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Universal and Language-Specific Predictors of Early Word Reading in a Foreign Language: An Analysis of the Skills That Underlie Reading Acquisition in Three Different Orthographies

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A central question in the field of foreign language acquisition is whether the processes involved in reading development in a foreign language are universal or dependent on characteristics of the specific language involved. We investigated the impact of orthographic depth and writing system on word reading acquisition in a foreign orthography, by studying children who are proficient readers in the transparent alphabetic Dutch orthography and who learn to read simultaneously in the transparent alphabetic Spanish orthography, the nontransparent alphabetic French orthography and the nonalphabetic Chinese orthography. Results showed that the skills that underlie foreign language word reading are not universal, but are different for alphabetic and nonalphabetic orthographies, and are also different for transparent and nontransparent alphabetic orthographies, albeit to a lesser extent. 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. Findings thus suggest that the processes underlying foreign language word reading acquisition are not universal but rather depend on the specific language involved.

Keywords: reading acquisition, foreign language learning, Chinese, orthographic depth, writing system

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The ability to read and write in more than one language is highly relevant, as it facilitates communication and access to information across cultures and countries. Consequently, bilingualism is the norm rather than the exception in most countries. An increasing number of people master even more than one foreign language or learn a foreign language with a different writing system than their native langue. It is therefore not surprising that scientific interest in foreign language acquisition increased sharply during past decades (Sparks, Patton, Ganschow, Humbach, & Javorsky, 2008).

The vast majority of studies investigated the acquisition of a foreign alphabetic orthography, either by native speakers of another language with an alphabetic orthography (e.g., Lindsey, Manis, & Bailey, 2003) or, to a lesser extent, by native speakers of a language with a nonalphabetic orthography (e.g., Pan et al., 2011). Studies that addressed the acquisition of a nonalphabetic orthography by native speakers of a language with an alphabetic orthography, however, are scarce, and none investigated the cognitive skills that underlie reading acquisition. Consequently, it is unclear which cognitive processes are involved when skilled readers of an alphabetic orthography learn to read in a foreign nonalphabetic orthography and whether these processes are similar to or different from the processes that underlie learning to read in a foreign alphabetic orthography. Therefore, the current study investigates which cognitive skills are involved when readers of an alphabetic writing system (Dutch) learn to read words in a foreign language with a nonalphabetic writing system (Chinese) and also in two foreign languages with alphabetic writing systems (Spanish and French).

Theoretical Perspectives on Foreign Language Acquisition

A pressing question in the field of foreign language acquisition is whether the processes involved in reading development in a foreign language are universal or dependent on the specific language involved. Theories on reading acquisition in a foreign language have provided different perspectives on this issue. According to the Interdependence hypothesis (Cummins, 1979, 1984, 1991), the level of competence that a reader achieves in a foreign language (L2) is a function of the competence that has been developed in the native language (L1). More specifically, L1

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reading skills serve as the foundation for L2 reading acquisition, and L2 reading proficiency is thus dependent on reading proficiency in L1. A related hypothesis, the linguistic coding differences hypothesis (Sparks & Ganschow, 1991, 1993, 1995) also stresses the commonalities between L1 and L2 but focuses on the cognitive skills that underlie reading development. This hypothesis is based on the assumption that a common "core" language component, consisting of phonological, orthographic, syntactic, and semantic skills underlies reading acquisition across languages (Kahn-Horwitz, Shimron, & Sparks, 2005). Skills in L1 are assumed to provide the foundation for L2 learning. Consequently, the underlying skills that are essential for reading in L1 are also important for learning to read in L2.

Because the linguistic coding differences hypothesis assumes that the same core language component underlies reading acquisition in all languages, this suggests that the influence of component skills on reading acquisition in foreign languages is universal and does not differ across languages. A contrasting view is proposed by the script-dependent hypothesis (Geva & Siegel, 2000; Geva & Wade-Woolley, 1998). This hypothesis suggests that the cognitive skills that contribute to foreign language reading acquisition depend on characteristics of the specific language that is to be learned, such as the transparency with which the spoken language is represented in written form.

In the current study, we focus on native language reading and cognitive skills, and examine whether their effect is the same or different for the foreign languages studied. We investigate whether native language reading skills or cognitive skills that underlie reading in the native language are most important for learning to read in a foreign language, thereby differentiating between the interdependence hypothesis and the linguistic coding differences hypothesis. In addition, we investigate to what extent the cognitive skills involved in foreign language reading development are universal or different for different foreign languages. Thereby, we aim to distinguish between the linguistic coding differences hypotheses and the script-dependent hypothesis.

Research trying to disentangle universal and language specific contributions to reading development in a foreign language has generally adopted multiple group designs. A disadvantage of these group comparisons is that participants may differ on more variables than their native language, including amount and type of reading instruction, L2 oral proficiency, and metacognitive awareness. Therefore, in the current study, we investigated reading acquisition in different orthographies within the same group of participants.

Linguistic Characteristics of the Foreign Languages

Two important characteristics of languages that may influence the processes involved in reading development are the language's writing system and orthographic consistency. The writing system indicates the structure that is used to reflect spoken language in written form. The languages in the current study, Spanish and French, as well as the participants' native language, Dutch, have alphabetic writing systems, whereas Chinese has a morphosyllabic writing system. Alphabetic writing systems consist of a restricted number of visual linear symbols (letters), which represent the sound structure of the language. Learning to read requires mastering the letter–sound mappings and the exceptions to these mappings. Morphosyllabic systems, in contrast, contain several thousand symbols (characters), which are visually complex and do not reflect the language's phonetic speech structure (DeFrancis, 1989; Mattingly, 1992). In the case of Chinese, most characters consist of at least two components and contain information about both the pronunciation at the syllable level and the meaning at the morpheme level. However, the clues about pronunciation are not always consistent and sometimes even misleading (Shu, Chen, Anderson, Wu, & Xuan, 2003). Learning to read in Chinese occurs, therefore, in a more holistic, rather than phonetic analytic, manner (Hanley, Tzeng, & Huang, 1999; Shu & Anderson, 1997).

The second characteristic of languages, orthographic consistency, refers to the consistency with which symbols correspond to speech sounds. In the current study, although Spanish and French have the same (alphabetic) writing system, they differ in the degree of orthographic consistency. Spanish is orthographically transparent, indicating that a given letter is generally pronounced identically across words. In contrast, French is orthographically nontransparent, with less consistent correspondences between letters and speech sounds. The native language of the participants, Dutch, is considered to be orthographically transparent, although somewhat less transparent than Spanish (Seymour, Aro, & Erskine, 2003). By investigating the simultaneous acquisition of Spanish, French, and Chinese by the same participants, the current study allows investigating to what degree different native language and cognitive skills are universal predictors of foreign language acquisition, or whether their influence depends on the language's writing system and orthographic consistency.

Reading Acquisition in Native Speakers of Languages With Alphabetic Orthographies

Most studies on the skills that underlie reading acquisition focused on children who learn to read an alphabetic orthography as their native language. Across orthographies, two cognitive skills appear to be most influential in predicting reading development. These are phonological awareness, which denotes sensitivity to the sound structure of words, and rapid automatized naming (RAN), reflecting the ability to quickly name a set of highly familiar stimuli (e.g., Caravolas et al., 2012; Moll et al., 2014; Ziegler et al., 2010). Other cognitive skills that have been found to contribute are vocabulary (Nation & Snowling, 2004; Ziegler et al., 2010), letter–sound knowledge (Caravolas et al., 2012; Foulin, 2005), orthographic processing skill (Cunningham, Perry, & Stanovich, 2001; Leslie & Thimke, 1986), and verbal short-term memory (STM; Landerl & Wimmer, 2008; Swanson, Zheng, & Jerman, 2009).

