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Beyond words: An analysis of skills underlying reading and vocabulary acquisition in three foreign languages

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Abstract

To capture the complexity of foreign language literacy acquisition, we investigated cognitive skills underlying word reading, sentence reading, word vocabulary and sentence vocabulary in three different foreign languages. Students fluent in Dutch simultaneously acquired three foreign languages that differed in orthographic transparency and writing system (Spanish, French, Chinese). Cognitive skills at the start of literacy acquisition (Grade 7) were longitudinally related to literacy attainment in each of the foreign languages after two years of instruction (end of Grade 8). Structural equation regression models indicated that three areas (word and sentence vocabulary, and sentence reading) related most strongly to verbal and nonverbal intelligence, indicating the involvement of academic skills. For word reading the influence of cognitive skills appeared language specific. Across languages, native reading skills seemed to be employed to varying degrees of efficiency to decipher foreign words, more so for foreign languages with a smaller orthographic distance from the native language.

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Introduction

Becoming literate is a long-lasting and complex process. It comprises multiple, interrelated aspects, including reading, writing, vocabulary, spelling and reading comprehension. Becoming literate in a foreign language is even more complex, since it by definition involves at least two languages and hence cross-linguistic processes (Koda, 2007). Nevertheless, an increasing number of people master one or more foreign language(s). Interesting insights in the processes involved in foreign language acquisition have come from research on underlying cognitive skills (Chiappe & Siegel, 1999; Cisero & Royer, 1995; Comeau, Cormier, Grandmaison & Lacroix, 1999; Durgunoğlu, Nagy & Hancin-Bhatt, 1993; Geva & Yaghoub-Zadeh, 2006; Geva, Yaghoub-Zadeh & Schuster, 2000; Lindsey, Manis & Bailey, 2003; Morfidi, van der Leij, de Jong, Scheltinga & Bekebrede, 2007).

Remarkably, despite the conventionality of including multiple aspects of literacy in foreign language programs (i.e., reading, vocabulary, writing), research thus far primarily focused on solely one aspect of literacy at a time. In addition, most studies focus on one foreign language only. This leaves questions open about the degree to which certain cognitive skills underlie literacy acquisition in general, or specific aspects of literacy in particular and the degree to which the skills that underlie literacy development are universal or language specific. These questions were addressed in the current study in students with fluent literacy skills in a transparent alphabetic orthography (Dutch, their native language), who simultaneously acquired three foreign languages in school: Spanish, a transparent alphabetic orthography, French, a nontransparent alphabetic orthography, and Chinese, a nonalphabetic orthography. A strength of the design was that all participants were followed from the first day of secondary school, where they acquired all three foreign orthographies, starting from the same, beginner, level. This allowed assessing the influence of the same set of cognitive skills on three different foreign languages within the same sample. The study adopted a longitudinal design, measuring the effect of cognitive skills at the start of foreign language literacy acquisition on the attained level of literacy acquisition in each of these languages two years later, through structural equation regression models. Thereby, the study aims to shed light on the processes that are involved in the broad and complex task of foreign language literacy acquisition. Insight into these processes is important both for theories about foreign language development and educational practices in foreign language programs.

One important literacy skill, that is often studied, is word reading. Research on the cognitive skills underlying children's word reading in the native language indicates that two cognitive skills are most important for word reading across orthographies: phonological awareness, the sensitivity to the sound structure of words; and rapid automatized naming (RAN), which denotes the speed of naming a set of highly familiar stimuli (e.g., Caravolas, Lervåg,

Mousikou, Efrim, Litavsky, Onochie-Quintanilla, Salas, Schöffelová, Defior, Mikulajová, Seidlová-Málková & Hulme, 2012; McBride-Chang & Kail, 2002; Moll, Ramus, Bartling, Bruder, Kunze, Neuhoff, Streiftau, Lyytinen, Leppänen, Lohvansuu, Tóth, Honbolygó, Csépe, Bogliotti, Iannuzzi, Démonet, Longeras, Valdois, George, Soares-Boucaud, Le Heuzey, Billard, O'Donovan, Hill, Williams, Brandeis, Maurer, Schulz, van der Mark, Müller-Myhsok, Schulte-Körne & Landerl, 2014; Pan, McBride-Chang, Shu, Liu, Zhang & Li, 2011; Zhou, Duff & Hulme, 2015; Ziegler, Bertrand, Tóth, Csépe, Reis, Faísca, Saine, Lyytinen, Vaessen & Blomert, 2010). Despite the universal importance of these two skills, it has been suggested that phonological awareness is more important in non-transparent than transparent orthographies, whereas RAN is more important in transparent orthographies (Georgiou, Parrila & Papadopoulos, 2008; Mann & Wimmer, 2002; Moll et al., 2014). In addition, the influence of phonological awareness may be slightly smaller in nonalphabetic orthographies than in alphabetic orthographies (Song, Georgiou, Su & Hua, 2016). Research on foreign language learning indicates that both phonological awareness and RAN are involved in children's word reading in a second language as well (Geva et al., 2000; Geva & Yaghoub-Zadeh, 2006; Gottardo, Yan, Siegel & Wade-Woolley, 2001; Lindsey et al., 2003; Pan et al., 2011; Wang, Perfetti & Liu, 2005).

Other cognitive skills that have been found to contribute to children's word reading in the native language are verbal short-term memory (Landerl & Wimmer, 2008; So & Siegel, 1997; Swanson, Zheng & Jerman, 2009), and in alphabetic orthographies also vocabulary (Nation & Snowling, 2004; Ziegler et al., 2010), letter-sound knowledge (Caravolas et al., 2012; Foulin, 2005) and orthographic processing skill (Cunningham, Perry & Stanovich, 2001; Leslie & Thimke, 1986). Moreover, some additional skills have been found to be important in nonalphabetic orthographies such as visual skills, including visual discrimination, visual-spatial attention and visual form, for early word reading (Huang & Hanley, 1995; Liu, Chen & Chung, 2015; Siok, Spinks, Jin & Tan, 2009), and morphological skills and subcharacter processing in somewhat later stages of reading development (Tong & McBride-Chang, 2010). Studies on foreign language acquisition have indicated that verbal memory (Comeau et al., 1999; Geva & Siegel, 2000), orthographic knowledge (Leong, Hau, Cheng & Tan, 2005; Sun-Alperin & Wang, 2011), vocabulary and letter knowledge (Lindsey et al., 2003) are important for acquiring reading skills in a foreign language as well. In addition, word reading skills in the native language are generally directly related to word reading in the foreign language (Geva & Siegel, 2000; Lindsey et al., 2003; Wang, Cheng & Chen, 2006).

Notwithstanding the importance of word reading, becoming literate in a foreign language comprises more than reading single words. In the current study we included word level reading, sentence level reading, word level vocabulary and sentence level vocabulary. The focus is on reading and vocabulary as these two skills are essential for written communication in a foreign language, are central elements in foreign language classes, and are considered the key components of reading comprehension, the ultimate goal of literacy development (Gough & Tunmer, 1986). By assessing both reading and vocabulary at the word and sentence level, similarities and differences between the cognitive skills underlying elementary (word level) literacy skills, and more complex (sentence level) literacy skills can be investigated.

