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Learning to read: English in comparison to six more regular orthographies

MIKKO ARO
University of Jyväskylä and Niilo Mäki Institute

HEINZ WIMMER
University of Salzburg

ADDRESS FOR CORRESPONDENCE
Mikko Aro, Niilo Mäki Institute, P.O. Box 35, FIN-40014 University of Jyväskylä, Finland.
E-mail: mikko.aro@nmi.jyu.fi

ABSTRACT
Reading performance of English children in Grades 1–4 was compared with reading performance of German-, Dutch-, Swedish-, French-, Spanish-, and Finnish-speaking children at the same grade levels. Three different tasks were used: numeral reading, number word reading, and pseudoword reading. The pseudowords shared the letter patterns for onsets and rimes with the number words. The results showed that with the exception of English, pseudowords in the remaining orthographies were read with a high level of accuracy (approaching 90%) by the end of Grade 1. In contrast to accuracy, reading fluency for pseudowords was affected not only by regularity but also by other orthographic differences. The results highlight the need for a revision of English-based characterizations of reading development.

The present study is an extension of Wimmer and Goswami's (1994) comparative study of reading development in young English and German children. The main finding of Wimmer and Goswami was that 7-, 8-, and 9-year old English children had substantially more difficulties in a pseudoword reading task than German children did. Landerl's (2000) replication supported Wimmer and Goswami's (1994) findings: in comparison to English children, young German readers in first and second grade displayed a distinct advantage in their ability to read pseudowords with a high degree of accuracy. Another recent replication with a comparison of Spanish and Portuguese children was reported by Defior, Martos, and Cary (2002). Their results show that the pseudoword reading accuracy of Spanish and Portuguese children is relatively similar to the performance of German children and much better than that reported for English children in the aforementioned studies.

Phonological recoding, the ability to translate a new letter string into a phonological code by which phonological word forms can be accessed, is considered to be the sine qua non of early reading development (Share, 1995). How easy or difficult this translation is for the young reader must depend to some extent on how simply and reliably the letters of new words map onto the sounds of the corresponding spoken words. Accordingly, the reading accuracy advantage of young or dyslexic German readers (Landerl, Wimmer, & Frith, 1997) over their English counterparts was interpreted as reflecting the higher grapheme–phoneme regularity of German.

To date, there have been no comprehensive attempts to quantify and compare the transparency of different orthographies, although some orthographies have been subjected to a computational linguistic analysis. For the English language, 31% of all monosyllabic words have been found to be feedforward inconsistent (in the direction of spelling to pronunciation; Ziegler, Stone, & Jacobs, 1997). The corresponding inconsistency is reported to be 12% in French monosyllabic words (Ziegler, Jacobs, & Stone, 1996), and 16% in German monosyllabic words (J. Ziegler, personal communication, February 20, 2001). It is worthy of note that the above-mentioned consistency calculations are based on spelling body–rime correspondences and not grapheme–phoneme correspondences. Seymour, Aro, and Erskine (2003) have presented a hypothetical classification of European languages according to their orthographic depth at the level of grapheme–phoneme correspondences. Based on the expert opinions of COST A8[1] representatives, they suggest that, of the orthographies included in the current study, English is the most inconsistent when placed on the continuum of orthographic depth. In degrees of increasing consistency, it is followed by French, Dutch and Swedish, German and Spanish, and Finnish as the most consistent orthography that displays regular and symmetrical grapheme–phoneme correspondences.

In addition to orthographic differences in regularity, Landerl (2000) found that difficulty with phonological coding of pseudowords can be reduced for English children through a systematic phonics approach to reading instruction (similar to that experienced by German children). By Grade 3, English-speaking children who have received phonics instruction read pseudowords as accurately as German children and significantly better than a standard instruction group, where the same level of accuracy was reached at Grade 4. Methods of reading instruction vary among countries and, as suggested by Goswami, Gombert, and de Barrera (1998), appear to be related to the transparency of the orthography. In transparent orthographies, reading is typically taught using purely phonics-based approaches with the focus on the grapheme–phoneme correspondences. In inconsistent orthographies, reading instruction is usually a combination of sight-word training and phonics.

A salient methodological problem in comparative studies of reading development is to be able to utilize stimuli of similar difficulty and to control for superficial phonological and articulatory language differences. Wimmer and Goswami (1994) tackled these problems by basing their reading tasks on short, simple names of numbers in English and German (e.g., two–zwei, three–drei, four–vier, twelve–zwölf). In particular, they contrasted children's reading aloud

performance on a number word reading task (alphabetically presented number words) with their performance on a pseudoword reading task (pseudowords created by exchanging the consonant onsets of number words). As a third task, they used a numeral reading task. Here, children had to read the same items as in the number word reading task, but the items were presented as digits. This latter task was intended to control for phonological and articulatory language differences.

