



# Predictors of word writing in Spanish and Arabic among 6- and 7-year-old children

Maria-José González-Valenzuela<sup>1</sup> · Dolores López-Montiel<sup>2</sup> · Fatma Chebaani<sup>3</sup> · Marta Cobos-Cali<sup>4</sup> · Elisa Piedra-Martínez<sup>4</sup> · Isaías Martín-Ruiz<sup>1</sup>

Received: 13 July 2023 / Revised: 30 July 2024 / Accepted: 10 November 2024  
© The Author(s) 2024

## Abstract

This study analyses the impact of certain cognitive processes on the writing of words in languages with different orthographic consistency (Spanish and Arabic) in the first and second years of Primary Education. One hundred twenty-eight schoolchildren from Ecuador and 109 from Algiers participated in this study. All the participants were aged between 6 and 7 years old, came from the middle classes, and had no special educational needs. We evaluated all the participants for word writing, knowledge of letters, phonological awareness, rapid automatised naming (alphanumeric and non-alphanumeric), and phonological memory. We performed descriptive-exploratory analyses and bivariate and multivariate regressions for the writing of words in each language. The results show that most of the cognitive variables considered do not contribute equally to the explanation of word writing

---

✉ Isaías Martín-Ruiz  
ismar@uma.es

Maria-José González-Valenzuela  
valenzu@uma.es

Dolores López-Montiel  
dlopezm@uma.es

Fatma Chebaani  
amer1808@hotmail.com

Marta Cobos-Cali  
mcobos@uazuay.edu.ec

Elisa Piedra-Martínez  
epiedra@uazuay.edu.ec

<sup>1</sup> Department of Developmental and Educational Psychology, Faculty of Psychology and Speech Therapy, University of Málaga, C/ Doctor Ortiz Ramos, nº 12 (Teatinos University Campus Extension), 29071 Málaga, Spain

<sup>2</sup> Department of Psychobiology and Methodology of Behavioral Sciences, Faculty of Psychology and Speech Therapy, University of Málaga, C/ Doctor Ortiz Ramos, nº 12 (Teatinos University Campus Extension), 29071 Málaga, Spain

<sup>3</sup> L'École Normale Supérieure de Kouba, Adresse: B.P. 92, Vieux-Kouba, 16308 Alger, Algeria

<sup>4</sup> Faculty of Psychology, University of Azuay, Av. 24 de Mayo 7-77, Cuenca, Ecuador Extended author information available on the last page of the article

in both languages at 6 and 7 years of age. However, in each language, at these ages, similar variables contribute to the explanation of word writing. These results have important implications for educational practice, as well as the explanatory theory of writing acquisition.

**Keywords** Writing · Cognitive predictors · Spanish · Arabic

Over the past decade, there has been an increase in research into the development of writing, possibly motivated, among other reasons, by the incorporation of new methodological paradigms to study the cognitive processes involved in this task, the need to implement new teaching methodologies for writing, or growing interest in analysing the relationship between reading and writing processes (De Bree & van der Boer, 2019; Georgiou et al., 2020; Nielsen & Juul, 2016; Ouellette & Senechal, 2017).

There is a larger body of research on the relationship of cognitive variables to the acquisition of reading in different languages and at different ages than the acquisition of writing (Asadi et al., 2017; Bar-Kochva & Nevo, 2019; Caravolas, 2018; Georgiou et al., 2016; González-Valenzuela et al., 2016; Pinto et al., 2016;). One of the reasons for this situation is the existence of different explanations about the association between reading and writing, which is one of the reasons for the interest in studying the writing of words at different ages. Some of the research highlights a strong relationship between reading and writing and finds that, at the start of literacy, the most relevant variable in the learning of writing is the learning of reading, especially in languages with a high degree of consistency for reading and less for writing (Aram et al., 2014; De Bree & Van der Boers, 2019; Ferroni et al., 2016; Georgiou et al., 2020; Khoury & Khateb, 2022). In some cases, the existence of a symmetrical relationship between the two is postulated in which they share knowledge, cognitive systems, communicative intentions, and activation of neural circuits (Ferroni et al., 2016; James & Engelhardt, 2012). However, other meta-analytical studies indicate that the relationship between these tasks is not symmetrical, since reading competence could explain up to 25% of writing performance at an early age (Graham et al., 2017), or that writing also seems to influence reading at later ages (Malpique et al., 2020). These discrepancies in the relationship between reading and writing partly justify the recent interest in analysing cognitive predictors of writing.

However, there does not seem to be any consensus on the processes that explain writing, according to the orthographical characteristics of the language. Some studies posit differences in the cognitive processes involved in writing. These studies are based on the double-path model and argue the importance of grapheme-phoneme conversion rules (phonological processing) in the writing of words, especially in languages with more consistent spelling systems and access to visual-orthographic representations (visual processing) in word reading, particularly in less consistent languages (Georgiou et al., 2008; Moll et al., 2014; Tolchinsky et al., 2012; Ziegler & Goswami, 2005). In addition, the theory of granularity supports the idea that the consistency of each language is relative since a language will be less orthographically consistent when graphemes represent phonemes less accurately due to their phonological structure (coarse grain), while it will be more consistent when graphemes more accurately represent phonemes (fine grain) (Ziegler & Goswami, 2005). This could justify why the predictors of writing differ depending on the grain of each language along with the interest of our study. Other studies, however, do not posit these differences between languages in the process of writing. They are based on the self-teaching model and argue that the orthographic representations formed in different

languages are based on the repeated use of phonological representations and phoneme-grapheme translation. Access to phonological representations would be the most relevant factor in different languages (Caravolas, 2018; Frost, 2005; Joshi & McCardle, 2018; Share, 2008; Share & Shalev, 2004; Ziegler & Goswami, 2005). As for the consistency of Spanish and Arabic, it should be noted that Spanish is a consistent language. It has 27 letters (5 vowels and 22 consonants) that are represented in upper and lowercase letters, which are used in various syllable structures (VC, VCV, CVC, CCV, CVV, CCVC, and CVVC). It has a finer grain structure because phonemes represent graphemes more accurately, with a high level of correspondence between phonemes (sounds) and graphemes (letters), since most letters correspond to a single sound and each phoneme corresponds to a unique grapheme. Although there are some exceptions between the phoneme-grapheme relationship (for example, the phoneme /b/ is written as the grapheme 'v' or 'b') and some spelling rules (for example, 'm' is written before 'p' and 'b'), each grapheme has a single written form and is always the same regardless of the adjacent letters, and all phonemes are written (except for the grapheme 'h'). The directionality of writing is, as in most languages, from left to right. Arabic, however, is a less consistent language. It has 28 letters (3 vowels that can be lengthened, 23 consonants, and 2 semi-consonants) that are represented only in lower case. Syllables must necessarily begin with a consonant and are dominated by the alternation of a vowel and a consonant, reducing syllable structures to CV, CVV, CVC, and, in some cases, CVVC (Baccouche, 2003; Cohen, 2007). It has a coarser grain structure since graphemes represent phonemes less accurately, and the correspondence between phoneme and grapheme is not as high. Many graphemes are not pronounced or are pronounced differently to the way they are written. In addition, some of the letters have more than one written form depending on their placement within the word (beginning, middle, and end) following the rules of linking with the preceding letter, and some have dots written in different positions (above or below the letters) while others do not (Taha, 2013; Taha et al., 2013). It also has a peculiar feature with respect to other languages, since the directionality of the writing is inverse, that is, from right to left. In particular, there are many phonologically ambiguous homographs in writing since كتب can correspond to [καταβα] (wrote), [κατταβα] (he wrote), [κυτυβ] (books), or [κυτιβα] (was written).

In relation to the learning of writing in Spanish and Arabic, it should be noted that, in Spanish, initially, pupils acquire global knowledge of words based on their frequency (they write their own name and some familiar words) and learn the correspondence between phoneme and grapheme. Subsequently, they learn orthographic characteristics, with exceptions and spelling rules for words. In Arabic, on the other hand, children initially learn vocalised writing, focusing more on teaching the sounds of letters at the syllable level rather than the phoneme level. Later on, they learn non-vocalised, orthographic, more opaque, and morphological writing, characterised by having a consonant root and a vowel scheme, which represent many homographs with phonological and semantic similarities (Ahmad & Share, 2021; Taha, 2013).

Differences in the explanatory models of writing, in the degree of orthographic consistency of Spanish and Arabic, as well as in the teaching methods of both languages are other reasons that justify the interest shown over the past decade in studying the predictors of writing.