With respect to the impact of orthographic depth on the strength of various cognitive predictors, findings are inconclusive. Some studies report equal impact of phonological awareness across orthographies (Caravolas, Lervåg, Defior, Seidlová Málková, & Hulme, 2013; Patel, Snowling, & de Jong, 2004), whereas others suggest that phonological awareness is more important in transparent than nontransparent orthographies (Georgiou, Parrila, & Papadopoulos, 2008; Mann & Wimmer, 2002; Moll et al., 2014). Similarly, RAN has been found to be of equal influence in different orthographies by some researchers (Caravolas et al., 2013; Patel et al., 2004; Vaessen et al., 2010; Ziegler et al., 2010), whereas others report RAN to be more important in transparent than nontransparent orthographies (Georgiou, Parrila, & Liao, 2008; Mann & Wimmer, 2002). The influence of phonological awareness and RAN has been attributed to different component processes of reading, with phonological skills being most strongly related to accurate decoding and RAN to reading fluency (Kirby et al., 2010; Moll et al., 2014; Swanson, Trainin, Necoechea, & Hammill, 2003). Consequently, phonological awareness seems to be most important for initial reading acquisition, whereas the contribution of RAN may increase during reading development (Caravolas et al., 2013; de Jong & van der Leij, 1999; Vaessen et al., 2010). Because readers of nontransparent orthographies take longer to become accurate decoders than readers of transparent orthographies (e.g., Seymour et al., 2003), phonological awareness has been suggested to exert a stronger and longer lasting influence in these nontransparent orthographies (Swanson et al., 2003; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997), whereas the influence of rapid naming is more modest (Parrila, Kirby, & McQuarrie, 2004; Powell, Stainthorp, Stuart, Garwood, & Quinlan, 2007).

Reading Acquisition in Native Speakers of Chinese

Because Chinese characters do not map onto phonemes as letters in alphabetic languages do, it has been questioned whether phonological awareness is involved in Chinese reading acquisition. Most research in Chinese children who learn to read in their native language has shown that, similar to alphabetic orthographies, phonological awareness is an important skill underlying reading acquisition (Ho & Bryant, 1997; McBride-Chang & Kail, 2002; Zhou, Duff, & Hulme, 2015). Rapid naming has also been identified as an important predictor of Chinese reading ability (Liao, Georgiou, & Parrila, 2008; McBride-Chang, & Kail, 2002; Pan et al., 2011; Yeung et al., 2011), and verbal memory has been found to contribute as well (Ho, 1997; So & Siegel, 1997). In fact, the effects of various cognitive predictors on reading development appeared rather similar in Chinese and English beginning readers (McBride-Chang & Kail, 2002). Despite these similarities, a recent meta-analysis (Song, Georgiou, Su, & Hua, 2016) suggests that the influence of phonological awareness may be somewhat smaller in Chinese than in alphabetic orthographies whereas the influence of RAN is of similar strength across writing systems.

Interestingly, visual skills is a category of skills that is of limited importance for alphabetic word reading, but has been identified as a predictor of reading acquisition in Chinese. Among the visual skills related to Chinese are visual discrimination, visual form recognition, visual closure, visual–spatial reasoning, picture copying, and visual–spatial attention (Huang & Hanley, 1995; Liu, Chen, & Chung, 2015; Siok, Spinks, Jin, & Tan, 2009). Visual skills seem to be especially important during the initial stages of reading development (Ho & Bryant, 1997; Siok & Fletcher, 2001). In sum, although findings from both native speakers of alphabetic languages and nonalphabetic languages like Chinese are not yet unequivocal, they suggest that some predictors of reading acquisition are universal, whereas other predictors may be language specific, and both orthographic depth and writing system appear to influence the strength of certain predictors on children's reading acquisition in their native language.

Reading Acquisition in a Foreign Language

Research on the acquisition of reading skills in a foreign orthography has predominantly focused on native speakers of languages with alphabetic orthographies who learn to read in other alphabetic orthographies. A central aim in this research is to identify whether the cognitive skills that are essential for reading in L1 are also important for L2 reading acquisition. Most studies focused on phonological awareness and RAN and showed that these skills, measured in both L1 and L2, predict reading development in L2 (Geva & Yaghoub-Zadeh, 2006; Geva, Yaghoub-Zadeh, & Schuster, 2000; Lindsey et al., 2003). Research on other cognitive skills has not yet converged to unambiguous results. Skills that have been shown to correlate between L1 and L2 are verbal memory (Comeau, Cormier, Grandmaison, & Lacroix, 1999; Geva & Siegel, 2000, but see Lindsey et al., 2003), orthographic knowledge (Sun-Alperin & Wang, 2011), oral language proficiency (Lindsey et al., 2003; Manis, Lindsey, & Bailey, 2004) and letter knowledge (Durgunoğlu, Nagy, & Hancin-Bhatt, 1993; Lindsey et al., 2003). In addition, word reading skills in L1 are generally directly related to word reading in L2, which indicates that the more proficient readers in their native alphabetic language, tend to perform better in reading a foreign alphabetic language as well (Bialystok, Luk, & Kwan, 2005; Geva & Siegel, 2000; Lindsey et al., 2003).

The few studies that focused on the skills that underlie cross-writing system literacy acquisition mainly investigated native speakers of Chinese who learn to read in English. It has been suggested that transfer of literacy related cognitive skills is limited to bilinguals whose L1 and L2 have the same writing system (Bialystok et al., 2005). However, several studies indicate that, similar to transfer between two alphabetic orthographies, phonological awareness in Chinese predicts reading development in English (Gottardo, Yan, Siegel, & Wade-Woolley, 2001; Pan et al., 2011; Wang, Perfetti, & Liu, 2005). There is also evidence for cross-writing system effects of RAN (Geva et al., 2000; Pan et al., 2011). Research on the cross-writing system transfer of other cognitive skills is scarce. Some studies report influences of Chinese orthographic processing skills on English word reading (Leong, Hau, Cheng, & Tan, 2005; Tong & McBride-Chang, 2010), whereas others do not find an effect for orthographic skills (Gottardo et al., 2001; Wang et al., 2005). Similarly, although in some studies a relation is found between Chinese and English word reading (Wang, Cheng, & Chen, 2006), word reading skills in Chinese are generally not found to be predictive of word reading in English (Bialystok et al., 2005; Gottardo et al., 2001; Wang et al., 2005). In sum, there is still quite some uncertainty about the degree to which literacy skills and related cognitive skills transfer between L1 and L2 and whether this transfer is influenced by the orthographic depth and especially the writing system of the languages involved.

Research Questions

In the current study, we aimed to clarify to what extent native language and cognitive skills involved in word reading acquisition in a foreign language are universal or depend on the writing system and orthographic transparency of the language concerned. We included language and cognitive skills on the basis of the research reviewed earlier and specified three research questions:

Research Question 1: Are the effects of native language and cognitive skills on foreign language word reading acquisition universal or different for alphabetic and morphosyllabic orthographies?

Research Question 2: Are the effects of native language and cognitive skills on foreign language word reading acquisition similar or different for transparent and nontransparent alphabetic orthographies?

Research Question 3: Do underlying cognitive skills have a specific effect on word reading acquisition in each of the three foreign languages under study, or is their effect due to a relation with native language reading skills?

Method

Participants

Participants were 185 students (83 boys) attending the first year of secondary education (seventh grade) at a high school in an urban area in the Netherlands. All the students attending Grade 7 were included; no specific in- or exclusion criteria were applied. Their mean age was 12 years and 4 months (SD = 5.19 months) at the start of the study. In the Netherlands, secondary education is provided in different levels. Participants were all in the highest two levels (top 50%), meaning that they were average to above-average students. They were provided with Dutch–English bilingual education. In addition, they received classes in three different foreign languages—Spanish, French, and Chinese—as part of their curriculum. For each of these languages, students had two 50-min classes per week. In this study, the students' reading development in these languages was assessed during the first 10 months of foreign language learning.

Although it is common for secondary school students in the Netherlands to be studying multiple foreign languages, the emphasis on foreign language learning at the participating school is above average for Dutch standards. The typical Dutch curriculum for Grade 7 includes English and French and sometimes German. The curriculum at the participating school thus included at least one more foreign language and also differed in the specific languages offered. In addition, all students had to master the English language to be eligible for entering this school. As a result, the school attracts students interested in foreign language learning, a relatively large percentage of them with a multilingual or multinational background. Although all participants were fluent in Dutch and most participants (97.8%) spoke Dutch at home, many children (40.5%) also spoke another language with their families. Children who spoke one of the foreign languages under study at home were allowed to participate in the study, yet their data were removed from the analyses of the specific language they already mastered at school entry (see the Data Cleaning section).