Reading and vocabulary are related skills, mutually reinforcing each other during development (Verhoeven, van Leeuwe & Vermeer, 2011). Therefore, it is not surprising that the cognitive skills that underlie vocabulary and reading development are to some extent similar. As was found for word reading, phonological awareness and verbal memory were shown to be related to vocabulary development in the native language (e.g., Gathercole, Willis & Baddeley, 1991; Gathercole, Willis, Baddeley & Emslie, 1994; Jarrold, Baddeley, Hewes, Leeke & Phillips, 2004; Majerus, Poncelet, Greffe & van der |Linden, 2006). The most widely reported skill underlying vocabulary development is verbal memory, which influences vocabulary in native as well as foreign languages in both children and adults (e.g., Bowey, 1996; Gathercole, Service, Hitch, Adams & Martin, 1999; Hummel, 2009; Majerus et al., 2006; Nicolay & Poncelet, 2013; Papagno & Vallar, 1995).

Nevertheless, some differences between vocabulary and reading development are also reported with respect to underlying cognitive skills. In native readers of English, vocabulary development was consistently influenced by both phonological awareness and phonological memory, whereas reading development was initially only influenced by phonological awareness. Phonological memory became involved after one year of reading instruction (Gathercole et al., 1991). Moreover, McBride-Chang, Cho, Liu, Wagner, Shu, Zhou, Cheuk, and Muse (2005) compared children who learned to read in their native language in either English, Chinese or Korean. They showed that English vocabulary development was influenced by both phonological and morphological skills, whereas for English reading development only phonological skills were involved. By contrast, in Chinese and Korean, both phonological and morphological skills played a role in reading as well as vocabulary. This study thus indicates that the pattern of skills underlying reading and vocabulary may be different, yet also suggests that differences between the skills underlying reading and vocabulary are language specific. Accordingly, research on Luxembourgish foreign language learners indicated that verbal memory was important for vocabulary development in the transparent alphabetic native language and transparent alphabetic L2 (German), but not in the nontransparent alphabetic L3 (French), whereas phonological awareness was involved in vocabulary acquisition in all three languages (Engel de Abreu & Gathercole, 2012). Reading development was only assessed in L2. In contrast to L2 vocabulary, L2 reading was influenced by phonological awareness, but not verbal short term memory.

Previous studies thus suggest that the processes involved in the development of foreign language vocabulary and reading skills, as assessed by underlying cognitive skills, may differ across foreign languages. However, the array of cognitive skills assessed in most studies of vocabulary development is limited. Therefore, there is currently no clear understanding of the similarities and differences between the processes involved in vocabulary and reading acquisition in foreign languages, let alone of the extent to which these similarities and differences are universal or language specific.

Previous studies in which skills underlying literacy at the word and sentence level are compared are scarce. In fact, to our knowledge no previous studies focused on vocabulary at the word and sentence level. Also, the studies that focused on reading at the word and sentence level were mainly conducted in the native language. In general, word reading is considered the foundation for sentence and text level reading (Hudson, Torgesen, Lane & Turner, 2012). Accordingly, reading skills at the word and sentence level are reported to be strongly related (Ahmed, Wagner

& Lopez, 2014; Biemiller, 1977). However, findings from eye-tracking and neurological paradigms suggest that the processes involved in reading at the word and sentence level may be somewhat different (Cutting, Clements, Courtney, Rimrodt, Schafer, Bisesi, Pekar & Pugh, 2006; Haberlandt, 1984; Xu, Kemeny, Park, Frattali & Braun, 2005). Specifically, in Korean children with one year of reading instruction, word reading fluency was uniquely predicted by skills in letter naming, phonology, orthography and RAN, whereas sentence reading fluency was uniquely predicted by phonological skills and vocabulary. The authors suggest that, although reading at the word and sentence level are highly related, sentence level reading involves meaning comprehension in addition to word level reading processes (Kim, 2015). Relatedly, in children reading English, sentence reading was more strongly related to reading comprehension than word reading (Jenkins, Fuchs, Espin, van den Broek & Deno, 2000). Furthermore, for Chinese readers, both RAN and phonological skills were related to word reading (character recognition), whereas only RAN, and not phonological skills, was related to sentence level reading (Pan et al., 2011).

Some research has also focused on word and sentence level reading in a foreign language. Geva and Yaghoub-Zadeh (2006) studied word and sentence level reading in children who learned to read in English as a second language. They report that although both phonological awareness and RAN were involved in word and sentence level reading for foreign language readers, only RAN played a role in word and sentence level reading for native English readers of the same age. The involvement of underlying skills was largely similar for word and sentence level reading in both groups. A longitudinal study following native and foreign readers of English did find differences between word and sentence level reading though. Geva and Farnia (2012) showed that word and sentence level reading formed one construct in Grade 2, but separate factors in Grade 5, where sentence level reading became more strongly related to reading comprehension. This developmental process was similar for native and foreign language readers.

Although the findings from previous studies are somewhat inconclusive, they indicate that reading at the word and sentence level may involve somewhat different processes in native readers. Little is known about reading in a foreign language, but some findings suggest that word and sentence reading develop somewhat differently over time and that findings for native speakers do not fully apply to foreign language learners. As such, it is unclear whether differences between word and sentence level reading in a foreign language are present across orthographies, and require the same underlying skills. Moreover, insight in the cognitive skills underlying vocabulary across different foreign languages, especially differences between word- and sentence level vocabulary, is currently nonexistent.

The current study therefore aims to specify whether different cognitive skills underlie literacy acquisition in general, or underlie specific aspects of literacy in particular. In addition, we investigate to what degree the importance of the skills that underlie literacy acquisition is universal or language specific. In a previous study (Zeguers, van den Boer, Snellings & de Jong, 2018), we addressed the question whether skills underlying literacy acquisition are universal or language specific, by focusing specifically on word reading. Results indicated that when fluent readers of a transparent alphabetic orthography (Dutch) started learning to read in Spanish (transparent, alphabetic), French (nontransparent alphabetic) and Chinese (nonalphabetic), the skills underlying foreign language word reading were largely language specific. Word reading acquisition in transparent alphabetic Spanish depended mainly on reading skills in the native language. In contrast, in nontransparent alphabetic French and nonalphabetic Chinese, word reading was mainly influenced by cognitive skills: French word reading by phonological awareness and verbal intelligence, and Chinese word reading by verbal and nonverbal intelligence. These results thus indicated that the processes underlying foreign language word reading are mainly language specific.

The study provided interesting findings on similarities and differences in the cognitive skills underlying foreign language literacy acquisition between different foreign languages. However, the study included only one aspect of literacy, i.e., word reading. This leaves it unclear to what extent findings relate to other aspects of literacy. Therefore, in the current study, we investigated the cognitive skills underlying word level reading, word level vocabulary, sentence level reading and sentence level vocabulary in the same sample of Dutch children. They were now in their second year of acquiring literacy skills in three foreign languages simultaneously: transparent alphabetic Spanish, nontransparent alphabetic French and nonalphabetic Chinese. Most studies comparing literacy acquisition across orthographies adopt group-comparisons, which entail the clear disadvantage that groups may differ on variables other than the language(s) under study. In the current study we were able to compare literacy acquisition in different orthographies in the same sample of participants.