Most studies on the learning of writing in languages with different orthographic consistency analyse cognitive predictors such as letter knowledge, phonological awareness, rapid automatized naming, and phonological memory, although not together in many cases (Bar-Kochva & Nevo, 2019; Batnini & Uno, 2014; Binamé & Poncelet, 2016; de Bree & van

der Boer, 2019; Georgiou et al., 2020; Harrison et al., 2016; Milburn et al., 2017; Moll et al., 2014; Nielsen & Juul, 2016; Ouellette & Senechal, 2017; Pinto et al., 2016). These variables appear to correlate to a greater or lesser extent with writing, and their influence is modulated by age and/or the linguistic complexity or consistency of the language (Bar-Kochva & Nevo, 2019; De Bree & van den Boer, 2019; Ferroni et al., 2016; Georgiou et al., 2016; Inoue et al., 2014; Pittas, 2018). In addition, in some languages, this relationship depends on whether reading is more transparent than writing, such as Greek or German (Verhoeven & Perfetti, 2022). This might explain why the predictors of writing are different depending on the granularity of each language. In Spanish, there are few studies conducted on predictors of writing, and those conducted at earlier ages do not consider all these variables together (Ferroni et al., 2016; Gómez-Velázquez et al., 2015; Gutiérrez & Díez, 2018; Suárez-Coalla et al., 2013). In Arabic, there are also few studies on predictors of writing, and the existing research is conducted at older ages (Asadi, et al., 2017; Khoury et al., 2018; Taha & Saiegh, 2016; Tibi & Kirby, 2018). There are few studies comparing predictors in Spanish with predictors in Arabic for word writing, although there are some studies where Spanish has been compared with less consistent languages (Caravolas et al., 2012.).

Letter knowledge (LK) is a strong predictor from early ages in more consistent languages (Aram et al., 2014; Ferroni et al., 2016; Guo et al., 2018) such as Spanish since it is necessary to know the letters of the alphabet to make the association between phoneme and grapheme. At younger and older ages, in less consistent languages such as Arabic, it is also a good predictor as pupils first know the name of the letter and later learn its sound (Ahmad & Share, 2021; Asadi et al., 2017; Batnini & Uno, 2014; Khoury & Khateb, 2022; Khoury et al., 2018), among other reasons, because large phonological units (consonants and vowels) are usually taught instead of isolated phonemes.

Phonological awareness (PA) has also been found to be one of the most relevant predictors of writing in languages with different orthographic consistency since this makes it easier for learners to break down and identify the sounds of words, prior to their conversion into graphemes (Biname & Poncet, 2016; De Bree & van der Boer, 2019; Malpique et al., 2020; Milburn et al., 2017; Moll et al., 2014; Nielsen & Juul, 2016; Pinto et al., 2016; Pittas, 2018; Suarez-Coalla et al. 2013; Vaessen & Blomert, 2013). However, its contribution to the explanation of writing differs according to the characteristics of the language and age of the schoolchildren (Ding et al., 2018). Thus, in Spanish, among younger and even older learners, PA is shown to be a good predictor of writing (Ferroni et al., 2016; Gómez Velázquez et al., 2010; Suárez-Coalla et al., 2013) since it is a highly consistent language. It should be noted that its contribution to the explanation of writing decreases as age increases because there are grapheme-phoneme conversion rules and spelling rules that must be learned (Gómez Velázquez et al., 2010). In Arabic, as a less consistent language in which letters are never associated with bigrams or trigrams and most of them change their form according to their position in the word following the rules of linking to the preceding letter (Besse, 2008), the size of the phonological unit seems relevant to understand the contribution of PA to the explanation of writing, especially at later ages (Asadi et al., 2017; Batnini & Uno, 2014; Saiegh & Taha, 2017; Taha & Saiegh, 2016). It should also be noted that syllable and intra-syllable awareness is more relevant than phonemic awareness (Saiegh & Taha, 2017; Tibi & Kirby, 2018).

According to some studies, rapid automatized naming (RAN) has a relevant effect in more consistent languages (Spanish, Finnish, or German) (Bar-Kochva & Nevo, 2019; De Bree & van der Boer, 2019; Ferroni et al., 2016; Georgiou et al., 2016; Gomez-Velazquez, et al., 2010), as well as in more inconsistent languages (English, Arabic, and

Chinese) (Batnini & Uno, 2014; Chen et al., 2021; Harrison et al., 2016; Inoue et al., 2017; Nielsen & Juul, 2016; Vaessen & Blomert, 2013). This is due to the fact that it is a measure of speed in the association of visual and verbal stimuli that facilitates access to orthographic representation. However, other studies have found no direct relationship between RAN and writing (Moll et al., 2014; Niolaki et al., 2020; Vaessen & Blomert, 2013) since the first would be a measure of speed and the second of accuracy. Importantly, not all of these studies differentiate between alphanumeric and non-alphanumeric RAN, which would make it impossible to ensure the influence of these variables on the writing of words at all ages and in all languages. In Spanish, some studies find that alphanumeric RAN influences word writing from the beginning of literacy up to later ages, facilitating the rapid association between phoneme and grapheme and the automation of the association process between phonological and graphic representations (Ferroni et al., 2016; Gómez-Velázquez et al., 2010). It has also been found that non-alphanumeric RAN influences this process at younger ages (Suárez-Coalla et al., 2013). In less consistent languages, such as Arabic, some studies show that alphanumeric RAN plays a relevant role in the initial phase of writing acquisition since it favours sub-lexical connections between grapheme and phoneme along with the construction and recovery of spelling patterns necessary for the writing of words by creating a repository for spellings or parts of words (Altani et al., 2020; Chen et al., 2021). However, non-alphanumeric RAN would be more related to the rapid association between a global stimulus and its meaning, influencing writing later on (Bar-Kochva & Nevo, 2019; De Bree & van der Boer, 2019; Georgiou et al., 2016).

Phonological memory (PM) is a variable that is not often considered in studies on predictors of word writing in different languages and at different ages. Some studies that have taken it into consideration find that it has an influence on the writing of words in languages of different consistencies since it is necessary to retain and retrieve phonological information, being related to phonological awareness (Binamé & Poncelet, 2016; Chalmers & Freeman, 2018; Harrison et al., 2016; Niolaki et al., 2020; Treiman, 2017). However, other studies indicate that its influence depends on language and age and that this influence would decrease as age progresses (Caravolas et al., 2012; Harrison et al., 2016; Nielsen & Juul, 2016; Ouellette & Senechal, 2017; Zoccolotti et al., 2020). In Spanish, it has been found that PM influences word writing at an early age (Suárez-Coalla et al., 2013). In Arabic, some studies find a positive effect for PM on word writing (Batnini & Uno, 2014), while others do not find any relationship (Ahmad & Share, 2021; Asadi et al., 2017). Some of the research that has found an influence was performed with older subjects, while studies that have found no influence are conducted at younger ages when the school children are not yet literate.

Because writing has been studied to a lesser degree than reading, and because there are differences and incongruencies in findings about the influence of different cognitive components on word writing, according to the consistency of the language and the age of the school children, the aim of this paper was to determine which of the cognitive variables studied (knowledge of letters, phonological awareness, alphanumeric and non-alphanumeric rapid automatized naming, and phonological memory) contribute to the explanation of word writing at 6 and 7 years of age (first and second year of primary education) in two languages of different orthographic consistency (Spanish and Arabic). In general, we expect to find different associations between the cognitive variables considered and word writing at six and seven years of age in Spanish and Arabic.

## Method

### Design

Since the fundamental objective of this research was to explore a functional relationship by predicting word writing through cognitive predictors, in general, we applied a cross-cutting predictive design (Ato et al., 2013). The criterion variable was Word Writing, and the predictor variables were Letter Knowledge, Phonological Knowledge, Phonological Memory, and Rapid Alphanumeric and Non-Alphanumeric Automatic Naming. This design was replicated for Spanish word writing, Arabic word writing, and for both ages in both languages.

### Participants

For this research, we recruited two samples of native Spanish and Arabic-speaking pupils (non-bilingual), in the first year of primary education, aged six, from Ecuador and Algeria, using non-probabilistic convenience sampling. To access both samples, we previously selected two schools from average sociocultural areas in the two countries. For both samples, we evaluated all variables at two points in time: when the pupils were in the first year of primary school and when they were in the second year of primary school, i.e. at 6 and 7 years of age. Participants in both groups did not present any special educational needs, according to reports issued by the school psychologists. In both groups, literacy instruction began when participants were in the last year of Early Years Education, at approximately 5 years of age. The learning outcomes for literacy instruction, in both groups, referred to the recognition of letters in each language, recognition and writing of frequent words, recognising the characters and main actions in a short read text, and writing short texts with their own code. In both groups, participants were taught to write through the copying and dictation of letters and frequent words in their language, taking care of directionality in writing in each language and firmness of pressure when writing.

The first group, evaluated in the first and second year of primary school, consisted of 128 Spanish-speaking pupils, 78 girls (60.9%) and 50 boys (39.1%), aged 6 ( $M=81.05$  months,  $SD=3.94$ ). The second group, in the first year of primary school, consisted of 109 Arabic language pupils, 61 girls (54%) and 48 boys (44%), aged 6 ( $M=80.83$  months,  $SD=4.17$ ). In the second year of primary school, out of the 109 initial pupils, three children could not be evaluated. Therefore, at this educational level, this sample consisted of 106 pupils, 61 girls (57.5%) and 45 boys (42.5%).

From the Spanish-speaking group, 1 mother (0.8%) and 1 father (0.8%) had a primary or pre-secondary level of education, 77 mothers (60.2%) and 72 fathers (66.1%) had a high school education (junior high and high school, technical and non-technical), and 45 mothers (35.2%) and 29 fathers (26.6%) possessed a higher education (college and graduate). From the Arabic-speaking group, 8 mothers (7.3%) and 11 fathers (10.1%) had a primary or pre-secondary level of education, 72 mothers (66.1%) and 69 fathers (63.3%) had a high school education, and 29 mothers and 29 fathers (26.6%) possessed a higher education. The level of education attained by mothers and fathers was related, both in Spanish ( $\chi^2(4, N=128)=139.40, p<0.01; V=0.76$ ) and in Arabic ( $\chi^2(4, N=109)=61.58, p<0.01; V=0.75$ ), with the majority holding a high school equivalent level of education ( $Mdn=2, Mo=2$ ).