Measures

Foreign language skills. We administered a Spanish, French, and Chinese word translation task at the beginning of the study, to determine whether children already mastered one of these languages. These tasks were designed for the current study. Stimuli were selected from the glossary of the first year curriculum. The study books used in the language classes contained word lists of all the words taught in the first year. These lists consisted of words that appeared in the study books and had to be memorized by the students as part of the curriculum. For each of the three foreign languages, items from the word list of that particular study book were divided over the translation and word reading fluency tasks. The set of items in both the translation task and word reading task 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 translation tasks aimed to measure whether students already knew the words they would be studying in class before classes started. Students were presented with a list of words of increasing difficulty (i.e., the order of presentation in their study books) and were asked to read the words and translate as many of them to Dutch as possible within 3 min. The Spanish and French versions consisted of 96 words each. The Chinese version consisted of 60 single- or multicharacter words in simplified script. The score for each task was the number of words that were translated correctly to Dutch. Parallel forms reliability in the current sample was .80 for French, .85 for Spanish, and .80 for Chinese. The items of the translation tasks for each of the three foreign languages is are presented in Table 2 in Appendix.

Foreign language word reading fluency. Children were administered a Spanish, French, and Chinese word reading task to measure reading fluency. Similar to the translation task, the items in the word reading tasks were selected from the study books of the students. The tasks were modeled after Dutch standardized reading tasks (see also the Dutch reading fluency section) in both form and task instruction. Similar to the Dutch word reading task, children were presented with a list of words of increasing difficulty that they were asked to read aloud as quickly and accurately as possible for 1 min. The Spanish and French versions consisted of 96 words each. The Chinese version consisted of 60 single- or multicharacter words in simplified script. The fluency scores were the number of words read correctly within 1 min. Parallel forms reliability in the current sample was. Eighty-nine for French, .88 for Spanish, and .75 for Chinese. The items of the word reading tasks for each of the three foreign languages is are presented in Table 2 in Appendix.

Dutch reading fluency. Reading fluency in Dutch was measured with two standardized reading tests regularly used in Dutch schools to measure reading achievement.

Word reading. Word reading was assessed with the One-Minute Test (*Eén Minuut Test*; Brus & Voeten, 1995; r = .89–.92). Children read aloud a list of 116 words of increasing difficulty as quickly and accurately as possible for 1 min. The score was the number of words read correctly.

Pseudoword reading. Pseudoword reading was assessed with the Klepel test (van den Bos, lutje Spelberg, Scheepstra, & de Vries, 1994; r = .91). Children read aloud a list of 116 pseudowords of increasing difficulty as quickly and accurately as possible for 2 min. The score was the number of pseudowords read correctly.

Cognitive skills. Seven cognitive skills were included in the study. Two or three measures were included to assess each of these skills, amounting to a total of 16 tasks. These tasks were all administered in Dutch.

Verbal intelligence. Verbal intelligence was examined with subtests of three different tests for intelligence or academic learning potential: the verbal scale of the Dutch intelligence test of educational level (*Nederlandse Intelligentietest voor Onderwijsniveau* [NIO]; van Dijk & Tellegen, 2004; $\lambda^2 = .91$), the subtest Dutch vocabulary from the Cito Test 0 (van Til & van Boxtel, 2015; $\alpha = .73$), and the subtest verbal reasoning from the General Aptitude Test Battery (van der Flier & Boomsma-Suerink, 1990; $r = .74–.78$).

Verbal IQ. The NIO verbal scale includes three subtests: synonyms, analogies, and categories. For each of these subtests children are asked to answer multiple choice questions as quickly and accurately as possible for 5 min. Based on the performance on these subtests a standardized score is calculated with a mean of 100 and a standard deviation of 15.

Dutch vocabulary. Cito Test 0 comprised six tasks, with a maximum duration of 50 min per task. The subtest Dutch vocabulary consisted of 50 multiple choice items. The number of items correct is converted to a scaled score. This scaled score can be used to compare scores across tests and school years, although this was not done in the current study.

Verbal reasoning. Children were presented with four words. They were asked to choose two words that were either synonyms or antonyms. The test consisted of 50 items. Children were asked to complete as many items as possible within 4 min. The score consisted of the number of items correct.

Nonverbal intelligence. Nonverbal intelligence was examined with subtests from the same tests as used for verbal intelligence: the symbolic scale from the NIO (van Dijk & Tellegen, 2004; $\lambda^2 = .92$), the subtest math from the Cito Test 0 (van Til & van Boxtel, 2015; $\alpha = .87$), and the subtest spatial reasoning from the General Aptitude Test Battery (van der Flier & Boomsma-Suerink, 1990; $r = .74–.75$).

Nonverbal IQ. The symbolic scale of the NIO consisted of three subtests: numbers, math, and figures. The duration of each of these subtests was 10 min (15 min for math). Based on the performance on these subtests a standardized score was calculated with a mean of 100 and a standard deviation of 15.

Math abilities. The subtest mathematics consisted of 68 multiple choice items. The number of items correct was converted to a scaled score.

Spatial reasoning. Children were presented with a target picture of a two-dimensional figure that included folding lines. They were asked to choose from among four options the three-dimensional figure that could be created by folding the target figure. The task consisted of 40 items. Children were asked to answer as many items as possible within 4 min. The score consisted of the number of items correct.

Phonological awareness. To assess phonological awareness we used a computerized version of a phoneme deletion task (de Jong & van der Leij, 2003), programmed in E-prime (Schneider, Eschman, & Zuccolotto, 2002). The task consisted of two parts for which separate scores were calculated. Internal consistency could not be calculated for the fluency scores, but was calculated for accuracy and speed separately. In the current sample, internal consistency was .64 for accuracy and .83 for speed.

Phoneme deletion: One phoneme. Children heard a bisyllabic nonword (e.g., *memslos*). Next, they heard the nonword again, but were asked to delete one phoneme (e.g., "What is *memslos* without 'l'?"). The task consisted of nine items. When the participant had answered the experimenter pressed the space bar to register reaction time (RT) and indicated whether the answer was correct or incorrect. The score was calculated as suggested by van Bergen, Bishop, van Zuijen, and de Jong (2015) to account for high accuracy rates and skewed RTs on this particular task. The median RT was converted to the number of items answered per minute and multiplied by the proportion of items correct to obtain a fluency score (i.e., items correct per minute).

Phoneme deletion: Two phonemes. Following the same procedure as for the deletion of one phoneme, children were presented with nine bisyllabic nonwords in which the phoneme to be deleted occurred twice (e.g., "What is *gepgral* without 'g'?").

Rapid automatized naming (RAN). RAN performance was measured with four subtests of the Test of Continuous Naming and Word Reading (*Continu benoemen en woorden lezen;* van den Bos & lutje Spelberg, 2007). A distinction was made between alphanumeric and nonalphanumeric RAN, because previous research indicated that performance on these two types of RAN tasks diverge after the age of 10 (van den Bos, Zijlstra, & lutje Spelberg, 2002; van den Bos, Zijlstra, & van den Broeck, 2003).

Alphanumeric RAN. Alphanumeric RAN was measured with the subtests digit naming ($r = .78–.91$) and letter naming ($r = .82–.85$). Five digits (2, 4, 5, 8, 9) were presented 10 times each in a semirandom order in five columns of 10 items each. Children were asked to name aloud all 50 digits as quickly and accurately as possible. The experimenter recorded the time needed to name all digits, which was converted to the number of items named per second. Naming of letters (a, d, o, p, s) was administered in the same way.

Nonalphanumeric RAN. Nonalphanumeric RAN was measured with the subtests color naming (black, blue, green, red, yellow; $r = .71–.82$) and picture naming (bike, chair, duck, scissors, tree; $r = .78–.82$) following the same procedure as for alphanumeric RAN.

Visual processing speed. Visual processing speed was assessed with coding ($r = .81$) and symbol search ($r = .45$), two subtests of the Dutch version of the Wechsler Intelligence Scale for Children (third edition; Kort et al., 2005). Although the reliability of these separate tests is rather low, especially for symbol search, reliability estimates are better for the combined score ($\alpha = .86$). Therefore, we included both tests as indicators of one factor.

Coding. Children were presented with a key consisting of the digits 1 through 9, each paired with a unique symbol. Underneath the key children encountered a sequence of 119 randomly ordered digits. They were asked to write down the corresponding symbol for as many digits as possible within 2 min. They were asked to work from left to right, without skipping digits. The score consisted of the number of symbols copied correctly.

Symbol search. Children saw a string with two symbols on the left and five symbols on the right. They were asked to indicate by selecting either "yes" or "no" whether one of the two symbols on the left also appeared in the row of symbols on the right. They were presented with a total of 45 items and were asked to complete as many items as possible within 2 min. The score consisted of the number of correct judgments.