Cognitive skills were selected based on previous research on reading acquisition in native speakers of languages with alphabetic orthographies and Chinese as well as in foreign languages (for a review see Zeguers et al., 2018). In addition to cognitive skills, we included native language reading skills as a predictor, based on previous studies showing that native language skills are an important source of individual differences in foreign language literacy acquisition (e.g., Bialystok, Luk & Kwan, 2005; Geva & Siegel, 2000; Sparks, Patton, Ganschow & Humbach, 2009). We aimed to answer two research questions:

1) What are the similarities and differences between the cognitive skills underlying reading and vocabulary at the word and sentence level in a foreign language?
2) To what extent are differences between the cognitive skills underlying reading and vocabulary at the word and sentence level universal or language specific?

Method

Design

In this longitudinal study, all students attending the first year of secondary education (Grade 7) at a high school in the Netherlands participated. In addition to receiving Dutch–English bilingual education, these students received classes in three foreign languages: Spanish, French and Chinese. These languages were all part of the standard curriculum and were each taught for two 50-minute lessons a week. The current study comprised two measurement points. In the first week of Grade 7, students' native language and cognitive skills were examined. At this moment, a vocabulary task was also administered for each of the three foreign languages under study, to identify participants who were already familiar with one of these languages. By the end of Grade 8, we examined students' foreign language skills on a broader range of literacy tasks, including word reading, sentence

reading, word vocabulary and sentence vocabulary. This study was approved by the ethics review board of the faculty of social and behavioral sciences of the University of Amsterdam, under the name 'Do you parlez la idioma Chino?' (number: 2014-DP-3749).

Participants

At the start of Grade 7, 185 students (102 girls) with a mean age of 12 years 4 months ($SD = 5.19$ months) participated in the study. In the Netherlands, secondary education is provided in different levels. The participating school provided education at the highest two levels, so all participants were average to above average students (top 50%). All participants were fluent in Dutch and most participants (97.8%) spoke Dutch at home, although many students (40.5%) also spoke another language with their families. In total, 29 different languages were spoken in the sample. In addition to Dutch, the three languages that were most commonly spoken at home were English (19.5%), Turkish (7.0%) and Arabic (3.8%). The other languages were all spoken by fewer than 5 children (less than 2.8%).

By the end of Grade 8, 159 students (92 girls) participated again. Their mean age at that time was 14 years 1 month ($SD = 5.16$ months). The remaining 26 students were unable to participate, because they no longer attended the school ($N = 22$) or were absent during testing ($N = 4$). Proficient speakers of Spanish ($N = 4$), French ($N = 5$), or Chinese ($N = 5$), identified with the vocabulary measures at the start of Grade 7 and students' report of their home language(s) were left out of the analyses for the language they already mastered, as they were not expected to learn new words or vocabulary from these basic level courses. Furthermore, 46 students dropped Chinese by the end of Grade 7. In all, language skills by the end of Grade 8 were assessed for 155 participants for Spanish, 154 participants for French, and 113 participants for Chinese.

Measures and procedure

Foreign language reading and vocabulary

Four foreign language literacy tasks were administered each for Spanish, French and Chinese. These tasks were all designed for the current study. Stimuli were selected from the study materials used in class. The words in the word reading and translation tasks were supposed to form a representative sample of the words studied in class. Therefore, an equal number of words was selected from each chapter in the study book. Items included nouns, verbs, and adjectives. If multiple conjugations of the same word were taught, only one form was included. The selected items were evenly divided over the word reading and translation tasks. The sentences for the reading and translation tasks were selected and/or designed for the current study on the basis of the words, sentences and texts presented in the study books. As for the word tasks, the stimuli used for the sentence-level tasks were selected from all chapters of the study books.

Sentence reading, word vocabulary and sentence vocabulary, preceded by a warm-up task (i.e., listening to a song in the language at hand), were all administered in a classroom session of 45 minutes per language. The word reading tasks were administered individually. The Chinese tasks were administered and scored by the teachers. For all tasks, the Chinese version comprised fewer items than the Spanish and French versions, as the students had acquired fewer words in Chinese than in the other

foreign languages and because reading and writing in Chinese was more time consuming.

Word reading

Word reading fluency tasks were administered in Spanish, French and Chinese. The tasks were modelled after the standardized test for word reading fluency in Dutch (Brus & Voeten, 1995; described below). Students were asked to read aloud a list of words of increasing length and difficulty as quickly and accurately as possible for 1 minute. The Spanish and French versions consisted of 96 words each. The Chinese version consisted of 60 single or multi-character words in simplified script. The score for each task was the number of words read correctly within 1 minute. Parallel forms reliability (at the end of Grade 8) in the current sample was .88 for Spanish, .89 for French, and .75 for Chinese.

Sentence reading

The sentence reading tasks were modelled after a standardized test for silent reading fluency (TOSREC; Wagner, Torgesen, Rashotte & Pearson, 2010). For Spanish and French students were presented with sentences that were either true or false. An example from the Spanish task is: 'Un perro es más grande que un elefante.', followed by the choice 'verdadero / falso' ('A dog is bigger than an elephant', 'true / false'). An example from the French task is: 'La sœur de ma mère est ma tante.', followed by the choice 'vrai / faux' ('The sister of my mother is my aunt', 'true / false'). Students were asked to read the sentences and circle the correct answer. They were presented with 50 items in each task and were asked to work as quickly and accurately as possible for five minutes. For both French and Spanish, two example sentences were presented and discussed with the class. The scores consisted of the number of correct judgements. For Chinese the task was slightly different, because students had not yet acquired enough characters to form a set of true/false sentences. Instead, students were presented with four stories of 11 or 12 short sentences each, followed by four or five questions about the text (18 in total). Students were instructed to read each text and indicate whether the following sentences were true or false (对／不对).They were instructed to work as quickly and accurately as possible for five minutes. The score consisted of the number of correct judgments.

Word vocabulary

Word vocabulary tasks were administered in Spanish, French and Chinese. The tasks were modelled after common classroom practice of foreign words. For each language, students were presented with a list of words of increasing difficulty. They were asked to read the words and write down the Dutch translation. Students were instructed to correctly translate as many words as possible within 3 minutes. The Spanish and French versions consisted of 96 words each. The Chinese version consisted of 60 single or multi-character words in simplified script. The score for each task was the number of words correctly translated to Dutch. Parallel forms reliability (at the end of Grade 8) in the current sample was .85 for Spanish, .80 for French, and .80 for Chinese.

Sentence vocabulary

In the absence of previous research on the acquisition of sentence level vocabulary, the vocabulary tasks at the sentence level were modelled after common classroom practice of foreign sentences. For Spanish and French, students were presented with eight sets

of three to five sentences to be translated from Dutch to either Spanish or French. Sentences within one set focused on the same topic. For Chinese, students were presented with 10 sentences to be translated from Dutch to Chinese. For all languages students were instructed to work as quickly and accurately as possible for 10 minutes. The tasks were preceded by one example sentence that was discussed with the class. Each correct word or character in the sentences was awarded a point. The maximum score was 120 points for Spanish and French and 40 points for Chinese.