Table 1 summarises the sociodemographic characteristics of the sample: age and sex of the children and the level of education attained by their mothers and fathers.

## Instruments

We evaluated *Word Writing* through the dictation of 44 words of different lengths, orthographic complexity, and frequency (see Appendix), which the pupils had to write down. The total score was the sum of the number of words written correctly (0–44). For the sample of Spanish-speaking children, we used the Word Writing exercise in the LEE Spanish Reading and Writing Test (Defior et al., 2006). This test evaluates the phonological and spelling skills children use when writing words. The internal consistency reliability for the word writing test in the first and second year of primary school using Cronbach's alpha statistics was  $\alpha=0.84$  and  $\alpha=0.79$ , respectively. Test–retest reliability was shown with a correlation of 0.82. The study of convergent validity also showed satisfactory indicators, with positive and significant correlations ( $r=0.59$ ,  $p<0.01$ ) found with the PROESC word writing test (Cuetos et al., 2004). For children who spoke Arabic, we used the Word Writing test given in the Appendix, which contained the same number of words as used in Spanish, using Arabic words with the same length (number of syllables), the same morphology (noun, adjective, and verb), and the same frequency (low, medium, and high) (Bauer, 1996) as those used in Spanish. The validity of the word writing test was adequate according to statistical analyses (Hutchenson & Sofroniou, 1999; Kline, 1999) with a one-dimensional structure and a saturation index greater than 0.52, as well as an explained variability of 41.65% and a sampling adequacy index of 0.88, respectively. All items presented a homogeneity index of 0.39 and adequate internal consistency of 0.95, respectively.

We evaluated *Knowledge of Letters* by asking the pupils to read out all the letters in each language, with the total score being the number of letters read correctly. In this test, the children had to say the name or sound of each letter in Spanish (0–29) or Arabic (0–28). For the Spanish-speaking children, we used the Knowledge of Letters exercise in the LEE Spanish Reading and Writing Test (Defior et al., 2006). Internal consistency obtained for this test using Cronbach's alpha statistic was 0.60 and 0.64 for the first and second years of primary school, respectively. Test–retest reliability indicated a correlation of 0.50 and showed positive correlations with the word-reading and word-writing tests of the PROLEC battery (Cuetos, 2010) and the PROESC battery (Cuetos et al., 2004) between 0.15 and 0.20. For the Arabic-speaking children, all the letters in that language were used (González-Valenzuela et al., 2022). The validity of the letter reading test was adequate according to statistical analyses (Hutchenson & Sofroniou, 1999; Kline, 1999). It presented a one-dimensional structure and a saturation index greater than 0.51, with an explained variability of 58.65% and a sampling adequacy index of 0.90. All items presented a homogeneity index of 0.30 and adequate internal consistency of 0.89.

We evaluated *Phonological Awareness* through 14 words presented orally. The children had to isolate and name the sounds that made up each word. The total score was of the number of words correctly segmented into sounds (0–14). For the Spanish-speaking children, we used the Phonological Awareness exercise in the LEE Spanish Reading and Writing Test (Defior et al., 2006). Cronbach's alpha statistic indicated an internal consistency of 0.91 and 0.86 for the first and second years, respectively, and test–retest reliability indicated a correlation of 0.64. For children who spoke Arabic, the same number of words was used with the same length (number of letters), the same morphology (noun, adjective, and verb), and the same frequency (low, medium, and high) (Bauer, 1996) as those used in

**Table 1** Sample sociodemographic characteristics

Language group	Age in months <i>M</i> ( <i>SD</i> )	Gender (F/M) <i>n</i> (%)	Mother's education level			Father's education level		
			<i>n</i> (%)	2 Middle	3 High	<i>n</i> (%)	1 Low	2 Middle
Spanish ( <i>n</i> = 128)	81.05 (3.94)	78 (60.9)/50 (39.1)	1 (0.8)	77 (60.2)	45 (35.2)	1 (0.8)	76 (59.4)	45 (35.2)
Arabic ( <i>n</i> = 109)	80.83 (4.17)	61 (56)/48 (44)	8 (7.3)	72 (66.1)	29 (26.6)	11 (10.1)	69 (63.3)	29 (26.6)

*M* mean, *SD* standard deviation, *F* female, *M* male, *Low* primary and pre-secondary studies, *Middle* junior high and high school (technical and non-technical); *High*, college and graduate

Spanish (González-Valenzuela et al., 2022). Cronbach's alpha statistic indicated reliability of  $\alpha=0.84$ .

We evaluated rapid automatized naming in both groups by means of the RAN test (Wolf & Denckla, 2003) adapted by Gómez-Velázquez et al. (2010). This test consists of naming 200 visual stimuli distributed across 50 letters, 50 numbers, 50 objects, and 50 colours. The total score achieved in alphanumeric rapid automatized naming is the time, in second, taken to name letters and numbers, and in non-alphanumeric rapid automatized naming it is the time taken to name the objects and colours shown. In the Arabic sample, we used the letters in Arabic, respecting the order in which the equivalent letters appear in the Spanish version (González-Valenzuela et al., 2022). Cronbach's alpha statistic indicated test reliability ( $\alpha=0.79$ ). The rest of the components of the test were the same in Spanish and Arabic.

We evaluated *Phonological Memory* in both groups using the Phonological Short-Term Memory (PSTM) test developed by Soriano and Miranda (2010), based on the Hebrew phonological memory task (Geva et al., 2000). The test consists of orally repeating a single list of 20 pseudowords (Latin words that do not match the Spanish or Arabic lexicon). Pseudowords were unknown words in Spanish and Arabic and were pronounced the same in both languages, and children had to repeat them orally (González-Valenzuela et al., 2022). The total score for this test is obtained by adding the number of pseudowords repeated correctly (0–20). Cronbach's alpha statistic for the test was 0.74.

## Procedure

The selected tests were administered individually to each pupil by some of the authors of the paper belonging to the Universidad de Azuay and the École Normale Supérieure de Kouba, all holders of a PhD in Psychology. These institutions have a collaboration agreement in place with the Universidad de Málaga, to which the rest of the researchers belong. The tests were administered simultaneously in each country. The children were evaluated when they were in the first year of primary education and then one year later when they were in the second year of primary education. On both occasions, the evaluations were carried out in October.

Evaluations took place in two sessions each lasting around 45 min. In the first session, the tests for writing words and knowledge of letters were administered. In the second session, phonological memory, phonological awareness, and rapid automatized naming (alphanumeric and non-alphanumeric) tests were administered.

The research conducted complied with the ethical requirements of the Helsinki Declaration (WMA, 2015). It was approved by the Experimentation Ethics Committee of the Universidad de Málaga (CEUMA). The head teachers from the participating schools gave their authorisation for the research to be carried out. The parents of the participating pupils gave their written consent for their children to participate in the research.

## Statistical analyses

To address the objectives of the study, we conducted statistical analysis in two stages: first, a preliminary analysis followed by subsequent multivariate linear regressions.

In the first stage, we explored, described, and correlated all variables in order to describe the sociodemographic characteristics of the samples, assess the relationship between the variables, and detect potential cognitive predictors of word writing in the

Spanish and Arabic language groups, at both 6 and 7 years of age. The initial descriptive analysis of the sociodemographic characteristics of the sample, the criterion variables, and the potential predictors analysed was carried out in terms of means and standard deviations or frequencies and percentages, depending on the categorical or continuous nature of the variable according to its scale of measurement. To determine the educational level of the study samples, we applied Pearson's Chi-square tests of independence. For bivariate analyses between all the variables, we calculated Pearson's correlation coefficients and their corresponding significance tests. The effect size was considered small, moderate, or strong, according to Cohen's criterion (1992) for Cramer's  $V$  and correlation coefficient  $r$ , respectively.

In the second stage, the main objectives of this study were answered. Taking into account the quantitative nature of the variables, multivariate linear regressions were constructed. We identified cognitive variables at 6 years of age that predict the written accuracy of words at six and cognitive variables at seven years of age that predict the written accuracy of words at this same age, as well as the joint and unique contribution of each of them to its variability, both in Spanish and Arabic.

To construct each of the models, we introduced the predictors sequentially, using the stepwise procedure, in decreasing order according to their corresponding correlation coefficient when in previous bivariate analyses they had an associated probability of less than 0.05 and an effect size equal to or greater than 0.20. To evaluate the overall significance of the estimated regression models and their parameters, we used Fisher's  $F$  test and Student's  $t$  test (two-tailed), respectively. We applied the coefficient of determination ( $R^2$ ) and the adjusted coefficient of determination (Adjusted  $R^2$ ) to assess overall the variance of written word accuracy attributable to the set of predictors included. We calculated the specific contribution of each predictor to the total variance of written word accuracy using the semi-partial correlation coefficient ( $sr_i^2$ ) and evaluated the practical significance of the final regression models estimated according to Cohen's criterion (1992) for the coefficient of determination ( $R^2$ ). Through the diagnosis of residuals, we verified the assumptions of linearity, normality, and homogeneity of variances and confirmed the assumption of multicollinearity by means of the variance inflation factor.