In the present extension, this method is applied in an identical manner to Dutch-, Swedish-, French-, and, with some modifications, Finnish-speaking children from Grade 1 to Grade 4. The English data reported by Landerl (2000) and the Spanish data published by Defior et al. (2002) are also included for comparison. The critical questions are, first, whether the originally observed advantage of young German readers over young English readers extends to these other orthographies, and second, in the case of Finnish and Spanish as the most transparent orthographies, whether this effect may even be intensified.

In addition to the effect of orthographic regularity on the acquisition of phonological coding accuracy, the present study also addressed the acquisition of the fluency and speed with which phonological coding can be carried out. The aforementioned English–German comparisons and other studies on reading development in more regular orthographies (reviewed in Landerl, 2000) have shown that the acquisition of accurate phonological coding poses less of a problem in regular orthographies. Consequently, the main developmental focus for these more regular orthographies is the acquisition of reading fluency. Our benchmark for maximum phonological coding fluency within each orthography was children's reading speed on the numeral reading task. In this task phonological whole-word representations have to be accessed in response to familiar visual symbols (digits). By contrasting the pseudoword and number word reading fluency with the numeral reading speed it is possible to control for the length differences in the names of the numbers between languages. It should be noted that the pseudowords of each language consisted of the same speech segments as the spoken number words.

METHOD

Participants

The present study integrates data from seven orthographies. This merges Landerl's (2000) Standard-English and German (Austrian) Study 2 samples and Defior et al.'s (2002) Spanish sample with approximate numbers of children of the same grade levels (Grades 1–4) in The Netherlands, France, and Finland. In addition to Finnish-speaking children, Swedish-speaking children were also tested in Finland. This latter group's language for education and mother tongue was Swedish, although most were bilingual. Gender distribution was balanced within the grades. Children were tested toward the end of their relevant school year. The chronological ages of the language groups in the participating countries differed due to differences in school entrance age. French and English children enter school at 5 years of age; Austrian, Spanish, and Dutch children enter at 6

Table 1. *Number of participants and mean age and standard deviations for each orthography and grade level*

	Grade 1			Grade 2			Grade 3			Grade 4		
		Age			Age			Age			Age	
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
English	26	6;3	0;2	27	7;4	0;2	28	7;10	0;3	29	8;10	0;3
French	32	6;9	0;5	35	7;8	0;3	34	8;8	0;3	33	9;9	0;5
German	26	7;5	0;4	26	8;10	0;5	25	9;10	0;3	25	10;7	0;4
Dutch	27	NA		34	NA		22	NA		18	NA	
Spanish	30	6;11	0;3	30	7;10	0;4	30	8;11	0;4	30	9;10	0;3
Swedish	29	7;10	0;4	29	8;11	0;3	23	10;0	0;5	18	11;0	0;4
Finnish	20	8;0	0;3	22	9;1	0;3	22	10;1	0;4	29	11;0	0;3

Note: For the Dutch children, no age (NA) information was available because of an error in the data collection procedure. On the basis of school entry age it can be concluded that their age is comparable to the age of the German (Austrian) children.

years; and Finnish children enter at 7 years. The demographic characteristics of the participants are presented in Table 1.

Our collaborators in each country selected a school with a typical approach to instruction and ensured that the school was not located within a socially underprivileged area. German, Swedish, Spanish, and Finnish children were subject to systematic phonics teaching. English children received a balanced mixture of sight-word and phonics instruction, with a phonics lesson every day as mandated by the British national curriculum. For the French and Dutch children, it appears that a sight-word vocabulary was used to support an analytical phonics approach, for example, by pointing out that rhyming words share the same letter spelling body. It is important to note that the English children were ahead with respect to national norms (Word Reading subtest of the British Ability Scales II; Elliott, 1996). Their mean reading age in Grade 1 was 9 months ahead of their chronological age, and in the subsequent grades, reading ages were always at least 1 year advanced. The German sample generally showed age equivalent reading performance; the median reading percentiles varied between 41 (second grade) and 61 (first and fourth grades). No reading age level data were available for the remaining orthographies.[2]

Materials

Appendix A shows the nine number words for each language and the nine pseudowords derived from these words. The number words for 1, 8, and 11 with vowel onsets were excluded in all orthographies (with the exception of Finnish).[3] This is because in the original English–German comparison the pseudowords were created by exchanging the consonant onsets between the number words.