Predictors

Reading fluency in Dutch as well as seven cognitive skills were included as predictors of foreign language literacy skills. Two or three measures were used per skill, amounting to a total of 18 tasks. These tasks are briefly described below (see also Zeguers et al., 2018). The tasks were all administered in Dutch during one classroom session and one individual test session of 45 minutes each, except for two of the intelligence tests. The NIO test was administered group-wise at the school by the end of Grade 6 as part of the school's registration procedure. The Cito tests were administered group-wise at the school, in the first week of Grade 7, as the first of a sequence of curriculum based measurements to follow students' progress in Dutch, English and mathematics. The scores on these tasks were provided by the school principal.

Dutch reading fluency

Word reading fluency in Dutch was measured with standardized word (One Minute Test; Brus & Voeten, 1995; $r = .89$-.92) and pseudoword (Klepel; van den Bos, lutje Spelberg, Scheepstra & de Vries, 1994; $r = .91$) reading tasks. Students read aloud lists of 116 words or pseudowords of increasing difficulty for one and two minutes respectively. The scores were the number of items read correctly.

Verbal intelligence

Verbal intelligence was assessed with subtests of three different standardized tests: the verbal scale of the 'Dutch intelligence test of educational level' (NIO; van Dijk & Tellegen, 2004; $\lambda^2 = .91$), 'Dutch vocabulary' from the Cito Test 0 (van Til & van Boxtel, 2015; $\alpha = .73$), and 'verbal reasoning' from the General Aptitude Test Battery (GAT-B, van der Flier & Boomsma-Suerink, 1990; $r = .74$−.78). The verbal scale of the NIO includes the subtests synonyms, analogies, and categories. For each subtest, students answered multiple choice questions for five minutes, resulting in a standardized score with a mean of 100 ($SD = 15$). Dutch vocabulary consists of 50 multiple choice items to be completed in 50 minutes. The number of items correct is reflected in a scaled score that takes into account the difficulty of the items to enable comparison of scores across schoolyears. Verbal reasoning contained 50 items of four words each. Students chose the two words that were either synonyms or antonyms for as many items as possible within four minutes. Scores were the number of items correct.

Nonverbal intelligence

Nonverbal intelligence was assessed with subtests from the same standardized tests used for verbal intelligence: the symbolic scale from the NIO (van Dijk & Tellegen, 2004, $\lambda^2 = .92$), the subtest 'Mathematics' from the Cito Test 0 (van Til & van

Boxtel, 2015; $\alpha = .87$), and the subtest 'Spatial reasoning' from the GAT-B (van der Flier & Boomsma-Suerink, 1990; $r = .74$-.75). The symbolic scale of the NIO includes the subtests numbers, math, and figures. For each subtest students answer multiple choice questions for 10 minutes (15 for math), resulting in a standardized score with a mean of 100 ($SD = 15$). Mathematics consists of 68 multiple choice items. Similar to Dutch vocabulary, the number of items correct was converted to a scaled score. Spatial reasoning contained 40 multiple choice items in which a two-dimensional target picture, including folding lines, needed to be matched to the corresponding three-dimensional figure. The score was the number of items correct within four minutes.

Phonological awareness

Phonological awareness was assessed using a computerized version of a phoneme deletion task (de Jong & van der Leij, 2003). Students heard a bisyllabic nonword, and were asked to delete a phoneme once (e.g., what is *memslos* without 'l') or twice (e.g., what is *gepgral* without 'g'). The experimenter registered both reaction time and accuracy. The task included nine items with one and two deletions each. Scores consisted of the median reaction times, converted to the number of items answered per minute and multiplied by the proportions of items correct. Internal consistency was .64 for accuracy, and .83 for speed in the current sample.

Alphanumeric RAN

Naming speed of alphanumeric stimuli was assessed with subtests Digits ($r = .78$-.91) and Letters ($r = .82$-.85) of the Test of Continuous Naming and Word Reading (*Continu benoemen en woorden lezen;* van den Bos & lutje Spelberg, 2007). Students were asked to name as quickly and accurately as possible 50 repeating digits (2, 4, 5, 8, 9) and letters (a, d, o, p, s) presented in five columns of 10 items. Scores consisted of the number of items named per second.

Nonalphanumeric RAN

Naming speed of nonalphanumeric stimuli was assessed with the subtests Colors (black, blue, green, red, yellow; $r = .71$-.82; van den Bos & lutje Spelberg, 2007) and Pictures (bike, chair, duck, scissors, tree; $r = .78$-.82) following the same procedure as for alphanumeric RAN. Both alphanumeric and nonalphanumeric RAN were assessed as previous research has indicated that performance on these two types of RAN tasks diverge after the age of 10 (van den Bos, Zijlstra & lutje Spelberg, 2002), and that both represent different components of lexical access with differential effects on reading outcomes (Poulsen & Elbro, 2013).

Visual processing speed

Visual processing speed was assessed with coding and symbol search, two subtests of the Wechsler Intelligence Scale for Children (WISC-III-NL; Kort et al., 2005; $\alpha = .86$ for the combination of these subtests). The tasks were administered group-wise. Coding consisted of a key of digits 1 through 9 each paired with a unique symbol. Students were asked to write down the corresponding symbol for 119 randomly ordered digits. Symbol search consisted of strings of two symbols on the left and five symbols on the right. Students were asked to cross 'yes' or 'no' depending on whether one of the symbols on the left appeared in the string on the right. Students worked two minutes on each task. Scores consisted of the number of items correct.

Verbal memory

Verbal memory was assessed with digit span from the WISC-III-NL (Kort et al., 2005; $r = .63$). Students were presented with digit sequences, increasing in length from two to nine with two sequences of each length. They were asked to repeat the digits in the same or reversed order until they repeated both sequences of the same length incorrectly. Scores consisted of the number of sequences repeated correctly.

Analyses

To answer the research questions the data was analyzed using Structural Equation Modeling. Three regression models were specified, one for each of the languages under study (see Figure 1). In these simultaneous regression models, the effect of each predictor reflects the unique contribution of the predictor to the dependent variable, controlled for the (relations with) other predictors in the model. The predictors in the model were eight latent variables – that is, Dutch reading fluency, verbal intelligence, nonverbal intelligence, phonological awareness, alphanumeric RAN, nonalphanumeric RAN, visual processing speed, and verbal memory. The factor structure was the same as in Zeguers et al. (2018), so has already been shown to fit the data. The dependent variables were the four foreign language literacy skills. Because the latent factors do not contain error variance, regression analysis within SEM is less vulnerable to Type I errors (Westfall & Yarkoni, 2016).

The models were fitted with Mplus Version 7.11 (Muthén & Muthén, 1998–2012), using full information maximum likelihood estimation. To evaluate model fit we looked at the chi-square statistic of overall goodness of fit, the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). A chi-square p-value larger than .05 indicates exact fit (Hayduk, 1996). A CFI larger than .95 in combination with a SRMR below .08 indicates good approximate fit (Hu & Bentler, 1999). Values of the RMSEA below .05 indicate close fit, below .08 satisfactory fit, and values over .10 indicate poor fit (Browne & Cudeck, 1993).

Results

Foreign language literacy skills

Before running analyses, data were inspected for missing values and outliers. Some scores were missing due to the exclusion of native speakers from the analyses. In addition, some scores were missing because students were absent during one of the sessions. Scores that were more than three standard deviations from the group mean were considered outliers and were therefore coded as missing. The number of observations is different for each task, so the exact N for each task is presented with the descriptive statistics. In total, 1.7% of the data was missing for the tasks tapping literacy skills (ranging from 0.6% to 4.5% per task), and 2.8% for the predictors (ranging from 0.5 to 11.4% per task).