Verbal memory. We used the digit span task from the Wechsler Intelligence Scale for Children (third edition; Kort et al., 2005; $r = .63$) to assess verbal memory. This task consists of two parts. Separate scores were calculated for each part.

Digit span forward. The experimenter read aloud a digit sequence and the child was asked to repeat the digits in the correct order. The sequences increased in length from two to nine digits with two sequences of each length. When both sequences of the same length were repeated incorrectly the task was discontinued. The score consisted of the number of sequences repeated correctly.

Digit span backward. For digit span backward, the experimenter again read aloud digit sequences. This time, however, children were asked to repeat these sequences in reversed order. The sequences increased in length from two to eight digits, with two sequences of each length. The same discontinuation rule as in digit span forward was applied. The score consisted of the number of sequences repeated correctly.

Procedure

Progress in foreign language word reading was assessed during the first 10 months that these languages were acquired. Accordingly, this study focuses on the very early stages of reading in a foreign language. All literacy and cognitive tasks were administered in one classroom session and one individual session of 45 min each in September 2014 by the first and second author and well-trained assistants. During a second and third session, in February and June respectively, the foreign language word reading tasks were administered again. The Chinese tasks were administered by the teachers. The NIO was administered groupwise in June 2014 by an external psychologist, as part of the school's registration procedure. The Cito Test 0 was administered groupwise at the school in September 2014 as the first of a sequence of measurements aimed at following students' progress in Dutch, English, and mathematics. The scores on these tasks were provided to the researchers by the school principal. The study was approved by the ethics review board of the faculty of social and behavioral sciences of the University of Amsterdam (Number 2014-DP-3749: "Do you parlez la idioma Chino?").

Analyses

Data were analyzed by use of structural equation modeling. To answer the first research question two models were compared. In the first model all predictors had an effect on a latent variable, named "foreign language reading skills." Reading skill in each of the three foreign languages loaded on this variable. The second, or alternative, model was identical to the first model, with the addition of direct effects of the predictors on reading skills in Chinese. These direct effects identified differences in the influence of the cognitive skills between alphabetic Spanish and French on the one hand and nonalphabetic Chinese on the other hand.

The second research question was answered by comparing the second model with a third model, in which direct effects of the predictors on reading skills in French were added. These direct effects identified additional differences in the influence of the predictors between transparent Spanish and nontransparent French. In this model, the direct effects on "foreign language reading skills" represent the specific effects that predictors have on word reading in Spanish. The third research question was answered by using the best fitting model of the three models mentioned above and constraining the direct effects of the predictor native language skills to zero.

From the best fitting model we learn which of the predictors contribute to foreign language word reading acquisition in three foreign languages by calculating the total effect (i.e., direct plus indirect effect) of the cognitive and native language reading skills on word reading in each of the foreign languages separately. In these simultaneous regression models, the effect of each predictor reflects the unique contribution of the predictor to foreign language word reading in a particular language, controlled for the (relations with) other predictors in the model.

Before testing our hypotheses, we fitted structural equation models with latent factors to the data, because multiple measures were used to assess each skill. Measurement models were specified for both dependent (i.e., foreign language word reading) and independent (i.e., native language reading and cognitive skills) variables. In these models, all tasks loaded on their respective latent variable and all latent variables were correlated.

The models were fitted with Mplus Version 7.11 (Muthén & Muthén, 2012) using full information maximum likelihood estimation. Model fit was evaluated using the chi-square statistic of overall goodness of fit, the comparative fit index (CFI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA). 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). To test the difference in model fit between two nested models, a chi-square test was used (Kline, 2011).

Results

Data Cleaning

Before running analyses, data were inspected for missing values and outliers. We examined foreign language word reading in the very early stages. In general, students had no or very little experience with Spanish, French, and Chinese at the start of the study. However, some children indicated to speak one of these languages at home, or performed exceptionally well on the translation task (i.e., more than three standard deviations above the group mean). For these children, data on the specific language they already mastered, were left out of the analyses (Spanish $N = 4$; French $N = 5$; Chinese $N = 5$). Across tasks, some scores were missing because children were absent during one of the sessions. In addition, scores that were more than three standard deviations above or below the group mean were considered outliers and coded as missing. As a result, the number of observations is different for each task. The exact N for each task is presented with the descriptive statistics.

Word Reading Acquisition

Descriptive statistics for the foreign language word reading tasks are presented in Table 1. As expected, the scores on these tasks increased throughout the year. At the start of the study, children knew hardly any words, especially in Chinese. The largest

Table 1
Descriptive Statistics of Reading Tasks

Task (T)	*N*	*M* (*SD*)	Range
Spanish word reading			
T1	179	22.66 (8.57)	4–52
T2	179	36.56 (11.04)	9–71
T3	179	46.15 (12.17)	14–82
French word reading			
T1	179	19.99 (9.31)	3–53
T2	179	34.07 (12.07)	8–66
T3	178	39.30 (14.08)	5–78
Chinese word reading			
T1	180	.08 (.68)	0–7
T2	178	13.80 (8.38)	0–33
T3	177	15.60 (9.65)	1–45

growth in the children's reading skills appears to occur between T1 and T2. Their skills continued to improve between T2 and T3, although at a slower rate. The correlations among the reading tasks at T2 and T3 are presented in Table 2. All correlations were significant ($ps < .01$). As expected, the strongest correlations were found within each language between T2 and T3 performance. Across languages, reading performance was found to correlate moderately, although strong correlations were found between word reading in Spanish and French. This was not unexpected, as Spanish and French are both Romance languages that have many words that are identical or similar in their written form (Schepens, Dijkstra, & Grootjen, 2012). This might result in similar acquisition of these languages, particularly in the first months of foreign language instruction, when the focus tends to be on the acquisition of words more than on for example grammar.

Native Language and Cognitive Skills

Descriptive statistics for the predictors of foreign language word reading are presented in Table 3. Scores were normally distributed for all tasks. The correlations among the predictors are provided in Table S1 in the online supplemental materials. As expected, the strongest correlations were found between tasks that were used to measure the same skill, although some correlations were lower than expected (see the Measurement Models section). The correlations of the predictors with foreign language word reading are shown in Table 4. The patterns in the correlations with the reading tasks were different for each predictor. Native language reading skills correlated moderately with Spanish, weakly with French, and very weakly with Chinese. Tasks used to measure verbal intelligence (verbal IQ, Dutch vocabulary, verbal reasoning) correlated weakly to moderately with all reading tasks. Tasks reflecting nonverbal intelligence (nonverbal IQ, math abilities, spatial reasoning) appeared to correlate mainly with Chinese. Phonological awareness correlated only with reading acquisition in the alphabetic languages Spanish and French. Alphanumeric RAN correlated only with reading in Spanish. For nonalphanumeric RAN, weak correlations were found with the Spanish and the Chinese reading tasks. Weak correlations were found between visual processing speed and reading acquisition in Chinese. Fi-

Table 2
Correlations Among the Reading Tasks

Task (T)	1	2	3	4	5	6
1. Spanish word reading T2	—					
2. Spanish word reading T3	.85	—				
3. French word reading T2	.74	.68	—			
4. French word reading T3	.57	.65	.73	—		
5. Chinese word reading T2	.46	.55	.42	.44	—	
6. Chinese word reading T3	.46	.52	.42	.40	.86	—

Note. All correlations are significant at $p < .01$.

Table 3
Descriptive Statistics of Native Language and Cognitive Skills

Task	*N*	*M* (*SD*)	Range
Dutch word reading	184	87.08 (11.78)	52–116
Dutch pseudoword reading	182	74.46 (15.11)	38–116
Verbal IQ	164	109.26 (11.24)	84–138
Dutch vocabulary	182	241.85 (25.53)	167–315
Verbal reasoning	180	13.77 (5.30)	0–28
Nonverbal IQ	164	111.50 (10.70)	87–140
Math abilities	182	240.43 (14.60)	197–274
Spatial reasoning	180	18.12 (4.57)	6–28
Deletion: 1 phoneme	183	16.63 (6.66)	1.05–33.40
Deletion: 2 phonemes	182	8.98 (4.54)	.00–23.01
RAN letters	181	2.54 (.37)	1.56–3.57
RAN digits	183	2.35 (.44)	1.22–3.57
RAN colors	182	1.37 (.25)	.70–2.08
RAN pictures	184	1.28 (.20)	.81–1.85
Coding	179	52.41 (10.40)	26–79
Symbol search	180	32.46 (5.05)	18–43
Digit span forward	183	8.28 (1.45)	5–12
Digit span backward	182	5.54 (1.61)	2–10

Note. RAN = rapid automatized naming.

