Research in Developmental Disabilities 35 (2014) 1177–1190

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Impact of orthographic transparency on typical and atypical reading development: Evidence in French-Spanish bilingual children

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ARTICLE INFO

Article history:
Received 19 September 2013
Received in revised form 17 January 2014
Accepted 23 January 2014
Available online 20 February 2014

Keywords:
Reading
Dyslexia
Orthographic transparency
Bilingualism
Visual attention span
Phonemic awareness

ABSTRACT

The present study aimed to quantify cross-linguistic modulations of the contribution of phonemic awareness skills and visual attention span (VA Span) skills (number of visual elements that can be processed simultaneously) to reading speed and accuracy in 18 Spanish-French balanced bilingual children with and without developmental dyslexia. The children were administered two similar reading batteries in French and Spanish. The deficits of the dyslexic children in reading accuracy were mainly visible in their opaque orthography (French) whereas difficulties indexed by reading speed were observed in both their opaque and transparent orthographies. Dyslexic children did not exhibit any phonemic awareness problems in French or in Spanish, but showed poor VA Span skills compared to their control peers. VA span skills correlated with reading accuracy and speed measures in both Spanish and French, whereas phonemic awareness correlated with reading accuracy only. Overall, the present results show that the VA Span is tightly related to reading speed regardless of orthographic transparency, and that it accounts for differences in reading performance between good and poor readers across languages. The present findings further suggest that VA Span skills may play a particularly important role in building-up specific word knowledge which is critical for lexical reading strategies.

1. Introduction

Literacy is a key determinant of a successful education and individuals' well-being. A large amount of studies have therefore investigated the nature of its neural and cognitive foundations (e.g., Carreiras et al., 2009). With both theoretical and applied perspectives in mind, some have taken on the challenge of establishing whether common bases support the

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0891-4222/$ – see front matter © 2014 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ridd.2014.01.021

reading network across languages (e.g., Paulesu et al., 2000), and others have stressed the importance of taking into account the languages' specificities when studying reading (e.g., Share, 2008). In line with the latter point, Ziegler and Goswami (2005) proposed the psychological grain size theory which offers a theoretical framework allowing testing hypotheses about the impact of cross-linguistic differences linked to orthographic transparency on reading development. Orthographic transparency is the degree of the regularity of the correspondences between letter units (graphemes) and sound units (phonemes) in a given language. In transparent and consistent orthographies, such as Spanish, most letters equal one sound and most single sounds equal one letter, except for a very limited number of two letter clusters, such as "ch" in the word "ocho" (/otʃo/, "eight") and sounds that could be written in different ways (e.g., /x/ can be written with the letter "j" or "g"). It is therefore easy for children to learn the letter-sound conversion rules since they follow an almost "one letter = one sound" mapping pattern. Conversely, in non transparent (i.e., opaque) and inconsistent orthographies such as French, the same letter can be associated with more than one sound (e.g., "a" can be pronounced /a/ in "patin", /ɑ/ in "pantin", /o/ in "peau", or /ɛ/ in "paix"), and vice versa (e.g., the sound /e/ can be written "et", "er", "é", "ées", etc.) increasing the likelihood to mispronounce or misspell words.

The psychological grain size theory posits that the orthographic transparency of a certain language puts some constraints on the development of reading procedures (or reading strategies). More specifically, it postulates that the size of the units relevant for the build-up of lexical representations of this language is inversely proportional to the regularity of its grapheme-to-phoneme conversion rules. In opaque orthographies, children have to rely on multi-letter chunks in order to access the correct phonological form since the rules which permit to convert a letter into the correct sound are generally determined by the preceding and/or following context in the letter string. Conversely, learning to read in a transparent language favors strategies which rely on small units, because children can apply very regular grapheme-to-phoneme conversion rules to them. Regular letter-sound correspondences have been shown to accelerate the acquisition of both decoding and reading skills (Seymour, Aro, & Erskine, 2003) and enhance the ability to identify and manipulate consciously the sounds units of one's language (Goswami, Ziegler, & Richardson, 2005; Spencer & Hanley, 2003). This ability (i.e., phonemic awareness) is moreover critical for reading development (Snowling, 2000). Indeed, poor phonemic awareness skills have been repeatedly associated with developmental dyslexia (Vellutino, Fletcher, Snowling, & Scanlon, 2004 for a review), a neuro-cognitive disorder that specifically impedes reading acquisition, despite of normal intelligence and the absence of sensory or psychiatric disorders in individuals having received adequate education.

Although it could be assumed that dyslexic readers of transparent languages benefit from the nature of their orthography to compensate potential phonological disorders, some authors claimed that learning to read in a transparent orthography does not prevent dyslexia from manifesting through phonological difficulties (Caravolas, Volín, & Hulme, 2005; Jimenez, 2012; Landerl et al., 2013). Moreover, regardless of orthographic transparency, the contribution of phonological awareness to reading development was shown to remain the same across languages (Caravolas et al., 2012; Caravolas et al., 2005). A recent cross-linguistic study however showed that the contribution of phonological awareness to reading is less important in the most transparent languages (Ziegler et al., 2010), which might explain why a smaller proportion of individuals are diagnosed with dyslexia in these languages compared to in opaque orthographies (Lindgren et al., 1985). Nevertheless, this low prevalence rate of dyslexia may stem from difficulties at detecting obvious signs of reading problems rather than a real reduction of the dyslexic syndrome in populations with transparent languages. Because of the one-to-one very regular grapheme-to-phoneme mappings, reading accuracy generally plateaus at ceiling as soon as pupils reach the end of the first year of reading tuition in transparent orthographies (Seymour et al., 2003). Reading fluency, however, remains a good measure of reading performance in the most transparent languages (e.g., Aro & Wimmer, 2003; Kirby, Georgiou, Martinussen, & Parrila, 2010) but is of course more difficult to quantify in the classroom or at home.

Whether phonological awareness is or is not equally important for reading acquisition in transparent and opaque orthographies remains a challenging question for research. Work that looks at the developmental dynamics of orthographic transparency's impact on the contribution of phonological skills to reading shed light on it. For example, Vaessen et al. (2010) showed that changes in phonological awareness contribution to reading speed from Grade 1 to Grade 4 was qualitatively similar but quantitatively different across three languages varying in orthographic transparency (Hungarian, Dutch and Portuguese, from the most transparent to the most opaque). The authors found that phonological awareness contribution to reading speed declined with higher reading expertise in the three languages, but that its strength was weaker in the more transparent languages.

Moving away slightly from the role of phonological awareness in reading, Vaessen et al. (2010) also reported that the contribution of visual-to-phonology mappings skills to reading fluency, measured through rapid automatized naming, increased similarly across the three languages throughout development (see also Vaessen & Blomert, 2010). Data from other research groups also suggests that abilities tapping into visual processing contribute to reading acquisition in addition to, and independently from, phonological awareness. Like in Vaessen et al. (2010), Bosse and Valdois (2009) reported a decline in the contribution of phonological awareness to reading speed along Grades 1, 3 and 5 in French children, but a sustained constant contribution of specific visual skills, i.e., the visual attention (VA) span, to reading speed. The VA span is defined as the number of distinct visual elements that can be processed simultaneously in a multi-element array regardless of the verbal nature of the stimuli (Lobier, Zoubrinetzky, & Valdois, 2012). The VA span hypothesis proposes that a limit in simultaneous visual attention reduces the maximum amount of visual elements that can be processed at once in an orthographic sequence, and results in a subtype of developmental dyslexia independent from the phonological subtype