Descriptive statistics for the foreign language literacy skills are presented in Table 1. The mean scores on the foreign language literacy tasks differed across languages. In particular, scores tended to be higher for Spanish and French than for Chinese. In this study, however, we do not analyze the means, but aim to interpret individual differences through correlations between these literacy tasks and of these literacy tasks with the predictors. As there was sufficient variation in scores for all tasks, no floor or ceiling effects

were observed, and the scores on all tasks were normally distributed, correlations can be estimated reliably.

The correlations between the foreign language literacy tasks are presented in Table 2. Within each language the various literacy tasks were moderately correlated (r's between .40 and .60), with the exception of word and sentence vocabulary, which were correlated more strongly (r's > .70). Also, word reading in Chinese correlated strongly with vocabulary of both words and sentences in Chinese. Across languages, the literacy tasks were in general moderately correlated. Correlations tended to be highest between the same tasks in different languages, especially performance on the vocabulary tasks correlated strongly across languages. Surprisingly, word reading in Chinese was found to correlate moderately with the vocabulary tasks in the other languages and these correlations were higher than with word reading in the other languages.

### Predictors of foreign language literacy skills

Descriptive statistics and correlations for the predictors of foreign language literacy skills are presented in Table 3. Scores on all tasks were normally distributed. As expected, the strongest correlations were found between tasks used to measure the same skill. The correlations of the predictors with the foreign language literacy skills are presented in Table 4. These correlations are discussed per language and per literacy skill.

For Spanish, word reading correlated with Dutch reading fluency, phonological awareness, RAN, verbal memory, and one of the visual processing speed tasks. Sentence reading correlated with Dutch reading fluency, but in addition with two of the three verbal and nonverbal intelligence tasks. Word vocabulary also correlated with Dutch reading fluency, and the majority of verbal and nonverbal intelligence tasks. Sentence vocabulary correlated with verbal and nonverbal intelligence, verbal memory, and specifically with Dutch word reading. Surprisingly, both vocabulary tasks correlated significantly with RAN pictures. Significant correlations were also found for word vocabulary with coding and the backward task of verbal memory.

For French, word reading fluency correlated with Dutch reading fluency, verbal intelligence, and phoneme awareness. Weak correlations were also found with two of the three nonverbal intelligence tasks. Sentence reading fluency correlated weakly with two of the three verbal and nonverbal intelligence tasks. For vocabulary of words and sentences, verbal and nonverbal intelligence were again the strongest correlates, although for word vocabulary, weak correlations were also found with word reading in Dutch and with the backward task of verbal memory.

For Chinese, word reading correlated with at least one of the tasks of all the predictors included, but especially with Dutch reading fluency, verbal intelligence, and RAN. Sentence reading correlated only with visual processing speed. Word vocabulary correlated mainly with nonalphanumeric RAN and visual processing speed, but also with Dutch word reading, several intelligence tasks and the backward task of verbal memory. Finally, sentence vocabulary correlated with two of the three nonverbal intelligence tasks, with symbol search and with the backward task of verbal memory.

To examine the effects of these predictors on the various foreign language literacy outcomes, while controlling for their interrelations, we fitted three regression models to the data (see Figure 1). For Spanish, the model provided a good approximate fit to the data: $\chi^2(147) = 197.475$, $p = .004$, RMSEA = .043
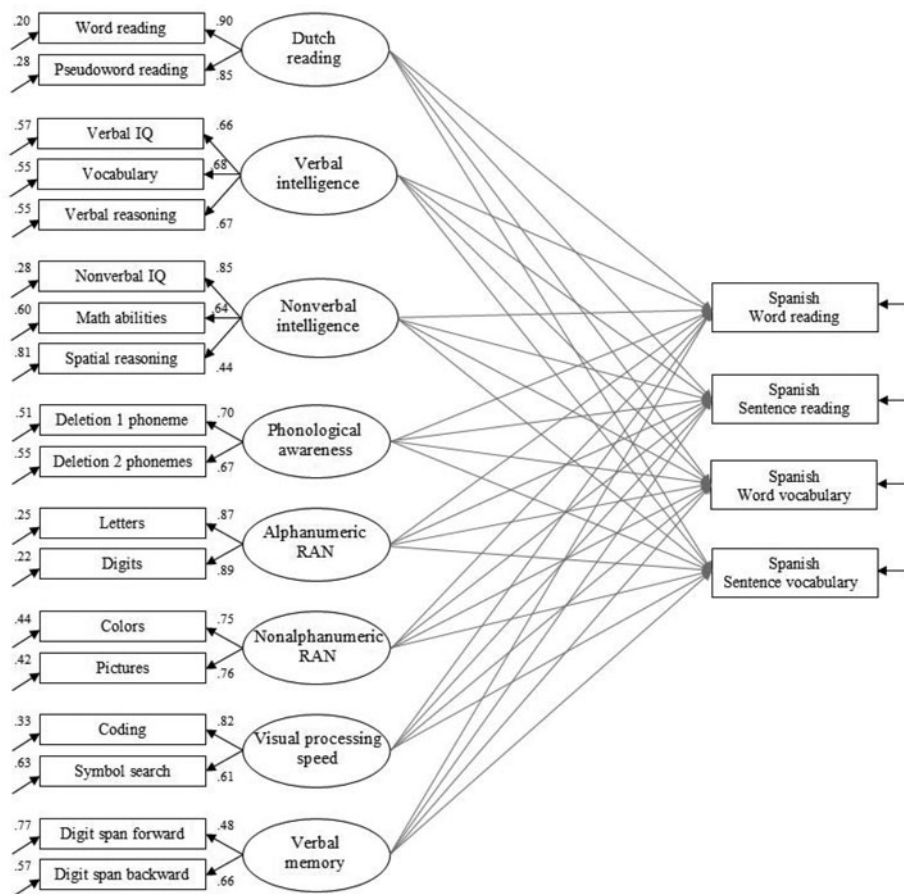
Figure 1. Example of the structural equation model fitted to the data for each language. Standardized factor loadings and residual variances for the predictors are taken from the model for Spanish. Estimates varied slightly for the other models. Standardized direct effects on and explained variance of the outcome measures are presented in Table 5. Correlations among the predictors and among the literacy skills were included in the analyses but are not presented for clarity purposes

[.026-.058], CFI = .960, SRMR = .055. The standardized direct effects are presented in Table 5. Dutch reading fluency was the only significant predictor of Spanish word reading fluency, whereas sentence reading fluency was predicted by both Dutch reading fluency and nonverbal intelligence. For word vocabulary, none of the predictors contributed significantly, whereas sentence vocabulary was predicted by nonverbal intelligence and verbal memory.