Statistical data processing and analysis were carried out using version 28.0 of the Statistical Package for the Social Sciences (SPSS) (IBM, 2021).

## Results

### Word writing in Spanish

Table 2 summarises the statistical description of all variables and the bivariate correlations between all cognitive measures and the written accuracy of words in Spanish at the ages of six and seven.

Between the cognitive variables and written word accuracy measured at 6 years of age, the statistically significant correlations found in decreasing order according to the size of the correlation were with phonological awareness, knowledge of letters, phonological memory, and alphanumeric rapid automatized naming. The magnitude of the effect of the first two associations can be considered strong and that of the other two moderate and small, respectively. No statistically significant relationship was found with non-alphanumeric rapid naming.

**Table 2** Descriptive statistics and correlations for the Spanish language broken down by age

Variables	Mean	SD	Range	1	2	3	4	5	6
Spanish language at 6 years old ( $n = 128$ )									
1. WW	18.71	8.09	0–38	-					
2. KL	23.52	4.19	9–29	0.60*** <sup>a</sup>	-				
3. PA	5.43	3.17	0–12	0.66*** <sup>a</sup>	0.55**	-			
4. ARN	102.02	30.22	56–189	-0.28*** <sup>a</sup>	-0.15	-0.13	-		
5. NARN	206.31	55.06	120–401	0.01	-0.13	-0.06	-0.10	-	
6. PM	15.59	2.81	6–20	0.30*** <sup>a</sup>	0.24**	0.32**	-0.13	-0.01	-
Spanish Language at 7 years old ( $n = 128$ )									
1. WW	27.92	5.90	8–41	-					
2. KL	27.08	2.05	14–29	0.41*** <sup>a</sup>	-				
3. PA	8.51	2.41	2–14	0.33*** <sup>a</sup>	0.34**	-			
4. ARN	87.90	27.34	53–255	-0.07	-0.09	-0.07	-		
5. NARN	170.37	44.65	87–312	-0.03	-0.02	-0.06	0.28**	-	
6. PM	17.95	2.40	8–20	0.23*** <sup>a</sup>	0.19*	0.23**	0.02	0.07	-

*SD* standard deviation, *WW* word writing (no. of correct responses), *KL* knowledge of letters (no. of correct responses), *PA* phonological awareness (no. of correct responses), *ARN* alphanumeric rapid naming (seconds), *NARN* non-alphanumeric rapid naming (seconds), *PM* phonological memory (no. of correct responses). \*\*Pearson's  $r$  correlation coefficient significant at  $p < 0.01$ ; \*Pearson's  $r$  correlation coefficient significant at  $p < 0.05$ . <sup>a</sup>Effect size of the correlation coefficient  $r$  (Cohen reference values: small = 0.10; moderate = 0.30; strong = 0.50 or higher)

The results obtained in the regression analyses at the age of six are summarised in Table 3.

At the age of six, in Spanish, with written word accuracy as the criterion variable and the cognitive variables phonological awareness, knowledge of letters, phonological memory, and alphanumeric rapid automatised naming as the predictor variables, the final adjusted model included the variables phonological awareness, knowledge of letters, and alphanumeric rapid automatised naming, which jointly explained 55% (54% adjusted) of the variance in written word accuracy at 6 years of age in Spanish. According to these values, the practical significance of the model is great.

The corresponding semi-partial correlation coefficients ( $sr_i^2$ ) indicated that these three cognitive variables contributed, respectively, 15.21%, 6.76%, and 2.89% to the total variance of written word accuracy when the pupils were 6 years old and in the first year of primary school (see Table 3).

At 7 years of age, in Spanish-speaking children (see Table 2), the statistically significant correlations found between cognitive variables and written word accuracy in decreasing order according to the size of the correlation were knowledge of letters, phonological awareness, and phonological memory. The magnitude of the effect of the first two associations can be considered moderate and that of the third association small. No statistically significant relationship was found with alphanumeric rapid automatised naming or with non-alphanumeric rapid naming.

At the age of seven, among Spanish-speaking children, with written word accuracy as the criterion variable and the cognitive variable knowledge of letters, phonological awareness, and phonological memory as the predictor variables, the final model ( $F(2, 128) = 16.44, p < 0.01$ ) included the variable knowledge of letters and phonological

**Table 3** Regression analysis results for word writing at 6 years old

Spanish language ( $n = 128$ )							
WW	$B$	SE $B$	$\beta$	$t$	$p$	sr	VIF
Constant	2.55	3.54		0.72	0.474		
PA	1.19	0.18	0.47	6.48	0.000	0.39	1.43
KL	0.61	0.14	0.32	4.39	0.000	0.26	1.44
ARN	-0.04	0.01	-0.17	-2.84	0.005	-0.17	1.03
Goodness-of-fit tests							
$F$	50.57**						
$R^2$	0.55 <sup>a</sup>						
Adjusted $R^2$	0.54 <sup>a</sup>						
$R$	0.74						

WW word writing, PA phonological awareness, KL knowledge of letters, ARN alphanumeric rapid naming, SE standard error, sr semi-partial correlation (unique), VIF variance inflation factor. \*\*Fisher's  $F$  test significant at  $p < 0.01$ . <sup>a</sup>Effect size of the coefficient of determination  $R^2$  and adjusted  $R^2$  (Cohen reference values: small=0.01; medium=0.10; large=0.25)

awareness, which jointly explained 21% (19% adjusted) of the variance in written word accuracy at 7 years of age in Spanish. According to these values, the practical significance of the model is moderate (see Table 4).

According to the corresponding semi-partial correlation coefficients ( $sr_i^2$ ), these two variables contributed 6.76% and 4%, respectively, to the total variance of written word accuracy when the Spanish-speaking pupils were 7 years old and in the second year of primary school (see Table 4).

**Table 4** Regression analysis results for word writing at 7 years old

Spanish language ( $n = 128$ )							
WW	$B$	SE $B$	$\beta$	$t$	$p$	sr	VIF
Constant	-2.61	6.23		-0.42	0.676		
KL	0.96	0.24	0.33	3.95	0.000	0.31	1.13
PA	0.53	0.21	0.22	2.56	0.012	0.20	1.13
Goodness-of-fit tests							
$F$	16.44**						
$R^2$	0.21 <sup>a</sup>						
Adjusted $R^2$	0.19 <sup>a</sup>						
$R$	0.45						

WW word writing, KL knowledge of letters, PA phonological awareness, SE standard error, sr semi-partial correlation (unique), VIF variance inflation factor. \*\*Fisher's  $F$  test significant at  $p < 0.001$ . <sup>a</sup>Effect size of the coefficient of determination  $R^2$  and adjusted  $R^2$  (Cohen reference values: small=0.01; medium=0.10; large=0.25)

## Word writing in Arabic

The results obtained for Arabic-speaking children at 6 and 7 years of age are presented below. Table 5 summarises the statistical description of all cognitive variables and written word accuracy, as well as the bivariate correlations.

At the age of six, a significant relationship was found between alphanumeric rapid automatised naming, non-alphanumeric automatised rapid naming, knowledge of letters, phonological memory, and written word accuracy. The magnitude of the effect of the first relationship is considered strong, the second moderate, and the third small. No statistically significant relationship was found between phonological awareness and written word accuracy.

At the age of six, among Arabic-speaking children, with written word accuracy as the criterion variable and the cognitive variables non-alphanumeric rapid automatised naming, alphanumeric rapid automatised naming, knowledge of letters, and phonological memory as the predictor variables, the final adjusted model ( $F(2, 109) = 36.88, p < 0.01$ ) included the variables non-alphanumeric rapid automatised naming and knowledge of letters, which jointly explained 41% (40% adjusted) of the variance in written word accuracy at 6 years of age in Arabic. According to these values, the practical significance of the model is high.

Both cognitive variables contributed 30.25% and 2.89%, respectively, to the total variance of written word accuracy when the 6-year-old Arabic-speaking children were in the first year of primary school (see Table 6).