Table 4
Correlations of Native Language and Cognitive Skills With Reading Performance

Task	Spanish		French		Chinese	
	T2	T3	T2	T3	T2	T3
1. Dutch word reading	$.51^{**}$	$.50^{**}$	$.34^{**}$	$.31^{**}$	$.18^{*}$	$.17^{*}$
2. Dutch pseudoword reading	$.51^{**}$	$.50^{**}$	$.32^{**}$	$.22^{**}$	.13	.14
3. Verbal IQ	$.32^{**}$	$.22^{**}$	$.28^{**}$	$.36^{**}$	$.34^{**}$	$.29^{**}$
4. Dutch vocabulary	$.21^{**}$	$.25^{**}$	$.23^{**}$	$.32^{**}$	$.37^{**}$	$.35^{**}$
5. Verbal reasoning	$.21^{**}$	$.18^{*}$	$.23^{**}$	$.34^{**}$	$.35^{**}$	$.32^{**}$
6. Nonverbal IQ	.13	.15	.11	.14	$.45^{**}$	$.44^{**}$
7. Math abilities	.12	$.16^{*}$	.14	.10	$.35^{**}$	$.40^{**}$
8. Spatial reasoning	−.02	.01	.05	.06	$.17^{*}$	$.19^{*}$
9. Deletion: 1 phoneme	$.36^{**}$	$.33^{**}$	$.25^{**}$	$.23^{**}$	.09	.11
10. Deletion: 2 phonemes	$.37^{**}$	$.35^{**}$	$.33^{**}$	$.30^{**}$	.08	.07
11. RAN letters	$.23^{**}$	$.30^{**}$	.11	.11	.07	.02
12. RAN digits	$.23^{**}$	$.24^{**}$	.05	−.02	.01	−.07
13. RAN colors	$.27^{**}$	$.32^{**}$	.14	.08	$.21^{**}$	$.19^{*}$
14. RAN pictures	$.23^{**}$	$.28^{**}$	.06	.10	$.17^{*}$	$.16^{*}$
15. Coding	.13	.13	.09	.04	$.20^{**}$	$.19^{*}$
16. Symbol search	.06	.02	.02	.03	.13	.13
17. Digit span forward	.14	$.19^{*}$	.04	.05	.08	.08
18. Digit span backward	$.19^{*}$	$.20^{**}$	.08	.11	$.19^{*}$	$.22^{**}$

Note. RAN = rapid automatized naming.
$^{*}p < .05$. $^{**}p < .01$.

nally, verbal memory correlated weakly with reading acquisition in Spanish and Chinese, although this was mainly true for digit span backward.

Measurement Models

We fitted structural equation models with latent variables to the data. Separate models were constructed for the foreign language word reading tasks and the predictors to be sure that the factor structures provided a good local fit to the data. Correlations between word reading on T2 and T3 were high in all three languages. Furthermore, the correlations of the predictor skills with reading performance were very similar at T2 and T3. Therefore, we opted for the most parsimonious model and modeled word reading performance on T2 and T3 as two indicators of one latent word reading variable for each of the languages, rather than specifying separate models for T2 and T3 or autoregressive effects. An additional benefit is that the latent construct is a more reliable estimate of individual differences in word reading in the foreign languages. Reading in each foreign language loaded on a second-order factor, foreign language reading skills. This model provided a poor fit to the data: $\chi^2(6) = 31.38$, $p < .001$, RMSEA = .15, 90% Confidence Interval (CI) [.10, .21], CFI = .97, SRMR = .02. As discussed, a larger relation between performance on the two Romance languages French and Spanish is to be expected, especially on T2. To take this into account, we added an additional correlation between T2 word reading in French and Spanish. With the addition of a correlation between these residuals, the model provided a good fit to the data: $\chi^2(5) = 3.05$, $p = .692$, RMSEA = .00, 90% CI [.00, .08], CFI = 1.00, SRMR = .01. Standardized factor loadings and residual variances are presented in Figure 1.

For each of the predictors, correlations between the tasks used to measure a specific skill were acceptable. For verbal memory, however, the correlation between the two tasks measuring this skill was low. Although the correlation might be too low to construct a latent variable, we nevertheless did so to include all the variables that previous research had indicated to be potentially important in the model as well as to control for individual differences in verbal memory when considering the effects of the other variables in the model. Importantly, the verbal memory tasks did not correlate higher with another cognitive skill than with each other, supporting

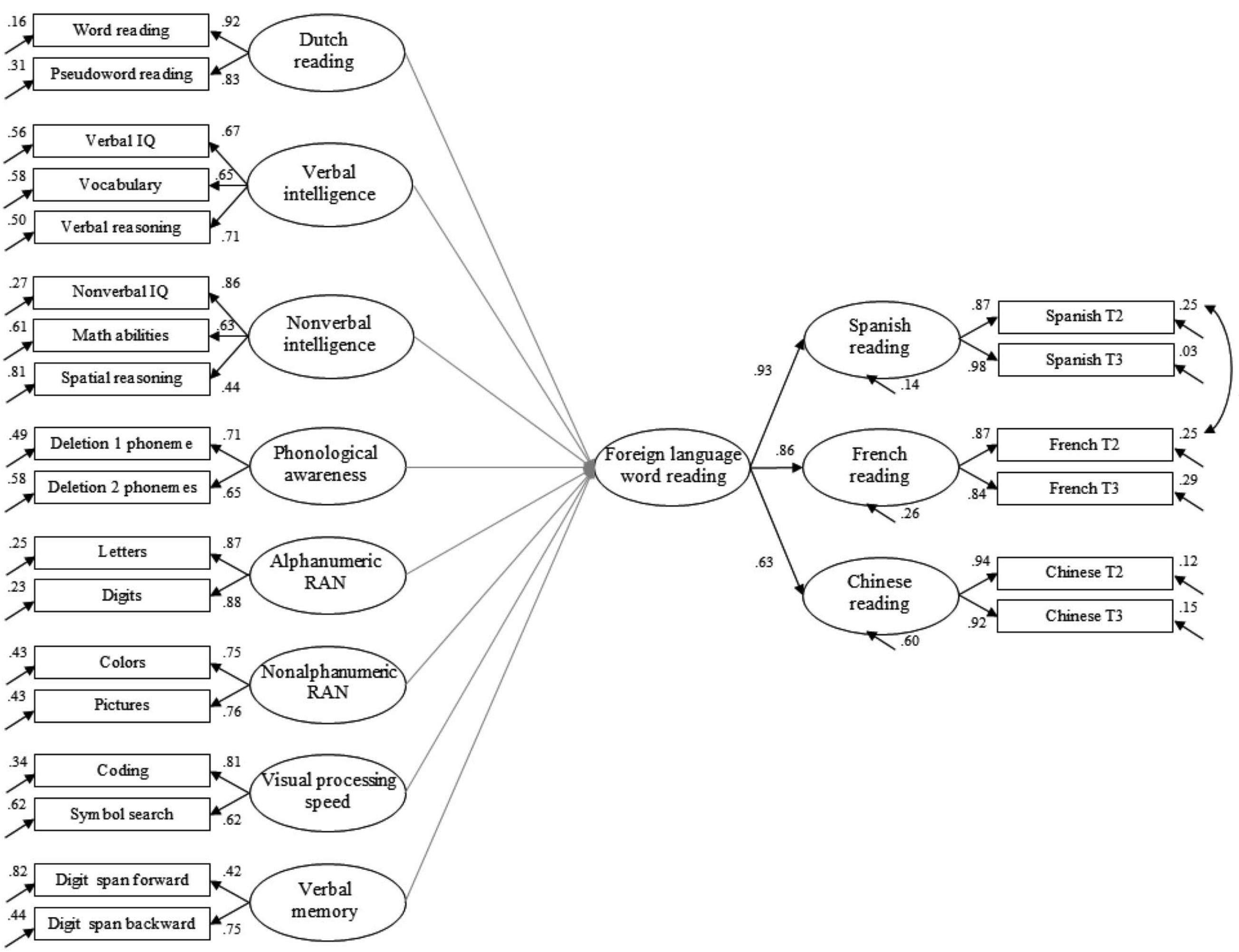

Figure 1. Standardized factor loadings and residual variances from the measurement models. Correlations among the predictors were included in the analyses, but are not presented for clarity purposes.

the inclusion of both tasks in one separate latent variable. The same reasoning applies to some measures of verbal and nonverbal intelligence. A model in which all the tasks loaded onto their respective latent variable provided a close approximate fit to the data: $\chi^2(107) = 148.46$, $p = .005$, RMSEA = .05, 90% CI [.03, .06], CFI = .96, SRMR = .06. Standardized factor loadings and residual variances are presented in Figure 1. Standardized correlations among the latent predictors are presented in Table S2 in the online supplemental materials.