Table 2. *Orthographic characteristics of the pseudoword reading items* (*mean values per item*)

	English	German	Dutch	Swedish	French	Spanish	Finnish
Number of							
Letters	4.2	4.4	4.3	3.2	4.2	4.4	6.1
Complex graphemes	0.3	1.0	0.6	0.1	0.6	0	0
Consonant clusters	0.4	0.7	0.4	0.3	0.3	0.1	0
Possible readings irrespective of graphemic context	3.9	1.3	1.0	1.3	1.7	1.4	1.0

Table 2 shows the orthographic characteristics of the items in each language. The mean letter length is similar for English, German, Dutch, French, and Spanish words and pseudowords but shorter for Swedish and substantially longer for Finnish. When counting the graphemes consisting of two letters (e.g., *ch* in German *sechs*) or graphemes consisting of one letter with a diacritic (e.g., *ü* in *fünf*), German ranked the highest with every word including one complex grapheme, followed by Dutch and French. The next count shows the mean number of consonant clusters, which may pose difficulties for phonological assembly (e.g., *thr-* in *thro*). Here again, German ranked the highest. The final measure in Table 1 is the theoretically determined mean number of possible readings per pseudoword item allowed by the graphemes, irrespective of graphemic context. This measure gives an impression of the consistency of the pseudoword items at the grapheme level.[4] To exemplify, for the English pseudoword *thrine*, there are six possible readings of the graphemes: /θrain/, /θraini/, /θrainə/, /θrin/, /θrini/, and /θrinə/; for the pseudoword *thro* there are three: /θru:/, /θrou/, and /θro/. The number of phonologically plausible pronunciations is clearly highest for English pseudowords, especially in relation to the number of vowel graphemes with many alternative pronunciations. For the French pseudowords, pronunciations of the silent letters were also counted as plausible. In Swedish, the grapheme /o/ can have two alternative pronunciations. In German, the graphemes /v/ and /ch/ have alternative pronunciations. In Spanish, the alternative pronunciation of the grapheme /c/ was counted as a plausible pronunciation. The Finnish and Dutch pseudowords have only one possible pronunciation for each grapheme.

In summary, Table 2 suggests varying difficulties for the pseudowords of the included orthographies; for young readers, these difficulties may also be pertinent to the reading of the number words. The English pseudowords may be especially difficult because the graphemes allow a number of different readings. However, with respect to length, number of complex graphemes, and number of consonant clusters, the English pose little additional difficulty in relation to the other orthographies. The Finnish pseudowords may be difficult because of their length; a larger number of phonemes have to be assembled in a coherent pronunciation than in any other orthography. The German pseudowords may be

difficult because of complex graphemes and consonant clusters. The French pseudowords may present some difficulty because of uncertainties about the pronunciation of "silent" letters in combination with some complex graphemes. The difficulties of pseudowords of the remaining orthographies should be rather low.

Procedure

Each child was seen for one session, during which three different list-reading tasks (pseudoword reading, number word reading, and numeral reading) were administered. Each task comprised two lists. Each list included 18 items with each of the 9 items of Appendix A presented twice in pseudorandom order. The total number of items was 36 for each task. The items of each list were printed in separate lines of text on one page to mimic "real" reading. The numerals were positioned to match the location of the first letter in each number word or pseudoword. The order of the items in the two lists was different, but it was the same across different tasks. Thus, if one numeral list began "2, *10*, *7* . . . ," the corresponding number word list would begin "*two*, *ten*, *seven* . . . ," and the pseudoword list would begin "*thro*, *sen*, *feven* . . . ." The child was instructed to read the lists as quickly and accurately as he or she could. The reading of each of the six lists was timed, and the incorrectly read items were noted. When a child paused for more than approximately 4 s on a particular item, he or she was encouraged to skip the item and move on to the next. The two lists for each condition were issued in immediate succession. Six different orders of the list pairs were used. Prior to the experimental tasks, each child had to read a practice page for each task. For the youngest group (the English Grade 1 children), the procedure was simplified. Here, the easiest task, numeral reading, was presented first, followed by number word reading, and then by pseudoword reading. The practice sheet was given immediately before each task.

For the English children the pseudoword reading accuracy was scored in a more lenient manner than in the original study by Wimmer and Goswami (1994), where only pronunciations that have a real word analogy were accepted. As Landerl (2000) describes, any grapheme to phoneme translations entailed in real words were accepted, irrespective of position and graphemic context. For example, the pseudoword *thrine* could be read as /θrain/ or /θrin/. In line with the criterion (no context sensitivity), responses that ignored the final-*e* rule, such as /θrini/ or /θrinə/, were also accepted. For French children, a similar scoring principle was also used. The rationale for using a more lenient scoring for the English and French children was that by accepting only responses with existing word analogies, the French and English children would have been placed at a disadvantage in comparison to other orthographies. For the more consistent languages, there is no real difference whether pseudoword reading is based on grapheme–phoneme correspondences or on analogy to a real word. In the other orthographies, the responses were scored as correct when they were pronounced through analogy to the corresponding number words or other existing words. In the most consistent orthographies, this principle is practically the same as was applied to English and French; in some orthographies, this means a slightly

Table 3. *Percentage of accurately read pseudowords* (*means and standard deviations*)