**Table 5** Descriptive statistics and correlations for the Arabic language broken down by age

Variables	Mean	SD	Range	1	2	3	4	5	6
Arabic language at 6 years old ( $n = 109$ )									
1. WW	20.32	11.73	0–42	-					
2. KL	27.31	1.62	17–28	0.33*** <sup>a</sup>	-				
3. PA	9.59	3.55	1–14	-0.14	0.09	-			
4. ARN	124.84	35.74	72–228	-0.39*** <sup>a</sup>	-0.21*	0.14	-		
5. NARN	385.03	167.37	139–840	-0.62*** <sup>a</sup>	-0.27**	0.22*	0.46**	-	
6. PM	16.72	2.99	5–20	0.21** <sup>a</sup>	0.08	0.04	-0.28**	-0.12	-
Arabic Language at seven years old ( $n = 106$ )									
1. WW	27.31	11.34	0–42	-					
2. KL	27.92	0.37	26–28	0.28*** <sup>a</sup>	-				
3. PA	11.78	2.73	0–14	0.26*** <sup>a</sup>	0.44**	-			
4. ARN	95.06	25.48	56–199	-0.33*** <sup>a</sup>	-0.31**	-0.18	-		
5. NARN	144.53	39.81	88–288	-0.32*** <sup>a</sup>	-0.13	0.03	0.47**	-	
6. PM	17.18	2.68	7–20	0.09	0.31**	0.21*	-0.09	0.12	-

*SD* standard deviation, *WW* word writing (no. of correct responses), *KL* knowledge of letters (no. of correct responses), *PA* phonological awareness (no. of correct responses), *ARN* alphanumeric rapid naming (seconds), *NARN* non-alphanumeric rapid naming (seconds), *PM* phonological memory (no. of correct responses). \*\*Pearson's  $r$  correlation coefficient significant at  $p < 0.01$ ; \*Pearson's  $r$  correlation coefficient significant at  $p < 0.05$ . <sup>a</sup>Effect size of the correlation coefficient  $r$  (Cohen reference values: small = 0.10; moderate = 0.30; strong = 0.50 or higher)

**Table 6** Regression analysis results for word writing at 6 years old

Arabic language ( $n=109$ )							
WW	$B$	SE $B$	$\beta$	$t$	$p$	sr	VIF
Constant	0.80	16.01		16.54	0.960		
NARN	-0.04	0.00	-0.57	-7.33	0.000	-0.55	1.08
KL	1.28	0.56	0.18	2.28	0.025	0.17	1.08
Goodness-of-fit tests							
$F$	36.88**						
$R^2$	0.41 <sup>a</sup>						
Adjusted $R^2$	0.40 <sup>a</sup>						
$R$	0.64						

WW word writing, NARN non-alphanumeric rapid naming, KL knowledge of letters, SE standard error; sr, semi-partial correlation (unique), VIF variance inflation factor. \*\*Fisher's  $F$  test significant at  $p < 0.01$ . <sup>a</sup>Effect size of the coefficient of determination  $R^2$  and adjusted  $R^2$  (Cohen reference values: small=0.01; medium=0.10; large=0.25)

At the age of seven, among Arabic-speaking children (see Table 5), a significant relationship was found between alphanumeric rapid automatised naming, non-alphanumeric rapid automatised naming, knowledge of letters, phonological awareness, and written word accuracy (see Table 5). According to these correlations, the effect size of the first two can be considered medium, and that of the other two small. No statistically significant relationship was found with phonological memory.

At 7 years of age, among Arabic-speaking children, from the initial regression model with written accuracy of words as the criterion variable and the cognitive variables alphanumeric rapid automatised naming, non-alphanumeric rapid automatised naming, knowledge of letters, and phonological awareness as the predictor variables, a good final model ( $F(2, 106) = 10.79, p < 0.01$ ) was adjusted and included the variables non-alphanumeric rapid automatised naming and phonological awareness, explaining 17% (16% adjusted) of the variance in written word accuracy among 7-year-old Arabic-speaking children. According to these values, the practical significance of the model is also moderate.

Each of these cognitive variables contributed 11.56% and 7.84%, respectively, to the total variance of written word accuracy among 7-year-old Arabic-speaking children (see Table 7).

Analysis of residuals and the variance inflation factor indicated that these models fit the assumptions of linear regression.

## Discussion

In this study, we analysed the degree to which certain cognitive variables (knowledge of letters, phonological awareness, alphanumeric and non-alphanumeric rapid automatised naming, and phonological memory) contribute to the explanation of written word accuracy in two languages with different orthographic consistency (Spanish and Arabic) among children in the first and second years of primary education (6 and 7 years of age).

The findings for the Spanish sample highlight that, at the age of six, phonological awareness, knowledge of letters, and alphanumeric rapid automatised naming contribute to

**Table 7** Regression analysis results for word writing at 7 years old

Arabic language ( $n = 106$ )							
WW	B	SE B	$\beta$	$t$	$p$	$sr$	VIF
Constant	27.56	5.77		4.78	0.000		
NARN	-0.09	0.02	-0.33	-3.65	0.000	-0.34	1.00
PA	1.12	0.38	0.27	2.98	0.004	0.28	1.00
Goodness-of-fit tests							
$F$	10.79**						
$R^2$	0.17 <sup>a</sup>						
Adjusted $R^2$	0.16 <sup>a</sup>						
$R$	0.42						

WW word writing, NARN non-alphanumeric rapid naming, PA phonological awareness, SE standard error,  $sr$  semi-partial correlation (unique), VIF variance inflation factor. \*\*Fisher's  $F$  test significant at  $p < 0.01$ . <sup>a</sup>Effect size of the coefficient of determination  $R^2$  and adjusted  $R^2$  (Cohen reference values: small=0.01; medium=0.10; large=0.25)

the explanation of word writing, whereas non-alphanumeric rapid automatised naming and phonological memory do not. At the age of seven, phonological awareness and knowledge of letters contribute to the explanation of word writing, but alphanumeric and non-alphanumeric rapid automatised naming and phonological memory do not. In Arabic, at the age of six, non-alphanumeric rapid automatised naming and knowledge of letters contribute to the explanation of word writing, but no relationship could be established with the other cognitive variables considered (phonological awareness, alphanumeric rapid automatised naming, and phonological memory). At the age of seven, something similar happens: non-alphanumeric rapid automatised naming contributes to the explanation of word writing as does phonological awareness, whereas knowledge of letters, alphanumeric rapid automatised naming, and phonological memory do not. In short, in both languages, at the age of six, knowledge of letters is presented as a strong predictor, but phonological memory does not contribute to the explanation of word writing. On the other hand, there are differences surrounding the contribution of phonological awareness and rapid automatised naming (alphanumeric and non-alphanumeric) in both languages. In Spanish, phonological awareness, letter knowledge, and alphanumeric rapid automatised naming contribute to the explanation of word writing, but non-alphanumeric rapid automatised naming does not. In Arabic, non-alphanumeric rapid automatised naming and knowledge of letters contribute to the explanation of word writing, while alphanumeric rapid automatised naming and phonological awareness do not. At 7 years of age, in both languages, phonological awareness is presented as a strong predictor, but phonological memory does not contribute to the explanation of word writing at this age. Furthermore, there are differences surrounding the contribution of knowledge of letters and rapid automatised naming (alphanumeric and non-alphanumeric) in Spanish and Arabic. In Spanish, knowledge of letters contributes to the explanation of word writing, but alphanumeric and non-alphanumeric rapid automatised naming does not. In Arabic, non-alphanumeric rapid automatised naming contributes to the explanation of word writing, while alphanumeric rapid automatised naming and knowledge of letters do not.

Therefore, the results show that most of the cognitive variables considered at the ages of six and seven do not contribute equally to the explanation of word writing in both

languages at either 6 or 7 years old, with a similar contribution at each age. Similar results are found in other studies that defend the predictive variability of the variables considered as a function of orthographic consistency (Chen et al., 2021; Georgiou et al., 2020), based on the theory of granularity (Ziegler & Goswami, 2005), and counter studies that defend a universal theory on the acquisition of written language (Caravolas, 2018; Hassunah-Arafat et al., 2017; Ziegler & Goswami, 2005).

Knowledge of letters is significantly present in the predictive models of writing in both languages and at different ages. The subject must know the letters of the alphabet in any language in order to write (Ferroni et al., 2016; Guo et al., 2018). This occurs in transparent languages such as Spanish, where the correspondence between phoneme and grapheme is almost univocal and the granularity of sounds is very fine (Aram et al., 2014; Ferroni et al., 2016; Zhang et al., 2021), as well as in less consistent languages, such as Arabic, where it is also necessary to know the names and sounds of the different letters (Ahmad & Share, 2021; Khoury & Khateb, 2022). Knowledge of the alphabet is therefore a necessary requirement for writing at any age and in any language.

Phonological awareness has been extensively studied at various ages and in different languages. The results of this study indicate that its role is patent in transparent languages and persists throughout the learning of writing (Binamé & Poncet, 2016; De Bree & van der Boer, 2019; Nielsen & Juul, 2016; Wealer et al., 2022). It seems that the role of phonological awareness is necessary in orthographic systems where phoneme and grapheme correspondence is more consistent and, therefore, it is necessary to isolate the different phonemes to be able to write graphemes. It is also relevant to note that research uses different measures of phonological awareness, which can be phonemic (Asadi et al., 2017) or syllabic and phonemic (Saiegh & Taha, 2017) as well as various phonological tasks (identification, omission, or addition) (Asadi et al., 2017; Khoury et al., 2018; Saiegh & Taha, 2017). This study has used phonological awareness measures at the finest level, phoneme identification, familiar in transparent, fine-grained languages such as Spanish (Gutiérrez & Diez, 2018), but less familiar in a more inconsistent and coarser-grained orthographic system such as Arabic. However, the results of this study do not find that the role of phonological awareness at the beginning of instruction in reading is relevant in less consistent orthographic systems, such as Arabic, where other variables may play a more specific role. Other studies in Arabic (Asadi et al., 2017; Khoury et al., 2018; Saiegh & Taha, 2017) and in other less consistent languages (Georgiou et al., 2020; Moll et al., 2014) find a significant role for phonological awareness in word writing, where correspondence is made between groups of sounds larger than the phoneme. In less consistent languages, phonological awareness may play a relevant role in word writing but nuanced by other variables (Inoue et al., 2017; Khoury & Khateb, 2022; Saiegh & Taha, 2017).