Alphabetic Versus Morphosyllabic Orthographies

To examine whether the effects of native language and cognitive skills on foreign language word reading are universal, we fitted a regression model to the data with effects of all predictors on foreign language word reading. This model provided a reasonable fit to the data: $\chi^2(212) = 327.84$, $p < .001$, RMSEA = .05, 90% CI [.04, .07], CFI = .94, SRMR = .07. Next, direct effects of all predictors on reading in Chinese were added to the model. This model provided a good approximate fit to the data: $\chi^2(204) = 255.40$, $p = .008$, RMSEA = .04, 90% CI [.02, .05], CFI = .97, SRMR = .06, and fitted the data significantly better than the previous model: $\chi^2(8) = 72.43$, $p < .001$. These results indicate that the effect of native language and cognitive skills on foreign language word reading is different for alphabetic and morphosyllabic orthographies.

Transparent Versus Nontransparent Alphabetic Orthographies

To examine whether the effects of native language and cognitive skills on foreign language word reading also differ between transparent and nontransparent alphabetic orthographies, we added direct effects of all predictors on reading in French. This model had a good approximate fit: $\chi^2(196) = 239.40$, $p = .019$, RMSEA = .04, 90% CI [.02, .05], CFI = .98, SRMR = .05, and fitted the data significantly better than the previous model: $\chi^2(8) = 16.00$, $p = .042$, although this improvement in model fit was smaller than the previous. This model was therefore accepted as the final model. Taken together, these results indicate that the effects of native language and cognitive skills on foreign language word reading clearly differ between alphabetic and morphosyllabic orthographies, and also differ, albeit to a lesser extent, between transparent and nontransparent alphabetic orthographies.

Standardized direct, indirect and total effects of the native language and cognitive skills on reading in Spanish, French, and Chinese are presented in the upper part of Table 5. Dutch reading skills relate significantly to reading in Spanish. Verbal intelligence is a significant predictor of word reading in French and Chinese. Nonverbal intelligence is significantly related to word reading in Chinese. Finally, phonological awareness is significantly related to word reading in French. Alphanumeric RAN, nonalphanumeric RAN, visual processing speed, and verbal memory were not uniquely related to foreign language word reading. These findings indicate that different skills are important in learning to read different languages. Morphosyllabic Chinese mainly draws on verbal and nonverbal intelligence, whereas verbal intelligence and phonological awareness are most important in learning nontransparent alphabetic French, and native language reading skills most strongly predict learning to read transparent alphabetic Spanish.

Native Language Versus Cognitive Skills

Finally, we examined whether the relation of the cognitive skills with word reading in the foreign languages studied might be affected by the relation between native and foreign language word reading. This model provided a good approximate fit to the data: $\chi^2(199) = 250.84$, $p = .008$, RMSEA = .04, 90% CI [.02, .05], CFI = .97, SRMR = .05. Standardized direct, indirect, and total effects of the cognitive skills are presented in the lower part of Table 5. Some changes are evident in the effects of cognitive skills in comparison to the previous model, but only for Spanish. Verbal

Table 5
Standardized Direct, Indirect, and Total Effects of Final Models

Skill	Spanish			French			Chinese		
	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
Native language and cognitive skills									
Native language reading	—	.46**	.46**	−.16	.42**	.26	−.31**	.32**	.01
Verbal intelligence	—	.19	.19	.13	.17	.30*	.22*	.13	.35**
Nonverbal intelligence	—	.12	.12	−.01	.11	.10	.31**	.08	.40**
Phonological awareness	—	.21	.21	.14	.19	.33*	−.20	.14	−.06
Alphanumeric RAN	—	−.01	−.01	−.04	−.01	−.05	−.04	−.01	−.05
Nonalphanumeric RAN	—	.02	.02	−.10	.01	−.08	.20	.01	.21
Visual processing speed	—	−.07	−.07	.04	−.06	.02	.07	−.05	.02
Verbal memory	—	.08	.08	−.11	.07	−.04	.05	.05	.10
Cognitive skills only									
Verbal intelligence	—	.36**	.36**	.07	.32**	.39**	.08	.27**	.35**
Nonverbal intelligence	—	.11	.11	−.04	.10	.09	.32**	.08	.40**
Phonological awareness	—	.48**	.48**	.06	.44**	.50**	−.43*	.37*	−.06
Alphanumeric RAN	—	.32*	.32*	−.15	.29	.14	−.29	.24	−.05
Nonalphanumeric RAN	—	−.07	−.07	−.08	−.07	−.15	.27	−.06	.21
Visual processing speed	—	−.08	−.08	.05	−.07	−.02	.08	−.06	.02
Verbal memory	—	.03	.03	−.09	.03	−.06	.08	.02	.11

Note. RAN = rapid automatized naming.
* $p < .05$. ** $p < .01$.

intelligence, phonological awareness and alphanumeric RAN relate significantly to word reading in Spanish. However, their relation with reading in Spanish seems to be due to their relation with reading in the native language, because native language reading skills are the strongest predictor of reading ability in Spanish when all predictors are included simultaneously. For both French and Chinese, excluding Dutch reading skills from the model did not change the findings. Verbal intelligence and phonological awareness have a unique relation with word reading in French, whereas both verbal and nonverbal intelligence have a unique relation with word reading in Chinese.

Discussion

The main aim of this study was to investigate whether native language reading skills and cognitive skills are universal predictors of word reading acquisition in foreign languages or whether their influence depends on the writing system or orthographic depth of the foreign language involved. To this end, we studied children who are proficient readers in transparent alphabetic Dutch and who learn to read simultaneously in transparent alphabetic Spanish, nontransparent alphabetic French and morphosyllabic Chinese.

Universal or Language Specific?

There were three main findings. First, effects of native language and cognitive skills on foreign language word reading are not universal, but different for alphabetic and morphosyllabic orthographies. Second, effects of these skills are also different, although only slightly, for transparent versus nontransparent alphabetic orthographies. And third, cognitive skills mainly have a specific effect on foreign language word reading acquisition, except when the orthography of a foreign language is highly similar to the native language, in which case native language reading skills is the strongest predictor of word reading in that language and effects of underlying cognitive skills are captured in the effect of native language reading skills.

The current findings bear upon each of the three perspectives on foreign language acquisition reviewed in the introduction. These perspectives, although originally developed to explain first-time reading acquisition in a foreign language, also seem valuable in explaining foreign language development in students who are already proficient readers in their first language. The results can be interpreted within the framework of the Interdependence hypothesis (Cummins, 1979, 1984, 1991). According to this theory, reading skills in a foreign language develop on the basis of reading skills already developed in the native language. Indeed, we found that for Spanish, Dutch reading skills were the most prominent predictor of word reading acquisition. In contrast, for reading in French and Chinese the contribution of Dutch reading skills was much smaller.

Importantly, the current findings indicate that unlike suggested by the interdependence (Cummins, 1979, 1984, 1991) and linguistic coding differences hypotheses (Sparks & Ganschow, 1991, 1993, 1995), a common language component cannot fully explain reading development in all foreign languages. There were striking differences in the cognitive skills that underlie reading development in the three foreign languages studied, suggesting, in line with the script-dependent hypothesis (Geva & Siegel, 2000; Geva & Wade-Woolley, 1998), that the cognitive skills contributing most strongly to reading acquisition depend on characteristics of the specific foreign language involved.

Cognitive Predictors of Foreign Language Word Reading

There are five conclusions concerning the cognitive predictors of foreign language word reading. First, verbal intelligence relates to word reading in all three foreign languages studied. Second, nonverbal intelligence is related mostly to word reading in a morphosyllabic orthography. Third, phonological awareness is related more strongly to word reading in alphabetic languages, than in a morphosyllabic language. Fourth, differences between the cognitive predictors of word reading in transparent and nontransparent orthographies are only subtle, but verbal intelligence and phonological awareness appear slightly more important for nontransparent orthographies, whereas alphanumeric RAN seems somewhat more predictive of reading in transparent orthographies. And fifth, nonalphanumeric RAN, visual processing speed and verbal memory are not specifically related to word reading in a foreign language.