	Grade 1		Grade 2		Grade 3		Grade 4	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
English	50.3	32.8	71.0	32.5	73.5	28.8	88.2	15.2
French	86.7	5.9	96.7	3.5	98.4	2.4	98.5	2.7
German	88.0	12.4	87.3	9.5	86.0	15.2	87.2	19.5
Dutch	85.2	8.0	88.9	9.1	91.2	8.1	95.1	5.8
Spanish	87.3	12.2	90.4	8.1	90.9	6.8	90.6	8.2
Swedish	93.2	9.6	90.8	10.5	95.4	8.2	97.4	4.3
Finnish	84.9	13.6	89.6	10.1	88.4	8.1	93.7	8.3

stricter scoring. In Appendix B, the actual pronunciations that were counted as correct are listed separately for English and French pseudoword items. It is worthy of note that this lenient scoring was especially advantageous for the English and French children because several distinct pronunciations could be counted as correct responses.

RESULTS

Because only a few children incurred errors on the number word reading and numeral reading tasks, only the accuracy scores for the pseudoword reading task are shown in Table 3.

As Table 3 shows, the attainment of high reading accuracy for pseudowords was a much more protracted process for English children than for the children reading more regular orthographies. At the end of Grade 1, reading accuracy levels were already around 85% for the German, Dutch, French, Spanish, and Finnish children and above 90% for the Swedish children, leaving little room for further improvement in all these orthographies. A markedly different developmental trend is apparent for the English children, who, having achieved only 50% accuracy by the end of Grade 1, did not attain the high accuracy shown by their Grade 1 counterparts in other orthographies until Grade 4.

The pseudoword reading accuracy of the English group was compared separately with the other orthography groups in Grade level (4) × Orthography (2) analyses of variance (ANOVAs). The interaction between grade level and orthography was significant for all comparisons: English and Finnish, F (3, 196) = 3.9, $p < .01$; English and French, F (3, 237) = 4.8, $p < .003$; English and Spanish, F (3, 223) = 6.9, $p < .000$; English and Swedish, F (3, 202) = 5.6, $p < .001$; English and Dutch, F (3, 204) = 3.7, $p < .012$; and English and German, F (3, 205) = 6.6, $p < .000$. As can be seen in Table 3, this interaction is due to the poorer accuracy of the English children at Grades 1, 2, and 3.

There was also a large variance in the performance of English children; although there were many accurate readers, 23% of the English children read less than half of the pseudowords correctly. In contrast, only 3 of the 649 children in the other language groups matched this figure.

Table 4. *Pseudoword reading time/numeral reading time ratio* (*means, standard deviations, and median values*)

	Grade 1			Grade 2			Grade 3			Grade 4		
	M	*SD*	*Mdn*	*M*	*SD*	*Mdn*	*M*	*SD*	*Mdn*	*M*	*SD*	*Mdn*
English	4.60	2.20	3.88	3.00	1.98	2.30	3.58	2.35	2.66	2.29	1.01	2.01
French	3.64	1.96	3.07	2.72	0.81	2.61	2.58	0.80	2.41	2.49	0.62	2.42
German	3.08	1.33	3.06	2.64	0.89	2.60	2.57	1.32	2.26	2.64	0.73	2.45
Dutch	4.00	1.35	3.90	2.67	0.86	2.53	2.21	0.82	2.05	2.19	0.44	2.16
Spanish	2.48	0.70	2.35	1.91	0.36	1.88	1.90	0.34	1.87	1.83	0.46	1.77
Swedish	2.59	1.39	2.03	1.96	0.51	1.83	1.73	0.55	1.52	1.51	0.33	1.51
Finnish	2.55	1.09	2.40	1.87	0.36	1.85	1.80	0.53	1.82	1.69	0.62	1.57

Table 4 shows orthography differences in pseudoword reading fluency. Instead of absolute time scores, a reading time ratio was used to control for language and developmental differences in the speed with which children performed on the numeral reading task. That is, pseudoword reading time was divided by numeral reading time. For example, a ratio of 2 means that the reading time for pseudowords was twice the reading time for numerals. This control is important as, due to the long number words, the Finnish children showed slower numeral reading speed in comparison to the children of the other languages. Furthermore, numeral reading speed improved with grade level. To illustrate, mean reading times per numeral for the English children were 0.69, 0.61, 0.52, and 0.45 s for Grades 1–4, respectively. In contrast, for Finnish children, mean reading times per numeral were much higher at 1.08, 0.80, 0.78, and 0.68 s for the respective grades.