In relation to rapid automatized naming, the study shows unequal results according to the language and the moment at which writing is learned. Thus, alphanumeric rapid automatized naming has proved to be significant in the writing of words in Spanish in the first year but not the second year of primary education. Other research has found an initial effect for alphanumeric RAN, linked to the speed of association between grapheme and phoneme in transparent orthographic systems (Bar-Kochva & Nevo, 2019; De Bree & van der Boer, 2019; Georgiou et al., 2016), allowing for speed of connection in the simultaneous processing of various sources of visual and phonological information (Altani et al., 2020). On the other hand, our study also points out the relevance of non-alphanumeric RAN in less consistent languages such as Arabic and in both school years, as other studies indicate (Asadi et al., 2017; Chen et al., 2021).

Non-alphanumeric RAN appears to be a relevant variable in the writing of words in less consistent languages (Chen et al., 2021; Harrison et al., 2016; Inoue et al., 2017; Moll et al., 2014; Nielsen & Juul, 2016; Vaessen & Blomert, 2013), since Arabic is a more orthographic language, and therefore quick access to orthographic representations and structures of irregular words is required (Asadi et al., 2017; Khoury & Khateb, 2022; Saiegh & Taha, 2017).

Phonological memory has not shown a relevant role in any predictive model according to age or language, despite presenting a statistically significant correlation with word writing. This could be because its role overlaps with knowledge of letters or phonological awareness (Caravolas, et al., 2012; Harrison et al., 2016; Nielsen & Juul, 2016; Ouellette & Senechal, 2017; Zoccolotti et al., 2020), forming part of a linguistic factor related to the alphabetical principle and losing its main effect on the writing of words.

In conclusion, the influence of the cognitive variables considered is not exactly the same in languages with different orthographic consistency, but their influence is somewhat similar between the ages of 6 and 7 in both languages. In general, the findings highlight the relevance of some cognitive variables, such as knowledge of letters, phonological awareness, and rapid automatized naming, for the acquisition of writing in both languages. However, interestingly, knowledge of letters only stands out as a factor at the age of six in Arabic, whereas it is also important at the age of seven in Spanish. On the other hand, the role played by phonological knowledge in Spanish is important at both ages, while in Arabic, it is important at the age of seven. Finally, the contribution of alphanumeric rapid automatized naming is relevant in Spanish at 6 years of age, and the contribution of non-alphanumeric rapid automatized naming is prominent in Arabic at 6 and 7 years of age.

These results follow the theory of granularity (Ziegler & Goswami, 2005) and move away from universal theory in the acquisition of written language (Caravolas, 2018; Has-sunah-Arafat et al., 2017; Ziegler & Goswami, 2005). Furthermore, these results have relevant educational implications for the teaching of word writing. Teaching methods for writing used at an early age in both languages should prioritise and promote knowledge of the letters of the alphabet, the ability to isolate phonemes and assign them to letters (grapheme-phoneme conversion mechanisms), and well as quick access to mental and orthographic representations of words.

The results must be taken with caution because it has not been possible to control for the type of previous literacy instruction carried out in the groups since they were made up of pupils in the first year of primary education in both countries. Furthermore, the influence of the effect of vowelisation (use of diacritical marks to represent short vowels) in Arabic has not been considered because these characteristics are not present in the Spanish alphabet. Likewise, the reading level of students in both groups could not be considered and might have influenced the results.

In future studies, it would be important to analyse the influence of these variables on the writing of words at younger ages in Arabic and to conduct studies at older ages in Spanish, given that there is little research to date along these lines. It could also be relevant to conduct longitudinal studies and to ascertain the joint effect of these cognitive variables over long periods of time in different languages, using samples of pupils with and without learning disabilities affecting writing. Finally, it could be interesting to include measures of reading as well as orthographic, morphosyntactic, and semantic knowledge, which have not been considered in this study, to see whether the variables studied change their role in languages of different consistency at these ages.

## Appendix

**Table 8** Words used in the writing task in Spanish and Arabic

Words in Spanish	Words in Arabic
Chiste	عصفور
Hipo	بيان
Flan	فم
Cruel	عطشان
Pompa	أرنب
Empeño	معلومات
Fundamental	متعاون
Monumento	تمثيلية
Presentimiento	جمهورية
Fijo	عد
Pendolo	قطانز
Aduana	استقبال
Soplo	مصروف
Tableta	اصطيفاف
Tallo	سلطان
Anguila	أرخبيل
Humilde	يضاهي
Lince	سنباب
Agente	مستورد
Astronauta	كهرباني
Animo	طرد
Faro	جناح
Repisa	اجتهاد
Yema	غزال
Veleta	دواجن
Dedal	قضيبيب
Pantano	قارورة
Fachada	مغامرة
Prensa	فلك
Inglesa	استعراض
Guiño	ثلث
Derrota	سبائخ
Pis	نوم
Hiena	عسل
Hamaca	مستطيل
Gentil	مرتاح
Celeste	خبير
Pelaje	ساعاتي
Sultan	حيلة
Fiel	ذكي
Mantel	باقة
Rima	حرفة

**Acknowledgements** We would like to thank the schools and pupils for participating.

**Author contribution** All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Fatma Chebaani, Marta Cobos-Cali, and Elisa Piedra-Martínez. The first draft of the manuscript was written by Maria-Jose González-Valenzuela, Dolores Lopez-Montiel, and Isafas Martín-Ruiz, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

**Funding** Funding for open access charge: Universidad de Málaga/CBUA. This research is an International Cooperation Project, which is financed by University of Malaga. The APC was funded by the University of Málaga and Research Group SEJ 521.

**Data availability** The data and materials presented in this study are available on request from the corresponding author.

## Declarations

**Ethics approval and consent to participate** The authors have respected the ethical and deontological standards, in accordance with the principles of the International Code of Ethics in Humanities and Social Sciences of the Center for Research Ethics and Bioethics and the Ethics Committee of the University of Malaga. Informed consent was obtained from all subjects involved in the study.

**Consent for publication** The actors give their consent for publication in the journal 'European Journal of Psychology of Education'.

**Competing interests** The authors declare no competing interests.

**Authors' information (optional)** Not applicable.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

## References

- Ahmad, A., & Share, D. L. (2021). Foundations of early literacy among Arabic-speaking pre-school children. *Applied Psycholinguistics*, 42(5), 1195–1220. <https://doi.org/10.1017/S0142716421000242>
- Altani, A., Protopapas, A., Katopodi, K., & Georgiou, G. K. (2020). From individual word recognition to word list and text reading fluency. *Journal of Educational Psychology*, 112(1), 22–39. <https://doi.org/10.1037/edu0000359>
- Aram, D., Abiri, S., & Elad, L. (2014). Predicting early spelling: The contribution of children's early literacy, private speech during spelling, behavioral regulation, and parental spelling support. *Reading and Writing: An Interdisciplinary Journal*, 27(4), 685–707. <https://doi.org/10.1007/s11145-013-9466-z>
- Asadi, I. A., Ibrahim, R., & Khateb, A. (2017). What contributes to spelling in Arabic? A cross-sectional study from first to sixth grade. *Writing Systems Research*, 9(1), 60–81. <https://doi.org/10.1080/17586801.2016.1218748>
- Ato, M., López, J. J., & Benavente, A. (2013). Un sistema de clasificación de los diseños de investigación en psicología. *Anales De Psicología*, 29(3), 1038–1059.
- Baccouche, T. (2003). La langue arabe: Spécificités et évolution. In M. N. Romdhane, J. E. Gombert & M. Belajouza (Eds.), *L'apprentissage de la lecture: Perspectives comparatives* (pp. 377–386) [Learning to read: comparative perspectives]. PUR.