Importantly, as discussed, when reading skills in the native language Dutch are also taken into consideration, word reading in Spanish relates most strongly to these native language reading skills. Cognitive skills that are involved in Spanish word reading, that is, phonological awareness, verbal intelligence, and alphanumeric RAN, seem to contribute only because of their relation with native language reading skills. In contrast, for word reading in French and Chinese, native language reading skills are less important. Regardless of Dutch reading skills, French word reading is mainly influenced by phonological awareness and verbal intelligence, and Chinese word reading by verbal as well as nonverbal intelligence.

Findings indicate that the cognitive skills involved in Chinese word reading are rather different from the skills involved in word reading in Spanish and French. They support the conclusion of some studies on Chinese reading development in native speakers of Chinese, that reading acquisition in morphosyllabic orthographies depends less on phonological processing and more on visual processing, than reading acquisition in alphabetic orthographies (Huang & Hanley, 1995; Siok & Fletcher, 2001). Although in the current study broader nonverbal reasoning skills rather than strictly visual skills were related to word reading in Chinese, the current results suggest that this pattern applies to foreign language reading acquisition as well. These results contrast with the majority of studies on Chinese reading development in native speakers of Chinese, where phonological skills have been shown to be involved (Ho & Bryant, 1997; McBride-Chang & Kail, 2002; Zhou et al., 2015). This diverging pattern might suggest that Chinese reading acquisition develops somewhat different in foreign language learners. Readers of alphabetic orthographies are used to a writing system in which visually simple letter symbols represent the phonemic structure of the language, and have to become acquainted with visually complex symbols for which the relation with speech sounds is either lacking or inconsistent. This may explain the relative importance of nonverbal or visual reasoning skills and limited influence of phonological processing skills.

However, two alternative explanations for these findings need to be considered. First, the grain size at which phonological information may be relevant differs between the alphabetic orthographies and Chinese. We measured phonological awareness at the phoneme level, which is essential for decoding in alphabetic orthographies. However, in Chinese, the relation between visual and phonological cues resides mostly at the syllable level and some studies have shown that syllable awareness is more important than phoneme awareness for reading Chinese, especially in the early stages of reading development (McBride-Chang, Bialystok, Chong, & Li, 2004; McBride-Chang et al., 2008; Shu, Peng, & McBride-Chang, 2008). Possibly, our phoneme awareness task did not capture the effect of phonological awareness on reading Chinese. A measure of syllable awareness, maybe even in Chinese, could be a valuable addition for future studies. Second, throughout the course of this study, children were taught about 120 Chinese characters. Possibly, this initial set of characters is too limited for foreign language learners to become aware of, and make use of, the phonological cues that the characters provide. Future studies might examine whether the moment that phonological awareness becomes important for reading in Chinese occurs later for nonnative than for native speakers.

Differences between the predictors of reading acquisition in transparent and nontransparent orthographies were not very pronounced, which is consistent with findings on reading development in the native language, that report more similarities than differences between orthographies (Moll et al., 2014; Vaessen et al., 2010; Ziegler et al., 2010). Nevertheless, the finding that phonological awareness was slightly more important for reading in French, whereas alphanumeric RAN was somewhat more predictive of reading in Spanish is also in line with many previous studies on native language reading development. These studies indicated that phonological awareness might be somewhat more important for reading nontransparent than transparent orthographies, whereas RAN is slightly more important for reading in transparent than nontransparent orthographies (Georgiou et al., 2008; Mann & Wimmer, 2002; Moll et al., 2014).

Unexpectedly, the contribution of verbal memory to word reading in each of the foreign languages was modest, even when taking into account the low reliability of this task. Interestingly, however, the relation with word reading in foreign languages was primarily attributable to the backward span task, whereas the influence of forward span appeared to be minimal. This suggests that working memory, the simultaneous storage and processing of information (Daneman, 1987), plays a role in foreign language reading acquisition, whereas short term memory (STM), that is, the temporary storage of information (Swanson, 1994), does not. Although research on reading development in the native language has also indicated working memory as more important than STM (Gathercole, Alloway, Willis, & Adams, 2006; Swanson, 1994; Swanson & Jerman, 2007), it is generally argued that both memory functions are involved in reading (Swanson & Howell, 2001; Swanson et al., 2009), and studies on foreign language learning indicate that STM plays a key role in vocabulary development (Baddeley, Gathercole, & Papagno, 1998). The relative importance of working memory over STM for reading development in a foreign language could indicate that reading a word in a foreign language requires not only the accurate storage and retrieval of the representation of this word, but also the suppression of representations of the same word or related words in the native language. In accord with this suggestion, working memory capacity has been shown to be larger in individuals who master two languages than in monolinguals (Adesope, Lavin, Thompson, & Ungerleider, 2010).

The Process of Foreign Language Reading Acquisition

Although not directly studied, the findings shed light on the processes involved in foreign language word reading. For foreign alphabetic orthographies, findings indicate that children read words through decoding, that is, the access to a word's phonology by grapheme-phoneme conversion, as evidenced by the importance of phonological awareness. In transparent foreign orthographies, children appear to also use knowledge about language structure that they acquired in their native language yet that also applies to transparent alphabetic orthographies in general, because Dutch reading fluency plays an important role as well. Developmental theories of reading development in the native language indicate that with increased knowledge of a language's orthography, readers store the new orthographic word forms in their lexicon and gradually read more and more words through retrieval from this lexicon (e.g., Ehri, 2005; Share, 1995). Possibly, reading development in foreign alphabetic orthographies comprises a similar shift in reading process from predominant decoding to merely retrieval. This would manifest as a reduction in the importance of phonological awareness and an increase in the importance of RAN (e.g., Vaessen et al., 2010). The current findings suggest that after one year of reading instruction, reading in French still relies most strongly on decoding, whereas for reading in Spanish retrieval has become more important. This indicates that the shift from decoding to retrieval may occur earlier in foreign transparent alphabetic orthographies, than in foreign nontransparent alphabetic orthographies, in line with findings on reading development in these languages as a native language (Seymour et al., 2003). This would indicate that for foreign nontransparent orthographies, RAN becomes more important during later stages of the reading acquisition process, when accurate decoding skills have been developed.

Learning to read Chinese, in contrast, might call upon different strategies, at least for native speakers of languages with alphabetic orthographies. The unavailable or unreliable letter-speech sound connections in Chinese render phonological strategies inefficient and may instead call for mappings between the visual and semantic form of the character. This would suggest that Chinese characters are initially acquired character by character. Some support for this assumption is derived from the finding that word reading in Spanish and French correlated strongly, whereas correlations with word reading in Chinese were much lower. Possibly, readers who are used to the alphabetic writing system initially perceive the Chinese characters as abstract figures, and recognize them on the basis of visual characteristics. Only later on might they gain sufficient knowledge about the phonological and semantic cues to be able to use this knowledge during reading. This interpretation is supported by previous research showing that English speakers who learn to read Chinese predominantly use visual-graphical cues when naming characters in the initial learning phase, but start using semantic cues and subsequently phonological cues as they become more skilled readers of Chinese (Liu, Perfetti, & Wang, 2006; Liu, Wang, & Perfetti, 2007). This would suggest that phonological awareness and RAN become more important during more advanced stages of reading development.

Limitations and Future Directions

This study expands our insight in reading development in foreign languages. However, certain characteristics of the study design may limit the interpretation and generalization of results. First, all reading tasks used in the current study contained a time limit. Consequently, findings relate only to reading fluency, not to accuracy.

Second, participants in this study were followed throughout the first school year of foreign language learning. Obviously, the process of learning to read in a foreign language spans across multiple years. Consequently, the findings in the current study apply specifically to the first stages of the foreign language learning process. Previous findings have shown that the relative importance of cognitive predictors changes when reading proficiency in the native language increases (e.g., Caravolas et al., 2013; Shu et al., 2008; Vaessen et al., 2010). Future studies might provide insight in the skills that underlie foreign language reading development in more advanced stages of reading development.