The reading fluency results for pseudowords in Table 4 show that the English data does not diverge from the other orthographies as was the case with pseudoword reading accuracy. Because of differing distributions, the orthography differences in pseudoword reading fluency were examined with Mann–Whitney *U* tests separately for Grades 1, 2, and 3. Throughout Grades 1–3, Finnish, Swedish, and Spanish children formed the fast group in pseudoword reading. In Grade 1, children in each of these fast group orthographies were significantly faster than English and Dutch children; in Grade 2, they were significantly faster than French, Dutch, and German children; and in Grade 3, they were significantly faster than the French and English children. All pairwise comparisons between the aforementioned fast and slow groups in each grade level reached significance ($p < .001$, all Zs < -3.30). An ANOVA for the pseudoword fluency score in Grade 4 demonstrated a significant effect of orthography, F (6, 175) = 10.3, $p < .001$. Pairwise post hoc tests (Scheffé, $p < .001$) showed that Finnish and Swedish children were significantly faster than French and German fourth graders. As can also be seen in Table 4, the advantage in pseudoword reading fluency for Finnish, Swedish, and Spanish children was stable from Grade 1 onward. These children were consistently the most fluent in pseudoword reading whereas at the end of Grade 4 the English, German, Dutch, and French children

Table 5. *Number word reading time/numeral reading time ratio* (*means, standard deviations, and median values*)

	Grade 1			Grade 2			Grade 3			Grade 4		
	M	*SD*	*Mdn*	*M*	*SD*	*Mdn*	*M*	*SD*	*Mdn*	*M*	*SD*	*Mdn*
English	2.12	1.79	1.27	1.11	0.43	0.96	1.64	1.26	1.08	1.01	0.23	0.95
French	1.49	0.51	1.37	1.02	0.16	0.98	0.97	0.16	0.97	1.01	0.11	1.00
German	2.29	1.25	2.02	1.49	0.73	1.11	1.20	0.77	1.00	1.05	0.18	1.07
Dutch	2.62	1.25	2.62	1.12	0.39	1.00	1.05	0.49	0.98	1.05	0.09	1.05
Spanish	2.02	0.89	2.00	1.08	0.17	1.07	1.10	0.14	1.06	1.04	0.17	1.05
Swedish	1.41	0.78	1.14	0.96	0.17	0.93	0.91	0.15	0.91	0.91	0.13	0.90
Finnish	1.55	0.83	1.27	0.86	0.13	0.88	0.85	0.12	0.84	0.90	0.15	0.85

still took more than twice the time for pseudoword reading than required for the naming of numerals.

Table 5 shows the reading fluency results for alphabetically presented number words. Again, the reading time for the number word lists was converted into a reading time ratio (number word reading time/numeral reading time). A ratio of 1 implies that the number words are read as fast as the numerals. The results show that the English, German, Dutch, and Spanish first graders read the number words rather slowly, taking about twice or more time than required for numerals. The Swedish, French, and Finnish first graders read more fluently. Between Grades 1 and 2, there is rapid progress in the fluency of number word reading in all orthographies.

As can be seen in Table 5, the performance of Finnish, Swedish, Spanish, and French children seemed to be quite stable from Grade 2 onward. However, the larger standard deviations of especially the English and German and also the Dutch children reflect more protracted development of fluency in number word reading. An impressive finding here is that from Grade 2 onward the Finnish children read their long number words faster than the corresponding numerals. To a lesser extent, this was also the case for the Swedish children, although their number words were much shorter than those of the Finnish children.

DISCUSSION

The present study applied the pseudoword/number word/numeral reading procedure originally introduced by Wimmer and Goswami (1994) for comparing reading development of English and German children to several additional orthographies. The present results extend the original findings, the English–German replication of Landerl (2000), and the Spanish–Portuguese replication of Defior et al. (2002). They also provide additional important information on reading development in different orthographic contexts.

A key question was whether the minimal difficulty in pseudoword reading found for the young German and Spanish readers in the foregoing studies ex-

tends to other orthographies. This question is provided with a definite affirmative answer. Dutch, Swedish, French, and Finnish readers at the end of Grade 1 read the presented pseudowords with the same high accuracy as the German and Spanish children (between 80 and 90% correct), and some of these samples tended to improve further in the following grade levels. To evaluate these results, it has to be remembered that the pseudowords were presented in list format and the instructions stressed speed as well as accuracy. Therefore, some of the few errors may have resulted from reading too hastily. The conclusion is that the translation of new letter strings into acceptable pronunciations is easily acquired in all alphabetic orthographies involved in this study, with the exception of English. Other studies provide converging evidence on highly accurate pseudoword reading in more regular orthographies than English (Coenen, van Bon, & Schreuder, 1997; Cossu, Gugliotta, & Marshall, 1995; Holopainen, Ahonen, & Lyytinen, 2001; Öney & Durgunoglu, 1997; Pinheiro, 1995; Porpodas, 1989; Wimmer & Hummer, 1990). Similar results have also been shown by a number of studies where reading development in English and other orthographies have been compared (Ellis & Hooper, 2001; Frith, Wimmer, & Landerl, 1998; Goswami et al., 1998; Goswami, Ziegler, Dalton, & Schneider, 2001; Landerl, 2000; Landerl et al., 1997; Öney & Goldman, 1984; Seymour et al., 2003; Wimmer & Goswami, 1994).