For French, the model provided a good approximate fit to the data: $\chi^2(147) = 202.076$, $p = .002$, RMSEA = .045 [.028-.060], CFI = .956, SRMR = .055. For sentence reading in particular, and for the other outcomes to a lesser extent, alphanumeric RAN had an effect on literacy skills that was in the unexpected direction; stronger alphanumeric RAN was associated with poorer literacy outcomes. This appeared to reflect a suppression effect, which can occur when a variable does not correlate with the dependent variable, but does correlate with one of the other independent variables (Maassen & Bakker, 2001). Suppression effects are reflected both in the regression coefficient of the suppressor variable, and in the regression coefficients of the predictors that are correlated with the suppressor variable. Since the correlations (Table 4) indicated that RAN did not correlate significantly with any of the literacy outcomes in French, alphanumeric RAN was excluded from the model, to avoid suppression effects and obtain reliable estimates of the effects of the other predictors. This alternative model also provided a good approximate fit to the data: $\chi^2(119) = 155.988$, $p = .013$, RMSEA = .041 [.020-.058], CFI = .962, SRMR = .052. The standardized direct effects of this model are presented in Table 5. Dutch reading fluency and verbal

intelligence were significant predictors of French word reading fluency, whereas nonverbal intelligence was the only significant predictor of sentence reading fluency. For vocabulary, verbal intelligence was the only significant predictor of word vocabulary, whereas sentence vocabulary was predicted by both verbal and nonverbal intelligence.

For Chinese, the model provided a good approximate fit to the data: $\chi^2(147) = 197.776$, $p = .003$, RMSEA = .043 [.026-.058], CFI = .959, SRMR = .056. Also for Chinese, significant suppression effects were found for alphanumeric RAN. This variable was therefore left out of the analysis. This alternative model also provided a good approximate fit to the data: $\chi^2(119) = 154.427$, $p = .016$, RMSEA = .040 [.018-.057], CFI = .963, SRMR = .053. The standardized direct effects of this model are presented in Table 5. When the suppression effects were controlled, Chinese word reading fluency was predicted by nonverbal intelligence and verbal memory, whereas sentence reading fluency was predicted by visual processing skills. Word vocabulary was not predicted significantly by any of the variables in the model, although the effect of verbal memory almost reached significance ($p = .053$). Sentence vocabulary was predicted significantly by nonverbal intelligence.

Discussion

In the current study we examined predictors of foreign language word reading, sentence reading, word vocabulary and sentence vocabulary in Dutch students who simultaneously acquired three foreign languages: transparent alphabetic Spanish,

Table 1. Descriptive Statistics for the Literacy and Vocabulary Tasks in Spanish, French and Chinese

	N	M (SD)	Range
Spanish			
Word reading	151	55.34 (11.99)	20–84
Sentence reading	151	28.48 (7.81)	9–48
Word vocabulary	152	12.49 (6.69)	0–30
Sentence vocabulary	150	18.28 (12.43)	0–50.5
French			
Word reading	151	42.54 (14.39)	10–82
Sentence reading	153	30.09 (7.78)	11–48
Word vocabulary	153	17.15 (8.14)	2–37
Sentence vocabulary	147	19.59 (14.39)	0–62.5
Chinese			
Word reading	112	15.82 (9.52)	0–39
Sentence reading	113	11.32 (3.29)	5–18
Word vocabulary	113	24.40 (11.38)	2–50
Sentence vocabulary	113	20.24 (9.12)	0–39

nontransparent alphabetic French, and nonalphabetic Chinese. We assessed their reading and cognitive skills at the start of foreign language acquisition and their performance on literacy skills after two years of foreign language instruction. The main research questions addressed similarities and differences in the influence of language and cognitive skills for the four different literacy skills, as well as the degree to which these are universal or language specific.

The effects of underlying language and cognitive skills on the different literacy skills, yielded three main conclusions. First, verbal and nonverbal intelligence were the strongest predictors of foreign language literacy skills. This finding may point out that foreign language literacy was taught in school and assessed with schoolrelated tasks and may therefore measure, at least partly, schoolrelated abilities. Alternatively, intelligence is specifically important in the initial stage of the acquisition of new skills. After one year of reading acquisition, intelligence appeared to have an important influence on the simple literacy skill word reading in all three foreign languages (Zeguers et al., 2018). Current findings indicate that one year later, the influence of intelligence on word reading was less pronounced, but intelligence was of major importance for the more advanced literacy skills sentence reading and vocabulary. In line with this assumption, intelligence has been found to be involved in early reading development in the native language (de Jong & van der Leij, 1999).

Second, our results point to intelligence as a predictor of foreign language sentence reading. This is in line with findings from native readers, indicating that the more complex task of sentence reading, as compared to word reading, requires comprehension in addition to word identification (Jenkins et al., 2000; Kim, 2015). In both French and Spanish, sentence reading was mainly predicted by nonverbal intelligence (i.e., reasoning skills), in addition to Dutch reading fluency for Spanish. In Chinese, there was an interesting difference between word and sentence reading, with word reading depending most strongly on verbal memory and

text reading on visual processing. This suggests that the simpler task of reading individual words allows addressing phonological properties of the characters, whereas the more complex task of reading whole sentences requires resorting to more superficial visual strategies.

Third, the processes underlying vocabulary acquisition seem different from the processes underlying reading in the three languages. In Spanish and French, phonological processes were found to be important for word reading, but not for word vocabulary, in line with previous findings for native as well as foreign readers (Engel de Abreu & Gathercole, 2012; Gathercole et al., 1991). These previous studies indicated that the relatively limited influence of phonological processing on vocabulary is accompanied by a relatively large influence of verbal memory. In the current study, verbal memory was indeed more strongly related to word vocabulary than word reading. However, verbal memory only had a unique effect on sentence level vocabulary in Spanish. Effects of intelligence appeared to be of greater importance than memory skills in the current sample, which may stem from the students' still limited foreign language experience. Possibly, the importance of verbal memory increases in later phases of literacy acquisition, when more word representations are stored in memory. Alternatively, the effect of verbal memory might become more visible in oral vocabulary tasks, rather than the written tasks used in the current study.

Furthermore, two findings relate to cross-linguistic differences. First, the relation between the Chinese literacy tasks and those in the other languages. Not only was the correlation between word reading and word vocabulary higher in Chinese than in the other languages, Chinese word reading also correlated more strongly with word vocabulary in French and Spanish than with word reading in those languages. In other words, word reading in Chinese acted more like a vocabulary task than a reading task. This might indicate that for native speakers of an alphabetic language who learn to read in a nonalphabetic language, literacy may develop in a character-by-character style – that is, learners either do or do not know a character. Once a character is known, all aspects, including visual, orthographic, phonological and semantic representations, are stored in memory. Consequently, the abilities to read and translate a given character could develop simultaneously.

Second, we observed clear cross-linguistic differences for one of the literacy measures, word reading. Spanish word reading correlated with several underlying language and cognitive skills, but only Dutch reading fluency had a unique effect. This suggests that when students learn to read words in a foreign language with a similar (alphabetic, transparent) structure as their native language, they can use the reading skills they had already acquired in Dutch to decode words in Spanish. In nontransparent alphabetic French, reading fluency and verbal intelligence exerted unique effects, indicating that when students are learning to read words in an orthography with a less transparent orthographic structure than their native language, they can use their native language reading skills, but also need to involve reasoning skills to decipher the unfamiliar letter-sound correspondences. For word reading ability in Chinese, a language with a nonalphabetic orthography, only verbal memory and nonverbal intelligence had a unique contribution. This suggests that when skilled readers in an alphabetic orthography learn to read in a nonalphabetic orthography, they use both linguistic and visual reasoning skills to make sense of the complex visual symbols. In sum, findings seem to indicate that the skills that exert unique contributions to foreign language word reading are largely language specific.