Third, the foreign languages included in the current study were selected because they differed in transparency and writing system. However, because languages are complex structures, they clearly differ on more dimensions, such as morphological, grammatical and syntactic structure. Future studies are needed to distinguish between these dimensions. In addition, it would be relevant to study the impact of linguistic similarity between the foreign and native languages on different dimensions. Recent updates of the interdependence hypothesis (Cummins, 2000, 2007) propose that the ease of transfer from native language skills to foreign language reading skills occurs most easily when the foreign language is linguistically similar to the native language.

Fourth, although the participants were novices in the foreign languages under study, they all mastered at least one foreign language (English). In addition, they acquired the three foreign languages simultaneously. Accordingly, as becomes clear from Table 2, development in each of the three languages interacted with development in the other languages. Mastering multiple foreign languages is common in the Netherlands, as well as in most other parts of the world (Cenoz, 2013). However, it is unknown to what extent the results of the current study can be generalized to foreign language acquisition in individuals without prior knowledge of other foreign languages and to learning situations were Spanish, French, or Chinese is acquired as the sole foreign language. Previous research suggests that the processes involved in foreign language acquisition are different for learning a foreign language for the first time than for those who have already acquired another foreign language, but the exact nature of the influences of L2 experience on L3 learning are still unclear as most previous studies focused on acquisition of a second language (e.g., Adesope et al., 2010; Cenoz, 2013; Dewaele, 2001).

Conclusion and Implications

To conclude, the contribution of native language and underlying cognitive skills to reading acquisition in a foreign language seems for the most part language specific and influenced by both the writing system and orthographic depth of the foreign language. Specifically, when native speakers of a language with a transparent alphabetic orthography learn to read in another transparent alphabetic orthography, they seem to mainly rely on their native language reading skills. However, when the foreign orthography employs more complex letter-speech sound mappings, phonological processing skills and verbal intelligence become more important, suggesting that when children cannot rely on the letter-sound connections that they have internalized from their native language, they have to use broader linguistic knowledge and academic reasoning strategies to get a grip on the language's orthographic structure. Furthermore, when reading skills are acquired in a nonalphabetic writing system, not only verbal but also nonverbal intelligence is addressed, and intelligence even becomes the most prominent contributor. This implies that when a foreign language is represented with visually complex characters, visual reasoning skills become important in encoding these characters and distinguishing one from another.

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Appendix

Items in the Translation Tasks and Word Reading Tasks

Table A1
Items in the Translation Tasks

French	Spanish	Chinese
oui	*no*	我
nous	*tú*	叫
j'ai	*también*	岁
huit	*azul*	家
le frère	*el amigo*	美国
alors	*el pueblo*	人
où	*´ultimo*	是
garçon	*la hermana*	翻师
mamie	*amarillo*	月
qui	*hasta luego*	号
la chambre	*delante de*	生日
douze	*buscar*	他的
moche	*juntos*	荷兰人
un cousin	*alrededor de*	没有
devant	*adelante*	很
près de	*la parada*	您
noir	*enamorado*	日文
la pomme	*aquí*	法文
toujours	*los pasteles*	姐姐
le grenier	*la manzana*	弟弟
seize	*la prima*	她
tu sais	*¿Cuál?*	你
dans	*a la izquierda*	多大
là-bas	*enfrente de*	吗
comment	*el hermanastro*	不是
un chat	*enfermo*	四十
habiter	*aburrido*	两
le palmier	*el pelo*	八月
trente	*llevar*	中文
chouette	*los gemelos*	男
jeune	*algo*	日文
à bientôt	*el despacho*	会
le rayon	*el partido*	说
je range	*el ordenador*	哥哥
surtout	*incluso*	什么
bête	*escuchar*	名字
sous	*a veces*	十月
la natation	*el plano*	学生
un ordinateur	*los deberes*	有
ècouter	*la planta*	也
faire	*sed*	对
je déteste	*cansado*	不
la chanson	*ahora*	妈妈
raconte	*temprano*	你呢
le dessin	*el vaso*	喜欢
sympa	*el recreo*	五月
trouver	*dormir*	谁
un arbre	*martes*	他
parfois	*feo*	二十七
facile	*a pie*	谢谢
la chose	*divertido*	朋友
l'anniversaire	*un montón*	学
le soleil	*propio*	妹妹
mille	*el regalo*	你们
j'adore	*la falda*	女
le vendeur	*pasar*	法国
triste	*comprar*	二
¸ca va	*el probador*	有
la cave	*el bolso*	爸爸
attendre	*la prenda*	我的
les oreilles	*el almacén*	也
la récré	*descansar*	
promis	*la pasarela*	
furieux	*llegar*	
le sac à dos	*el guante*	
les voisins	*la mochila*	
la glace	*el otoño*	
l'enfants	*rellenar*	
le poisson	*olvidar*	
casser	*la maleta*	
le biscuit	*tener miedo*	
les courses	*nadar*	
parfait	*quedar*	
prendre	*el recorrido*	
le panier	*inolvidable*	
la viande	*disfrutar*	
oublier	*el perfil*	
après-midi	*el corazón*	
je voudrais	*bailar*	
la boucherie	*la ola*	
acheter	*empezar*	
le beurre	*la edad*	
jouer	*estúpido*	
une fraise	*el postre*	
de l'argent	*duro*	
faim	*la primavera*	
le poivre	*hace calor*	
une canette	*el viento*	
manger	*la linterna*	
un verre	*el horario*	
le sel	*odiar*	
travailler	*famoso*	
désirer	*pagar*	
quelque chose	*reír*	
pomme de terre	*encantar*	
regarder	*por fin*	

(*Appendix continues*)

Table A2
Items in the Word Reading Tasks

French	Spanish	Chinese
il	*si*	不
mal	*yo*	吗
eau	*muy*	多大
ami	*casi*	喜欢
chez	*bien*	中国
ans	*gris*	人
deux	*chico*	是
pain	*hoy*	您
salut	*cerca*	今天
aussi	*grande*	明天
seul	*ciudad*	生日
chaise	*hija*	快乐
cinq	*lejos*	荷兰
jardin	*guapo*	美国
beau	*bosque*	很
sœur	*vecino*	翻师
tout	*ahora*	英文
quoi	*vale*	法文
derrière	*hospital*	妈妈
petit	*allí*	爸爸
ferme	*caja*	她
maison	*bacalao*	你
fils	*guay*	岁
jaune	*instituto*	你好
voiture	*abuela*	是
quelle	*padres*	四
œuf	*libre*	两
chien	*habitación*	月
tarte	*anticuado*	号
vingt	*siempre*	的
lait	*rubia*	日文
souris	*canción*	会
ville	*toalla*	说
cent	*todavía*	哥哥
loin	*gracioso*	什么
soif	*aventura*	名字
cœur	*cumpleaños*	十
joli	*domingo*	几
exemple	*´atico*	没有
cuisine	*hambre*	也
nouveau	*escuela*	叫
problème	*coche*	我
couleur	*talla*	姐姐
jambon	*dormitorio*	呢
sévère	*después*	家
casquette	*pequeño*	五
pénible	*verde*	谁
joueur	*profesora*	他
beaucoup	*cocina*	二十七
vraiment	*inglés*	男
difficile	*pasillo*	朋友
formidable	*jueves*	个
professeur	*pantalones*	妹妹
maintenant	*amable*	你们
èquipe	*comedor*	女
histoire	*desayuno*	法国人
matière	*bocadillo*	二
vélo	*matemáticas*	有
important	*miércoles*	弟弟
amoureux	*asignatura*	我的
gentil	*panadería*	
paquet	*collar*	
quatorze	*suéter*	
méchant	*química*	
livre	*difícil*	
pays	*reloj*	
anglais	*preferida*	
poème	*montañas*	
fâché	*artículo*	
content	*guitarra*	
devoirs	*invierno*	
portable	*camiseta*	
grand-père	*encantado*	
légume	*dinero*	
bouteille	*zapatilla*	
combien	*elegante*	
fromage	*estatua*	
ensuite	*dependiente*	
fatigué	*folleto*	
librairie	*pendientes*	
yaourt	*monedero*	
poulet	*calcetines*	
huile	*verano*	
géographie	*videojuego*	
deuxième	*formulario*	
confiture	*demasiado*	
monsieur	*estupenda*	
èpinards	*anuncio*	
dégoûtant	*vaqueros*	
immeuble	*bañador*	
magasin	*bolígrafo*	
saucisson	*complemento*	
èquitation	*impermeable*	
chanteuse	*jóvenes*	
délicieux	*chanclas*	
malheureuse	*alojamiento*	

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