This converging evidence requires a revision of English-based characterizations of reading acquisition. It has been suggested, that the acquisition of phonological recoding is the major hurdle in reading development (e.g., Share, 1995) due to the general difficulty of breaking down spoken words into phonemic segments (Liberman, 1973). However, it seems that this hurdle is easily surmounted by children reading regular orthographies. Apparently, the difficulty of phonological recoding is specific to English with its complex grapheme–phoneme relations, which are confusing for beginning readers. The problem may be aggravated when instruction does not explicitly introduce children to word recognition via phonemic assembly ("blending"). The young age of English children at school entrance may also further compound the difficulty. Landerl (2000) found that relatively accurate reading of the present pseudowords was reached earlier in a group of English children who were exposed to systematic phonics instruction. In Landerl's study, no differences were observed between the two youngest age groups in the high number of misreadings relative to either the "standard" instruction of the present English sample or the strict phonics instruction. The phonics instruction group reached the accuracy level comparable to the German children by Grade 3, whereas the standard instruction group reached the same level of accuracy by Grade 4. It should be remembered that the present English and German samples were the same as those reported by Landerl (2000).

The present observations concerning pseudoword and number word reading fluency (in relation to numerals) point towards various orthographic factors. One, of course, concerns how uniformly the letters of an orthography map onto speech sounds. This factor may have slowed down English children's reading of pseudowords in addition to exerting an effect on accuracy. It is possible that French children were also negatively affected by uncertainties about whether to

sound a silent letter. The interesting observation here is that French children were slow with pseudowords but fast with number words. In the latter case, knowledge of existing words reduces the uncertainty. An orthographic factor, which may have negatively affected German children's reading fluency of pseudowords, is the substantial number of complex graphemes (two letter graphemes, letters with diacritics).

The most impressive finding with regard to fluency is certainly the high reading speed of the Finnish children for both pseudowords and words. The Finnish children were confronted with the longest letter strings of all orthographies. However, when their reading time for these long strings was related to their reading of numerals, they turned out to be the fastest readers, together with the Swedish-speaking children. It is particularly impressive that from Grade 2 onward the Finnish children consistently read the long number words faster than the corresponding digits. Apparently, even with a relatively high number of letters, the perfectly reliable association between letters and sounds is advantageous for accessing an existing pronunciation. Furthermore, reading instruction of the Finnish children is strictly phonics based and they start school at a relatively older age. This triple advantage stands in stark contrast to the triple disadvantage of the English children.

It is also worthy of note that in this study the pseudoword reading accuracy of the French children did not reflect the supposed inconsistency of the French writing system. In fact, French children were the most accurate readers from second grade onward.[5] However, it is also interesting that the French children were among the slowest in pseudoword reading, even though they were among the fastest in number word reading. In this study, the only clear-cut differences in reading accuracy were seen between English and the other orthographies. There are at least two possible explanations for this. From a theoretical perspective, it could be hypothesized that when the number of explicit spelling to sound rules exceeds a certain threshold, the decoding skills of a beginning reader are handicapped, as well as his or her reliance in phonological assembly on the level of graphemes. Studies that examine the number of correspondences required to master the majority of English words have uncovered hundreds of relevant pairings, as summarized by Adams (1990, p. 242). In more transparent languages, even the inconsistent correspondences are generally learned in an easy and explicit manner. For example, in Spanish the pronunciation of the grapheme *c* is inconsistent but perfectly predictable, stable, and governed by a simple rule: if the following grapheme is *e* or *i* it is read /θ/; otherwise it is read /k/. Thus, it is not necessarily the high number of inconsistent words, but the high number of explicit rules required to master these inconsistencies that creates problems in reading acquisition. Methodological aspects could also explain the lack of more subtle differences between the orthographies in this study. It may be the case that, in order to expose these differences in reading performance, one would require more demanding reading materials that are carefully controlled with respect to the inconsistencies of the languages being compared. In this study, the children performed close to ceiling level with the obvious exception of English. To date, crosslinguistic studies on reading acquisition have largely concentrated on comparing English with more regular orthographies. To fully

answer the question in hand, one would also require comparisons within more consistent orthographies. Attempts to systematically quantify the feedforward and feedback consistency of different orthographies, both on the level of larger units, such as spelling bodies/rimes, and on the level of single graphemes/phonemes, would be valuable.