Table 2. Correlations Among the Literacy and Vocabulary Tasks in French, Spanish and Chinese

	1	2	3	4	5	6	7	8	9	10	11	12
Spanish												
1. Word reading	-											
2. Sentence reading	.406**	-										
3. Word vocabulary	.576**	.519**	-									
4. Sentence vocabulary	.483**	.454**	.725**	-								
French												
5. Word reading	.701**	.409**	.506**	.489**	-							
6. Sentence reading	.227**	.620**	.436**	406**	.443**	-						
7. Word vocabulary	.441**	.445**	.737**	.677**	.540**	.553**	-					
8. Sentence vocabulary	.377**	.366**	.639**	.724**	.541**	.519**	.752**	-				
Chinese												
9. Word reading	.567**	.415**	.659**	.622**	.423**	.249**	.586**	.524**	-			
10. Sentence reading	.144	.266**	.399**	.417**	.103	.251**	.394**	.270**	.514**	-		
11. Word vocabulary	.417**	.312**	.568**	.497**	.299**	.200*	.519**	.417**	.828**	.584**	-	
12. Sentence vocabulary	.386**	.203*	.521**	.465**	.334**	.248**	.509**	.511**	.707**	.349**	.703**	-
Note. ** $p < .01$; * $p < .05$												

Interestingly, the current findings on word reading skills after two years of reading instruction could be related to previously reported outcomes for word reading by the same participants at an earlier stage (i.e., after one year) of foreign language instruction (Zeguers et al., 2018). For Spanish, current findings were highly similar to the findings on word reading one year earlier. At both stages of language acquisition, word reading in Spanish is predominantly affected by language skills in the native language. Since the way speech sounds are represented in letters is quite similar in Spanish and Dutch, students may quickly be able to decode Spanish words rather efficiently. Consequently, they start to acquire orthographic knowledge of Spanish and start to identify words by sight, similar to the native language (Share, 1995).

For nontransparent alphabetic French, phonological awareness becomes less important, whereas Dutch reading fluency becomes more important after two years of reading instruction as compared to one year. This suggests that word reading in French initially relies heavily on decoding to acquire and use unfamiliar letter-sound connections. Yet with increasing foreign language skills, students increasingly employ direct word recognition, which means that their reading skills in a foreign language become more similar to the reading skills they already developed in their native language Dutch (e.g., Caravolas, Lervåg, Defior, Málková & Hulme, 2013; Geva et al., 2000; Share, 1995).

For word reading ability in Chinese, the influence of verbal intelligence is smaller after year two as compared to year one, whereas the influence of verbal memory is more pronounced. The increasing use of verbal memory skills for word recognition might be indicative of an enhanced ability to store Chinese words' phonological representations, or to utilize phonological processing skills, though not yet at the level of phonemes (i.e., no contribution was found of phonological awareness). These findings do align with the hypothesized developmental shift in Chinese reading processes, shown in native as well as foreign readers, from predominant visual-graphical processing in the initial learning phase, to the use of phonological cues when reading proficiency increases (Liu, Perfetti & Wang, 2006; Liu, Wang & Perfetti, 2007; Zhang & Perfetti, 1993). However, nonverbal intelligence also remained important, the learners in the current study seem to not yet have developed enough proficiency in Chinese to allow word recognition through phonological processes without interpretation of the visual cues of the characters.

These findings and interpretations should be viewed in the light of some important limitations to the current study. This study is one of the few studies that examine cognitive predictors of literacy outcomes in foreign language learners and is unique in studying three different foreign languages that are acquired simultaneously by the same group of participants. However, as

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Table 3. Descriptive Statistics and Correlations for the Predictors

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Dutch word reading	—																	
2. Dutch pseudoword reading	.747*	—																
3. Verbal IQ	.196*	.073	—															
4. Dutch vocabulary	.161*	.033	.371*	—														
5. Verbal reasoning	.138	.074	.505*	.454*	—													
6. Nonverbal IQ	.039	−.015	.165*	.253*	.222*	—												
7. Math abilities	.071	.097	.068	.238*	.177*	.533*	—											
8. Spatial reasoning	−.240*	−.238*	.170*	.119	.079	.391*	.233*	—										
9. Deletion 1 phoneme	.370*	.350*	.029	.144	.107	.026	.036	.024	—									
10. Deletion 2 phonemes	.307*	.344*	.066	.060	.098	.024	−.017	−.071	.463*	—								
11. RAN letters	.477*	.417*	−.175*	−.119	−.026	−.108	−.052	−.194*	.220*	.166*	—							
12. RAN digits	.530*	.461*	−.177*	−.155*	−.026	−.027	−.031	−.288*	.246*	.160*	.747*	—						
13. RAN colors	.416*	.333*	−.068	−.018	.065	−.030	.041	−.087	.241*	.237*	.458*	.487*	—					
14. RAN pictures	.423*	.329*	−.004	.038	.133	.059	.027	−.023	.261*	.174*	.383*	.418*	.564*	—				
15. Coding	.217*	.189*	−.029	.008	.194*	.145	.154*	−.014	.037	.044	.268*	.260*	.266*	.285*	—			
16. Symbol search	.121	.072	.073	−.061	.150*	.150	.103	.134	.052	.027	.255*	.150*	.205*	.206*	.502*	—		
17. Digit span forward	.125	.146	−.089	.092	.023	.022	.022	−.089	.138	.168*	.117	.077	.082	.198*	−.030	−.086	—	
18. Digit span backward	.168*	.179*	−.026	.088	.189*	.081	.092	−.035	.108	.201*	.137	.130	.165	.315*	.164*	.117	.309*	—
N	184	182	164	182	180	164	182	180	183	182	181	183	182	184	179	180	183	182
M	87.08	74.46	109.26	241.85	13.77	111.50	240.43	18.12	16.63	8.98	2.54	2.35	1.37	1.28	52.41	32.46	8.28	5.54
SD	11.78	15.11	11.24	25.53	5.30	10.70	14.60	4.57	6.66	4.54	0.37	0.44	0.25	0.20	10.40	5.05	1.45	1.61
Min.	52	38	84	167	0	87	197	6	1.05	0.00	1.56	1.22	0.70	0.81	26	18	5	2
Max.	116	116	138	315	28	140	274	28	33.40	23.01	3.57	3.57	2.08	1.85	79	43	12	10

Note. * $p < .05$

Table 4. Correlations of Cognitive Skills with Literacy and Vocabulary Tasks in French, Spanish and Chinese