- Bar-Kochva, I., & Nevo, E. (2019). The relations of early phonological awareness, rapid-naming and speed of processing with the development of spelling and reading: A longitudinal examination. *Journal of Research in Reading*, 42(1), 97–122. <https://doi.org/10.1111/1467-9817.12242>
- Batnini, S., & Uno, A. (2014). Investigation of basic cognitive predictors of reading and spelling abilities in Tunisian third-grade primary school children. *Brain & Development*, 37, 579–591. <https://doi.org/10.1016/j.braindev.2014.09.010>
- Bauer, T. (1996). Arabic writing. In P. T. Daniels & W. Bright. (Eds.), *The world's writing systems* (pp. 559–563). Oxford University Press.
- Besse, A. S. (2008). Caractéristiques des langues et apprentissage de la lecture en langue première et en français langue seconde: Perspective évolutive et comparative entre l'arabe et le portugais. Thèse de Doctorat, Université Rennes 2. <https://theses.hal.science/tel-00267662>
- Binamé, F., & Poncet, M. (2016). Order short-term memory capacity predicts nonword reading and spelling in first and second grade. *Reading and Writing: An Interdisciplinary Journal*, 29, 1–20. <https://doi.org/10.1007/s11145-015-9577-9>
- Caravolas, M. (2018). Growth of word and pseudoword reading efficiency in alphabetic orthographies: Impact of consistency. *Journal of Learning Disabilities*, 51(5), 422–433. <https://doi.org/10.1177/0022219417718197>
- Caravolas, M., Lervag, A., Mousikou, P., Efrim, C., Litavsky, M., Onochie-Quintanilla, E., Salas, N., Schöfelová, M., Defior, S., Mikulajová, M., Seidlová-Málková, G., & Hulme, Ch. (2012). Common patterns of prediction of literacy development in different alphabetic orthographies. *Psychological Science*, 23(6), 678–686. <https://doi.org/10.1177/0956797611434536>
- Chalmers, K. A., & Freeman, E. E. (2018). A comparison of single and multi-test working memory assessments in predicting academic achievement in children. *The Journal of Psychology*, 152(8), 613–629. <https://doi.org/10.1080/00223980.2018.1491469>
- Chen, Y.-J.I., Thompson, C. G., Xu, Z., Irey, R. C., & Georgiou, G. K. (2021). Rapid automatized naming and spelling performance in alphabetic languages: A meta-analysis. *Reading and Writing: An Interdisciplinary Journal*, 34, 2559–2580. <https://doi.org/10.1007/s11145-021-10160-7>
- Cohen, J. (1992). Statistical power analysis. *Current Directions in Psychological Science*, 1(3), 98–101. <https://doi.org/10.1111/1467-8721.ep10768783>
- Cohen, D. (2007). Langue arabe. *Encyclopædia universalis*. [https://www.universalis.fr/encyclopedie/arabe-monde-langue/#i\\_6645](https://www.universalis.fr/encyclopedie/arabe-monde-langue/#i_6645)
- Corp, I. B. M. (2021). *IBM SPSS statistics for Windows (Version 28) [Computer software]*. IBM Corp.
- Cuetos, F., Ramos, J., & Ruano, E. (2004). *PROESC: Evaluación de los procesos de escritura* (2a ed.) [*PROESC: evaluation of writing processes*]. TEA.
- Cuetos, F. (2010). *Batería de evaluación de los procesos lectores, revisada (PROLEC-R)* (3a. ed.) [*Battery for evaluation of reading processes, revised*]. TEA.
- de Bree, E., & van den Boer, M. (2019). Knowing what we don't know: Cognitive correlates of early spelling of different target types. *Reading and Writing: An Interdisciplinary Journal*, 32, 2125–2148. <https://doi.org/10.1007/s11145-019-09936-9>
- Defior, S., Fonseca, L., Gottheil, B., Aldrey, A., Jiménez, M., Pujals, M., Rosas, G., & Serrano, F. D. (2006). *LEE. Test de lectura y escritura en español [LEE. Reading and writing test in Spanish]*. Paidós.
- Ding, Y., Liu, R.-D., McBride, C. A., Fan, C.-H., Xu, L., & Wang, J. (2018). Pinyin and English invented spelling in Chinese-speaking students who speak English as a second language. *Journal of Psycholinguistic Research*, 47(5), 1163–1187. <https://doi.org/10.1007/s10936-018-9585-4>
- Ferroni, M., Diuk, B., & Mena, M. (2016). Desarrollo de la lectura y la escritura de palabras con ortografía compleja: Sus predictores [Development of reading and writing words with complex spelling: Its predictors]. *Avances en Psicología Latinoamericana*, 34(2), 253–271. <https://doi.org/10.12804/apl34.2.2016.04>
- Frost, R. (2005). Towards a universal model of reading. *Behavioral Brain Sciences*, 35(5), 263–279. <https://doi.org/10.1017/S0140525X11001841>
- Georgiou, G. K., Parrila, R., & Papadopoulos, T. C. (2008). Predictors of word decoding and reading fluency across languages varying in orthographic consistency. *Journal of Educational Psychology*, 100(3), 566–580. <https://doi.org/10.1002/dys.401>
- Georgiou, G. K., Aro, M., Liao, C. H., & Parrila, R. (2016). Modeling the relationship between rapid automatized naming and literacy skills across languages varying in orthographic consistency. *Journal of Experimental Child Psychology*, 143(1), 48–64. <https://doi.org/10.1016/j.jecp.2015.10.017>
- Georgiou, G. K., Torppa, M., Landerl, K., Desrochers, A., Manolitsis, G., de Jong, P. F., & Parrila, R. (2020). Reading and spelling development across languages varying in orthographic consistency: Do their paths cross? *Child Development*, 91(2), e266–e279. <https://doi.org/10.1111/cdev.13218>

- Geva, E., Yaghouh-Zadeh, Z., & Schuster, B. (2000). Understanding individual differences in word recognition skills of ESL children. *Annals of Dyslexia*, 50(1), 123–154. <https://doi.org/10.1007/s11881-000-0020-8>
- Gómez-Velázquez, F. R., González-Garrido, A. A., Zarabozo, D., & Amado, M. (2010). La velocidad de Denominación de letras El mejor predictor temprano del desarrollo lector en español [The speed of naming letters The best early predictor of reading development in Spanish]. *Revista Mexicana de Investigación Educativa*, 15(46), 823–847.
- González-Valenzuela, M. J., Díaz-Giráldez, F., & López-Montiel, M. D. (2016). Cognitive predictors of word and pseudoword reading in Spanish first-grade children. *Frontiers in Psychology*, 7, 774. <https://doi.org/10.3389/fpsyg.2016.00774>
- González-Valenzuela, M. J., López-Montiel, D., Chebaani, F., Cobos, M., Piedra-Martínez, E., & Martín-Ruiz, I. (2022). Predictors of word and pseudoword reading in languages with different orthographic consistency. *Journal of Psycholinguistic Research*, 52, 307–330. <https://doi.org/10.1007/s10936-022-09893-5>
- Graham, S., Liu, K., Bartlett, B., Ng, C., Harris, K. R., Aitken, A., Barkel, A., Kavanaugh, C., & Talukdar, J. (2017). Reading for writing: A meta-analysis of the impact of reading and reading instruction on writing. *Review of Educational Research*, 88, 243–284. <https://doi.org/10.3102/0034654317746927>
- Guo, Y., Sun, S., Puranik, C., & Breit-Smith, A. (2018). Profiles of emergent writing skills among preschool children. *Child & Youth Care Forum*, 47(3), 421–442. <https://doi.org/10.1007/s10566-018-9438-1>
- Gutiérrez, R., & Díez, A. (2018). Conocimiento fonológico y desarrollo evolutivo de la escritura en las primeras edades [Phonological knowledge and evolutionary development of writing in the early ages]. *Educación XXI*, 21(1), 395–416. <https://doi.org/10.5944/educXX1.20212>
- Harrison, G. L., Goegan, L. D., Jalbert, R., McManus, K., Sinclair, K., & Spurling, J. (2016). Predictors of spelling and writing skills in first- and second-language learners. *Reading and Writing: An Interdisciplinary Journal*, 29(1), 69–89. <https://doi.org/10.1007/s11145-015-9580-1>
- Hassunah Arafat, S., Korat, O., Aram, D., & Saiegh-Haddad, E. (2017). Continuity in literacy achievements from kindergarten to first grade: A longitudinal study of Arabic-speaking children. *Reading and Writing: An Interdisciplinary Journal*, 30(5), 989–1007. <https://doi.org/10.1007/s11145-016-9709-x>
- Hutchenson, G., & Sofroniou, N. (1999). *The multivariate social scientist*. Sage.
- Inoue, T., Georgiou, G., Muroya, N., Maekawa, H., & Parrila, R. (2017). Cognitive predictors of literacy acquisition in syllabic Hiragana and morphographic Kanji. *Reading and Writing: An Interdisciplinary Journal*, 30(6), 1335–1360. <https://doi.org/10.1007/s11145-017-9726-4>
- James, K. H., & Engelhardt, L. (2012). The effects of handwriting experience on functional brain development in pre-literate children. *Trends in Neuroscience and Education*, 1(1), 32–42. <https://doi.org/10.1016/j.tine.2012.08.001>
- Joshi, R. M., & McCardle, P. (2018). Models of reading in different orthographies: An introduction. *Journal of Learning Disabilities*, 51(5), 419–421. <https://doi.org/10.1177/0022219417718196>
- Khoury, A., & Khateb, A. (2022). Exploring the writing-reading connection among Arabic-speaking kindergarten children: The role of fine motor skills and orthographic knowledge. *Reading and Writing: An Interdisciplinary Journal*, 35(7), 1525–1547. <https://doi.org/10.1007/s11145-021-10235-5>
- Khoury, A., Asadi, I. A., & Khateb, A. (2018). The contribution of basic linguistic skills to handwriting among fifth-grade Arabic-speaking children. *Writing Systems Research*, 10(2), 95–110. <https://doi.org/10.1080/17586801.2018.1540375>
- Kline, P. (1999). *The handbook of psychological testing*. Routledge.
- Malpique, A., Pino-Pasternak, D., & Roberto, M. (2020). Writing and reading performance in Year 1 Australian classrooms: Associations with handwriting automaticity and writing instruction. *Reading and Writing: An Interdisciplinary Journal*, 33(3), 783–805. <https://doi.org/10.1007/s11145-019-09994-z>
- Milburn, T., Hipfner-Boucher, K., Weitzman, E., Greenberg, J., Pelletier, J., & Girolametto, L. (2017). Cognitive, linguistic and print-related predictors of preschool children's word spelling and name writing. *Journal of Early Childhood Literacy*, 17(1), 111–136. <https://doi.org/10.1177/1468798415624482>
- Moll, K., Ramus, F., Bartling, J., Bruder, J., Kunze, S., Neuhoff, N., Streiftau, S., Lyytinen, H., Lepänen, P. H., Lohvansuu, K., Tóth, D., Honbolygó, F., Csépe, V., Bogliotti, C., Iannuzzi, S., Démonet, J. F., Longeras, E., Valdois, S., George, F., . . . Landerl, K. (2014). Cognitive mechanisms underlying reading and spelling development in five European orthographies. *Learning and Instruction*, 29, 65–77. <https://doi.org/10.1016/j.learninstruc.2013.09.003>
- Nielsen, A. V., & Juul, H. (2016). Predictors of early versus later spelling development in Danish. *Reading and Writing: An Interdisciplinary Journal*, 29(2), 245–266. <https://doi.org/10.1007/s11145-015-9591-y>
- Niolaki, G. Z., Vousden, J., Terzopoulos, A. R., Taylor, L., Sephton, S., & Masterson, J. (2020). Predictors of single word spelling in English speaking children: A cross sectional study. *Journal of Research in Reading*, 43(4), 577–596. <https://doi.org/10.1111/1467-9817.12330>