Finally, it should be noted that a crosslinguistic study of reading development is complicated by a number of methodological problems. In addition to orthographic differences, there may be other social and cultural factors affecting reading development that are difficult to control in a crosslinguistic study involving several countries. Furthermore, we are not claiming that the samples in this study are fully representative. The participants were selected from schools with mostly middle-class families. Thus, the data present an optimal picture of reading acquisition. Duncan and Seymour (2000) have shown that low socioeconomic status in Scotland is associated with delayed acquisition of foundation literacy skills. It remains to be confirmed whether the differences observed in the current study apply across different socioeconomic groups and whether the possible effects of socioeconomic status are similar across orthographies (countries).

However, this study does reveal a consistent pattern of findings, which are in line with earlier studies. We strongly feel that the observed pattern supports the need for future studies that attempt to clarify the specific orthographic characteristics that account for the variability in learning to read in different orthographies.

APPENDIX A

Number word and pseudoword items in each language

English		German		Dutch	
Two	Thro	Zwei	Nei	Twee	Tee
Three	Nee	Drei	Fei	Drie	Nie
Four	Nour	Vier	Zwier	Vier	Twier
Five	Twive	Fünf	Sünf	Vijf	Zijf
Six	Tix	Sechs	Vechs	Zes	Twes
Seven	Feven	Sieben	Zieben	Zeven	Veven
Nine	Thrine	Neun	Dreun	Negen	Dregen
Ten	Sen	Zehn	Zwehn	Tien	Vien
Twelve	Felve	Zwölf	Sölf	Twaalf	Zaalf

Swedish		French		Spanish	
Två	Sjå	Deux	Seux	Dos	Sos
Tre	Ne	Trois	Dois	Tres	Ces
Fyra	Tvyra	Quatre	Datre	Cuatro	Duatro
Fem	Tem	Cinq	Dinq	Cinco	Ninco
Sex	Tex	Six	Nix	Seis	Ceis
Sju	Tru	Sept	Trept	Siete	Diete
Nio	Sio	Neuf	Seuf	Nueve	Dueve

APPENDIX A (*cont.*)

Number word and pseudoword items in each language

Swedish		French		Spanish	
Tio	Fio	Dix	Quix	Diez	Siez
Tolv	Folv	Douze	Souze	Doce	Troce
Finnish					
		Kaksi	Naksi		
		Kolme	Ylmi		
		Neljä	Keljä		
		Viisi	Siisi		
		Kuusi	Vuusi		
		Seitsemän	Keimmeksan		
		Kahdeksan (8)	Katsenen		
		Kymmenen	Kyhdemän		
		Yksi (1)	Kokse		

APPENDIX B

English and French pseudoword pronunciations counted as correct

Pseudoword Item	Accepted Pronunciations	
English/French	English	French
Thro/seux	/θruː/, /θrou/, /θro/	/sø/, /søks/
Nee/dois	/niː/, /nə/	/dwa/
Nour/datre	/noːr/, /nauə/, /nau/	/datr/
Twive/dinq	/twaiv/, /twiv/, /twiːv/, /twivi/, /twivə/, /twaivi/, /twəvi/	/dɛ̃k/
Tix/nix	/tiks/	/ni/, /niks/ /nis/
Feven/trept	/fevən/, /fivən/, /fiːvən/	/trept/, /tret/
Thrine/seuf	/θrain/, /θrin/, /θriːn/, /θrini/, /θrinə/	/sœf/
Sen/quix	/sen/, /siːn/, /sin/	/ki, /kiks/, /kis/
Felve/souze	/felv/, /felvi/, /felvə/	/suz/

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NOTES

1. COST A8 was an EC network that brought together researchers sharing an interest in reading acquisition and dyslexia from 16 European countries.
2. Reading age level data were not collected because such a test was not available in some of the languages involved. However, such data were collected for the English and German samples that were originally reported by Landerl (2000).
3. The Finnish number word for 9 (*yhdeksän*) was replaced with the word for 8 (*kahdeksan*) because it begins with a vowel. Also, the number word for 12 (*kaksitoista*) was replaced with the word for 1 (*yksi*), because it is a compound word that consists of four syllables. Furthermore, exchanging only the first consonant of the three-syllable number words would have resulted in pseudowords closely resembling the corresponding word. To avoid this problem, not just the first, but all consonants/consonant combinations of the three-syllable Finnish number words were exchanged to form pseudowords. Additionally, the vowel graphemes in the final position of two pseudoword items had to be exchanged to avoid real words. Because of these modifications, the Finnish pseudowords are less similar to their corresponding number words than the pseudowords in the other orthographies.
4. It is evident that the number words and the derived pseudowords cannot be fully representative of the overall consistency in each orthography. Nevertheless, the theoretically determined number of possible pronunciations seems to be more or less in line with the hypothetical classification of orthographic depth presented by Seymour et al. (2003).
5. One of the items in the French pseudoword list, *dois* (must) is a frequent word. It is clear that children make fewer errors with familiar items. To check how much this error in item construction could have affected the results, the French pseudoword reading accuracy was recalculated by dividing the total number of errors with 32 (4×8 presentations of the remaining eight pseudoword items). With this conservative assumption that all pseudoword reading errors were distributed among the remaining eight items, the mean accuracy percentages for Grades 1–4 were 85.1, 96.3, 98.3, and 98.3%, respectively. Therefore, it seems safe to conclude that the effect of this error was minimal.

