the few other studies with deaf adults have reported no evidence for the use of phonological coding by deaf readers during word reading. For example, Bélanger, Baum, and Mayberry (2012) concluded that skilled deaf readers might activate visual, orthographic and semantic codes during reading, but not phonological codes in French. Furthermore,

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http://dx.doi.org/10.1016/j.cognition.2017.06.015
0010-0277/

Bélanger, Mayberry, and Rayner (2013) investigated the phonological and orthographic preview benefit in parafovea in English readers. The authors manipulated whether, when reading sentences, the word processed in the parafovea corresponded to a homophone or an orthographically similar word to the target word, which only appeared once the eye gaze came to that word and it was within the foveal area. They showed that skilled hearing readers, skilled deaf readers and less-skilled deaf readers benefited from orthographic coding in parafoveal vision during reading, showing shorter fixations for target words in the orthographically similar condition. In contrast, only the hearing group benefited from phonological coding, since they showed shorter first fixations on the target word, suggesting that homophones seen in the parafovea were recognized and that phonological information influenced the subsequent reading time. This benefit and processing of phonological information during parafoveal viewing was not present in the deaf group. Mayberry, Del Giudice, and Lieberman (2011) conducted a meta-analysis of 57 studies of reading outcomes in deaf adults and children. They showed that language ability (measured in terms of sign or spoken language comprehension and vocabulary production) accounted for 35% of the variance in reading ability, while speech phonological awareness accounted for 11% of the variance, a figure similar to that reported in hearing children (Mayer, 2007). Thus, although important, activation of phonological code may not be a determining factor for reading skills, at least in languages with opaque orthographies.

Importantly, previous studies have demonstrated that the presence of phonological mediation in tasks of word-processing is a necessary step to lexical access (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Frost, 1998; Van Orden, Johnston, & Hale, 1988). These studies conclude that the basis of word visual recognition rests on the phonological representation, rather than on the orthographic representation. However, this seems to depend on the degree of transparency of the language in which reading occurs (e.g., languages with a transparent orthography such as Spanish vs. languages with an opaque orthography such as English; Ehri, 1986; Frith, 1985; Harm & Seidenberg, 2004; Share, 1995). Frost and Katz (1992) hypothesized that transparent orthographies are more easily able to support a word recognition process that involves phonological coding. In contrast, in opaque orthographies, readers can process printed words by relying on alternative strategies (e.g., by relying on the visual-orthographic structure). Crucially, it has been shown that phonological codes are automatically accessed during reading in Spanish, a language with a transparent orthography (e.g., Carreiras et al., 2009; Pollatsek, Perea, & Carreiras, 2005), suggesting that efficient phonological processing may be an obligatory step for word identification in transparent languages.

Reading mechanisms in deaf skilled readers may be modulated by the nature of the orthographical system they have to master. Most research with deaf readers has been conducted in languages with an opaque orthography. Therefore, it is critical to investigate how deaf skilled readers carry out visual word recognition in a transparent orthography to better understand the real contribution of phonological processes to reading in this population. The current study focuses on deaf skilled readers of Spanish, a transparent language in which phonological coding has been claimed to be an obligatory and automatic step in the visual word recognition process. Besides, and in contrast to preceding studies relying on meta-phonological tasks, here we used a simple lexical decision task to test phonological and orthographic coding in skilled deaf readers. If phonological processes are at work in deaf skilled readers, the prediction is that they should certainly be seen during reading in a transparent orthography.

Hence, in the present study we investigated the role of phonological and orthographic processing in deaf and hearing skilled readers in Spanish, a language with a transparent orthography. Experiment 1 tested phonological processing in a lexical decision task with two types of nonwords: pseudohomophones (nonwords that sound like real words) and control nonwords. The pseudohomophone effect is one of the strongest indicators of phonological processing in visual word recognition (Briesemeister et al., 2009; Ferrand & Grainger, 1994; Ziegler, Jacobs, & Klüppel, 2001), as indicated by slower reaction times and/or more errors for pseudohomophones than control nonwords. Experiment 2 tested orthographic processing in a lexical decision task with two types of nonwords: transposed-letter nonwords (TL) and replaced-letter nonwords (RL). The transposed-letter effect is a robust indicator of orthographic processing (Perea & Carreiras, 2006; Perea & Lupker, 2004), as shown by slower reaction times and more errors for TL nonwords than RL nonwords.

On the one hand, if deaf skilled readers activate phonological codes they should perform like hearing readers and show longer reaction times and/or higher error rates for pseudohomophones than control nonwords. In contrast, if they do not activate phonological codes they should show no differences between pseudohomophones and control nonwords. On the other hand, if, similarly to hearing readers, deaf readers activate orthographic codes, then both deaf and hearing readers should show longer reaction times and/or higher error rates for transposed-letter nonwords than replaced-letter nonwords. Thus, the combination of the two experiments will show whether deaf skilled readers activate phonological and/or orthographic codes to the same extent as hearing readers, and to what extent phonological mediation is necessary for skilled reading in a language with a transparent orthography.

2. Experiment 1: phonological coding

2.1. Method

2.1.1. Participants

Fifteen adult Spanish severely (70–90 dB) to profoundly (>90 dB) deaf proficient readers (11 females; mean age = 33.93 - years; SD = 7.44; range = 23–45) participated in the study. All participants provided self-reports on their hearing loss, and reported having lost audition before the age of 3 (i.e., prelingual deafness). Also, all of them learned Spanish Sign Language before 10 years old and used it as main language for communication. In addition, most of them learned to read at an early age, particularly at school, except two who learned after 16 years old. Fifteen hearing Spanish readers (7 females; mean age = 29.13 years; SD = 5.8; range = 20–42 years old) were also included as a control group. All participants completed the ECL-2 reading assessment Test (De la Cruz, 1999) to assess their reading comprehension level. This test is a standardized reading test, which evaluates different types of texts and aspects of reading comprehension: knowledge of the meaning of words, synonyms, antonyms, understanding the meaning of sentences and the ability to integrate information into a text. The test consisted of five short paragraphs followed by multiple-choice questions, 27 in total. It is normed with a sample of 16-year-olds and does not require a reading aloud task for percentile rating (which would have been problematic for the deaf group). Only participants who scored at least at the 75th centile (more than 17 correct answers) on the test were included in the study and considered relatively skilled readers, and the two groups were matched according to the raw scores (deaf: mean = 21.90, SD = 3.08, range = 18–27; hearing: mean = 23.70, SD = 3.25, range = 17–27). All the participants also completed the Spanish version of LexTALE (Izura, Cuetos, & Brysbaert, 2014), a lexical decision test comprising 60 real words and 30 nonwords that provides a good estimate of language knowledge (e.g., De Bruin,