- Ouellette, G., & Sénéchal, M. (2017). Invented spelling in kindergarten as a predictor of reading and spelling in Grade 1: A new pathway to literacy, or just the same road, less known? *Developmental Psychology*, 53(1), 77–88. <https://doi.org/10.1037/dev0000179>
- Pinto, G., Bigozzi, L., Tarchi, C., Vezzani, C., & Accorti, B. (2016). Predicting reading, spelling, and mathematical skills: A longitudinal study from kindergarten through first grade. *Psychological Reports*, 118(2), 413–440. <https://doi.org/10.1177/0033294116633357>
- Pittas, E. (2018). Longitudinal contributions of phonemic awareness to reading Greek beyond estimation of verbal ability and morphological awareness. *Reading & Writing Quarterly*, 34(3), 218–232. <https://doi.org/10.1080/10573569.2017.1390807>
- Saiegh, E., & Taha, H. (2017). The role of morphological and phonological awareness in the early development of word spelling and reading in typically developing and disabled Arabic readers. *Dyslexia*, 23(4), 345–371. <https://doi.org/10.1002/dys.1572>
- Share, D. L. (2008). On the Anglocentricities of current reading research and practice: The perils of overreliance on an “outlier” orthography. *Psychological Bulletin*, 134(4), 584–615. <https://doi.org/10.1037/0033-2909.134.4.584>
- Share, D. L., & Shalev, C. (2004). Self-teaching in normal and disabled readers. *Reading & Writing: An Interdisciplinary Journal*, 17, 769–800. <https://doi.org/10.1007/s11145-004-2658-9>
- Soriano, M., & Miranda, A. (2010). Developmental dyslexia in a transparent orthography: A study of Spanish dyslexic children. In T.E. Scruggs & M.A. Mastropieri (Eds.), *Advances in Learning and Behavioural Disabilities* (pp 95–114). Emerald Group Publishing Limited. [https://doi.org/10.1108/S0735-004X\(2010\)0000023006](https://doi.org/10.1108/S0735-004X(2010)0000023006).
- Suárez-Coalla, P., García de Castro, M., & Cuetos, F. (2013). Variables predictoras de la lectura y la escritura en castellano. *Infancia y Aprendizaje*, 36(1), 77–89. <https://doi.org/10.1174/021037013804826537>
- Taha, H. (2013). Reading and spelling in Arabic: Linguistic and orthographic complexity. *Theory and Practice in Language Studies*, 3(5), 721–727. <https://doi.org/10.4304/tpls.3.5.721-727>
- Taha, H., & Saiegh, E. (2016). The role of phonological versus morphological skills in the development of Arabic spelling: An intervention study. *Journal of Psycholinguistic Research*, 45(3), 507–535. <https://doi.org/10.1007/s10936-015-9362-6>
- Taha, H., Ibrahim, R., & Khateb, A. (2013). How does Arabic orthographic connectivity modulate brain activity during visual word recognition: An ERP study. *Brain Topography*, 26(2), 292–302. <https://doi.org/10.1007/s10548-012-0241-2>
- Tibi, S., & Kirby, J. R. (2018). Investigating phonological awareness and naming speed as predictors of reading in Arabic. *Scientific Studies of Reading*, 22(1), 70–84. <https://doi.org/10.1080/10888438.2017.134094>
- Tolchinsky, L., Levin, I., Aram, D., & McBride-Chang, C. (2012). Building literacy in alphabetic, abjad and morphosyllabic systems. *Reading & Writing: An International Journal*, 25, 1573–1598. <https://doi.org/10.1007/s11145-011-9334-7>
- Treiman, R. (2017). Learning to spell words: Findings, theories, and issues. *Scientific Studies of Reading*, 21(4), 1–12. <https://doi.org/10.1080/10888438.2017.1296449>
- Vaessen, A., & Blomert, L. (2013). The cognitive linkage and divergence of spelling and reading development. *Scientific Studies of Reading*, 17, 89–107. <https://doi.org/10.1080/10888438.2011.614665>
- Verhoeven, L., & Perfetti, C. (2022). Universals in learning to read across languages and writing systems. *Scientific Studies of Reading*, 26(2), 150–164. <https://doi.org/10.1080/10888438.2021.1938575>
- Wealer, C., Fricke, S., Loff, A., & Engel de Abreu, P. M. J. (2022). Preschool predictors of learning to read and spell in an additional language: A two-wave longitudinal study in a multilingual context. *Reading and Writing: An Interdisciplinary Journal*, 35(5), 1265–1288. <https://doi.org/10.1007/s11145-021-10239-1>
- Wolf, M., & Denckla, M. (2003). *Rapid automatized naming tests*. Super DuperN.
- World Medical Association (2015). *Ethical manual*. Author.
- Zhang, S., Hudson, A., Ji, X., Joshi, R., Zamora, J., Gómez-Velázquez, F., & González-Garrido, A. (2021). Spelling acquisition in Spanish: Using error analyses to examine individual differences in phonological and orthographic processing. *Scientific Studies of Reading*, 25(1), 64–83. <https://doi.org/10.1080/10888438.2020.1754834>
- Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin*, 131(1), 3–29. <https://doi.org/10.1037/0033-2909.131.1.3>

Zoccolotti, P., De Luca, M., Marinelli, C. V., & Spinelli, D. (2020). Predicting individual differences in reading, spelling and maths in a sample of typically developing children: A study in the perspective of comorbidity. *PLoS ONE*, *15*(4), e0231937. <https://doi.org/10.1371/journal.pone.0231937>

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

*Current themes of research learning processes and teaching of reading and writing*

Cognitive and Linguistic Predictors of Literacy in Different Languages

Early literacy

Prevention of learning difficulties

Dyslexia

*Most relevant publications*

González-Valenzuela, M. J., Díaz-Giráldez, F., & López-Montiel, M.D. (2016). Cognitive Predictors of Word and Pseudoword Reading in Spanish First-Grade Children. *Frontiers in Psychology*, *7*, 774. <https://doi.org/10.3389/fpsyg.2016.00774>

González-valenzuela, M.J., Martín-Ruiz, I. (2017). Effects on Reading of an Early Intervention Program for Children at Risk of Learning Difficulties, *Remedial and Special Education*,*38* (2), 67 – 75. DOI: <https://doi.org/10.1177/0741932516657652>

González-Valenzuela, M.J., Martín-Ruiz, I., Prieto, G., & Rivas-Moya, M.T. (2018). Analysis of performance and improvement in Reading and Writing in Preschool, *Revista de Educación*, *382*, 225–247. DOI: <http://dx.doi.org/10.4438/1988-592X-RE-2018-382-398>

González-Valenzuela, M.J., Martín Ruiz, I. (2020). Effects of early intervention on the writing skills of pupils who present a risk of learning disabilities within Spain's Early Years and Primary Education system, *Revista de Educación*, *388*, 85–107. <https://doi.org/10.4438/1988-592X-RE-2020-388-448>

González-Valenzuela MJ, López-Montiel D, Díaz-Giráldez F and Martín-Ruiz I (2021) Effect of Cognitive Variables on the Reading Ability of Spanish Children at Age Seven. *Front. Psychol.* *12*:663596. <https://doi.org/10.3389/fpsyg.2021.663596>

Martín-Ruiz, I. & González-Valenzuela (2022). Analysis of reading comprehension and disabilities among teenagers. *Annals of Psychology*, *38* (2), 251–258. <https://doi.org/10.6018/analesps.419111>

González-Valenzuela, MJ., López-Montiel, D., Chebaani, F., Cobos, M., Piedra-Martínez, E., & Martín-Ruiz, I. (2022) . Predictors of Word and Pseudoword Reading in Languages with Different Orthographic Consistency. *Journal of Psycholinguistic Research*, <https://doi.org/10.1007/s10936-022-09893-5>

González-Valenzuela, M.J. & Martín-Ruiz, I. (2023). Early intervention of reading and writing in Spanish students. *Annals of Psychology*, *39* (3) <https://doi.org/10.6018/analesps.472161>

González-Valenzuela, MJ., Lopez-Montiel, D., Díaz-Giraldez, F., & Martín-Ruiz, I. (2023). Word Writing and Cognitive Predictors in Spanish at the Age of Seven. *International Journal of Early Childhood* . <https://doi.org/10.1007/s13158-023-00359-w>