REFERENCES

Adams, M. J. (1990). *Beginning to read: Thinking and learning about print.* Cambridge, MA: MIT Press.

Coenen, M. J. W. L., von Bon, W. H. J., & Schreuder, R. (1997). Reading and spelling in Dutch

first and second graders: Do they use an orthographic strategy? In C. K. Leong & M. Joshi (Eds.) *Cross-language studies of learning to read and spell: Phonological and orthographic processing* (pp. 249–269). Dordrecht: Kluwer Academic.

Cossu, G., Gugliotta, M., & Marshall, J. C. (1995). Acquisition of reading and written spelling in a transparent orthography: Two non-parallel processes? *Reading and Writing, 7*, 9–22.

Defior, S., Martos, F., & Cary, L. (2002). Differences in reading acquisition development in two shallow orthographies: Portuguese and Spanish. *Applied Psycholinguistics, 23,* 135–148.

Duncan, L. G., & Seymour, P. H. K. (2000). Socio-economic differences in foundation-level literacy. *British Journal of Psychology, 91,* 145–166.

Elliott, C. D. (1996). *British Ability Scales II: Word reading.* Windsor, UK: NFER–Nelson.

Ellis, N. C., & Hooper, A. M. (2001). Why learning to read is easier in Welsh than in English: Orthographic transparency effects evinced with frequency-matched tests. *Applied Psycholinguistics, 22,* 571–599.

Frith, U., Wimmer, H., & Landerl, K. (1998). Differences in phonological recoding in German- and English-speaking children. *Journal of the Society for the Scientific Study of Reading, 2,* 31–54.

Goswami, U., Gombert, J. E., & de Barrera, L. (1998). Children's orthographic representations and linguistic transparency: Nonsense word reading in English, French and Spanish. *Applied Psycholinguistics, 19,* 19–52.

Goswami, U., Ziegler, J. C., Dalton, L., & Schneider, W. (2001). Pseudohomophone effects and phonological recoding procedures in reading development in English and German. *Journal of Memory and Language, 45,* 648–664.

Holopainen, L., Ahonen, T., & Lyytinen, H. (2001). Predicting delay in reading achievement in a highly transparent language. *Journal of Reading Disabilities, 5,* 401–413.

Landerl, K. (2000). Influences of orthographic consistency and reading instruction on the development of nonword reading skills. *European Journal of Psychology of Education, 3,* 239–257.

Landerl, K., Wimmer, H., & Frith, U. (1997). The impact of orthographic consistency on dyslexia: A German–English comparison. *Cognition, 63,* 315–334.

Liberman, I. Y. (1973). Segmentation of the spoken word and reading acquisition. *Bulletin of the Orton Society, 23,* 65–77.

Öney, B., & Durgunoglu, A. (1997). Beginning to read in Turkish: A phonologically transparent orthography. *Applied Psycholinguistics, 18,* 1–15.

Öney, B., & Goldman, S. R. (1984). Decoding and comprehension skills in Turkish and English: Effects of the regularity of grapheme–phoneme correspondences. *Journal of Educational Psychology, 76,* 557–568.

Pinheiro, A. M. V. (1995). Reading and spelling development in Brazilian Portuguese. *Reading and Writing, 7,* 111–138.

Porpodas, C. D. (1989). The phonological factor in reading and spelling Greek. In P. G. Aaron & R. M. Joshi (Eds.), *Reading and writing disorders in different orthographic systems* (pp. 177–190). Dordrecht: Kluwer Academic.

Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94,* 143–174.

Share, D. L. (1995). Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition, 55,* 151–218.

Wimmer, H., & Goswami, U. (1994). The influence of orthographic consistency on reading development: Word recognition in English and German children. *Cognition, 51,* 91–103.

Wimmer, H., & Hummer, P. (1990). How German-speaking first graders read and spell: Doubts on the importance of the logographic stage. *Applied Psycholinguistics, 11,* 349–368.

Ziegler, J. C., Jacobs, A. M., & Stone, G. O. (1996). Statistical analysis of the bidirectional inconsistency of spelling and sound in French. *Behavior Research Methods, Instruments & Computers, 28,* 504–515.

Ziegler, J. C., Stone, G. O., & Jacobs, A. M. (1997). What is the pronunciation for -ough and the spelling for /u/? A database for computing feedforward and feedback consistency in English. *Behavior Research Methods, Instruments & Computers, 29,* 600–618.