	Spanish				French				Chinese			
	Reading		Vocabulary		Reading		Vocabulary		Reading		Vocabulary	
	Word	Sentence	Word	Sentence	Word	Sentence	Word	Sentence	Word	Sentence	Word	Sentence
Dutch word reading	.525**	.270**	.197*	.174*	.364**	.110	.167*	.102	.320**	.059	.220*	.029
Dutch pseudoword reading	.531**	.236**	.204*	.142	.336**	.087	.145	.069	.250**	−.015	.175	.093
Verbal IQ	.116	.233**	.136	.307**	.289**	.183*	.227**	.269**	.164	.143	.147	.012
Dutch vocabulary	.118	.229**	.233**	.396**	.327**	.190*	.300**	.315**	.151	.074	.104	.125
Verbal reasoning	.130	.024	.206*	.276**	.358**	.038	.175*	.261**	.218*	.113	.246*	.167
Nonverbal IQ	.073	.272**	.224*	.243**	.183*	.188*	.204*	.250**	.302**	.180	.263**	.235*
Math abilities	.109	.214**	.185*	.182*	.191*	.227**	.239**	.272**	.200*	.077	.191*	.161
Spatial reasoning	−.094	−.032	.053	.198*	.058	.030	.058	.212*	.029	−.002	.030	.234*
Deletion 1 phoneme	.262**	.055	.120	.134	.204*	.015	.033	.089	.138	.072	.079	.129
Deletion 2 phonemes	.301**	.083	.104	.144	.308**	.121	.092	.146	.212*	−.056	.108	.114
RAN letters	.343**	.028	.109	.047	.106	−.067	.015	.011	.219*	.028	.117	−.012
RAN digits	.270**	.006	.017	−.055	.037	−.130	−.121	−.138	.031	−.067	−.036	−.187
RAN colors	.306**	.044	.127	.098	.104	.104	.063	.100	.269**	.009	.257**	.147
RAN pictures	.284**	.048	.166*	.180*	.100	.069	.005	.056	.241*	.074	.191*	.111
Coding	.199*	.048	.224**	.079	.093	.023	.108	.154	.185	.210*	.197*	.037
Symbol search	.112	−.009	.111	.009	−.019	−.017	−.015	.117	.208*	.236*	.272**	.203*
Digit span forward	.180*	.086	.101	.222**	.054	−.052	.030	.089	.128	.058	.064	.028
Digit span backward	.239**	.142	.209*	.215**	.152	.037	.164*	.101	.355**	.142	.289**	.198*

Note. **$p < .01$; * $p < .05$.

Table 5. Standardized Direct Effects in the Final Models

	Spanish				French				Chinese			
	Reading		Vocabulary		Reading		Vocabulary		Reading		Vocabulary	
	Word	Sentence	Word	Sentence	Word	Sentence	Word	Sentence	Word	Sentence	Word	Sentence
Native language reading	.614**	.516**	.210	.093	.333**	.024	.230	−.037	.103	−.063	−.014	−.224
Verbal intelligence	−.002	.036	.150	.366**	.345**	.097	217*	.306**	.135	.119	.184	.122
Nonverbal intelligence	.073	.217*	.109	.122	.130	.224*	.189	.220*	.248*	.058	.177	.252*
Phonological awareness	.072	−.176	−.038	−.038	.219	.036	−.078	.115	.019	.012	−.040	.173
Alphanumeric RAN	−.103	−.168	−.169	−.136	-	-	-	-	-	-	-	-
Nonalphanumeric RAN	−.046	−.175	−.039	.064	−.195	.130	−.193	−.044	.132	−.150	.154	.164
Visual processing speed	.035	−.011	.214	.010	−.025	−.098	.014	.113	.041	.363*	.154	.026
Verbal memory	.197	.204	.231	.300*	.069	−.066	.197	.061	.304*	.158	.240	.131
R^2	.463	.229	.232	.374	.423	.078	.202	.256	.365	.179	.296	.205

Note. ** $p < .01$; * $p < .05$

a result, the study is mostly exploratory in nature, as few specific hypotheses could be deduced from the literature and no standardized tests were available to measure the foreign language skills of this particular group of participants. Consequently, we chose latent variable multiple regression, as this procedure allows to minimize error variance (i.e., decrease the chance of a type I error) and take into account interrelations among language and cognitive predictors, when determining which skill(s) is/are most important for the acquisition of foreign language literacy skills. Future studies are needed to develop standardized, more validated tests to measure foreign language literacy skills in teenagers, as these would allow the comparison of mean scores or growth rates across different languages, in addition to the individual differences in learning central to the current study. Moreover, with increasing knowledge of the acquisition of literacy skills across languages, future studies could test directly and more specifically crosslinguistic differences, as well as individual differences – using, for example, Bayesian or linear mixed effects models.

Additionally, knowledge about the processes involved in the acquisition of sentence level reading and vocabulary across foreign languages is scarce. The current study shows that predictors selected on the basis of literature on word reading are of limited importance for other literacy skills – specifically, vocabulary. Previous studies on predictors of vocabulary development focused mainly on young children both in the native language (e.g., Fernald, Marchman & Weisleder, 2013; Hoff, 2003; Rowe, 2012) and foreign language (e.g., Duursma et al., 2007; Leseman, 2000; Poulin-Dubois, Bialystok, Blaye, Polonia & Yott, 2013; Uchikoshi, 2006). Consequently, characteristics of caretakers and the home environment are predominantly examined as predictors. This is very different from the situation of the large and increasing group of learners who learn foreign languages at a later age. Although the development of vocabulary itself is sometimes studied for this population (e.g., David, 2008; Laufer, 1998), little is known about the cognitive predictors influencing vocabulary development. Therefore, it seems highly relevant to devote future studies to skills involved in the development of broad literacy skills in different foreign languages.

Moreover, it is difficult to study emerging literacy skills in foreign languages as these skills build on existing language and literacy skills in the native language, in the specific foreign language and in other foreign languages mastered. It seems important to account explicitly for these native language as well as foreign language skills. In the current study we included only a basic measure of reading fluency in the native language. We did not take into account proficiency in other literacy skills in the native language(s), thereby preventing conclusions about the impact of native language literacy on the development of foreign literacy skills. Students in the current study all spoke Dutch, but often also spoke another language at home. In addition, they all spoke English and were being offered classes in German, Latin and/or Greek at school in addition to the languages under study. Previous research suggests that processes involved in foreign language acquisition are different for learning a second language, than for learning a third, or fourth language (e.g., Adesope, Lavin, Thompson & Ungerleider, 2010; Cenoz, 2013; Dewaele, 2001). It seems important, yet hardly possible, to account explicitly for skills in all these other languages.

To conclude, different foreign language literacy skills, including sentence reading and vocabulary at the word and sentence level, appeared to be scarcely influenced by the cognitive skills involved in word reading. The relatively large importance of intelligence for these skills might indicate the involvement of academic reasoning for the acquisition of new knowledge and skills. In light of the large and increasing group of people that acquire literacy in one or more foreign languages after achieving proficient literacy skills in their native language, current knowledge of these foreign language literacy acquisition processes is remarkably scarce. Hence the current findings may function as a starting point for future studies that focus on multiple foreign languages and various literacy components, including a broader range of predictors in the native as well as foreign languages.

The findings on word reading were most clear. Word reading in foreign languages seems to be increasingly based on native language reading skills. Although this developmental pattern appears to be universal, the stage at which native language reading skills can be effectively employed for foreign language word reading seems to be reached earlier for foreign languages with a smaller orthographic distance to the native language (in line with Cummins, 2000, 2007). For languages with a large orthographic distance, i.e., with a completely different script, native language reading skills are still of limited importance after two years of instruction and general reasoning skills remain most influential. Findings thus underscore the importance of studying different stages of foreign language acquisition and suggest that teaching strategies may need to be adapted to the specific learning stage of students.

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