The Development of Reading across Languages

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A selective review is presented of empirical evidence from different languages concerning phonological development and reading development in children. It is demonstrated that the development of reading depends on phonological awareness in all languages so far studied. However, because languages vary in syllable structure and in the consistency with which phonology is represented by the orthography, there are developmental differences in the grain size of lexical representations and in the reading strategies that develop across languages. It is argued that these cross-language data can be explained by a *psycholinguistic grain size* theory of reading and its development, as proposed by Ziegler and Goswami.

Key words: **phonology; orthography; reading**

Introduction

During the course of human development, a variety of symbolic systems have been invented to represent spoken language. These include alphabetic systems, character-based systems, and Braille. The efficient use of these systems is called reading. The acquisition of reading requires social transmission (e.g., by teachers), but some cognitive prerequisites on the part of the child are also necessary. These cognitive prerequisites are generally similar across languages because the "learning problem" faced by a child acquiring reading is also similar across languages. These cognitive factors are the focus of this chapter.

The Development of Reading across Languages

Orthographies are visual codes for spoken language. Meaning is communicated via printed symbols. Reading is thus in essence the cognitive process of understanding speech when it is written down. This suggests that factors affecting the development of speech processing will also affect the acquisition of reading. For example, awareness of the phonological structure of words (the sounds making up the words and the order in which they occur) is important for both language and reading acquisition. Skilled readers may appear to access meaning directly from visual codes, but, in fact, phonological activation is mandatory for them, too (Ziegler & Goswami, 2005). Visual codes differ across languages, however, in the units of sound that are represented by print. Ziegler and Goswami (2005) termed this a difference in psycholinguistic "grain size." For example, Japanese characters (called Kana) represent individual syllables, Chinese characters (called Kanji) represent whole words, and the alphabet represents small units of sound called "phonemes." Alphabets represent phonemes with more transparency in some languages than in others. For example, Italian, Greek, and Spanish are all highly consistent in their spelling-sound correspondences: one letter makes only one sound. English, Danish, and French are markedly less consistent: one letter can make multiple sounds. For example,

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Ann. N.Y. Acad. Sci. 1145: 1–12 (2008). © 2008 New York Academy of Sciences.
doi: 10.1196/annals.1416.018

the letter *A* in English makes different sounds in the highly familiar words *man*, *make*, *car*, and *walk*. All of these factors matter in explaining cross-language differences in reading acquisition by children.

Early Phonological Development

Phonological development is an important part of language acquisition. Children need to learn the sounds and combinations of sounds that are permissible in the language that they are learning, so that their brains can develop "phonological representations" of the sound structures of individual words. Children also need to be able to produce these words themselves. Both processes require extensive development. Between the ages of 1 and 6 years, children acquire more than 14,000 words (Dollaghan, 1994). Powerful learning mechanisms are at work, such as statistical learning mechanisms. For example, babies need to learn the phonemes (individual sound elements) that make up words in their particular language. The physical changes in speech sounds where languages place phonetic boundaries are not random (Kuhl, 1986). This may explain why infants are sensitive to the acoustic boundaries that separate phonetic categories in all human languages from birth. Rapid token-based learning during the first year leads the infant brain to specialize in the phonemes particular to their language. The infants track the distributional properties of the sounds in the language that they hear and register the acoustic features that regularly co-occur. These relative distributional frequencies then yield phonetic categories (Kuhl, 2004).

Words are composed of sequences of phonemes, and so the infant also needs to group together the phonemes that make up individual words. The infant must learn which phonemes belong to one word and which phonemes belong to the next word. The rules that govern the sequences of phonemes used to make words in a particular language are called phonotactics. Infants also learn the phonotactics of their language during the first year of life, for example, by tracking the transitional probabilities between different phonemes (e.g., Jusczyk & Aslin, 1995). Furthermore, when caregivers talk to babies, they talk in a particular way (called "motherese" or "infant-directed speech"). Prosodic cues are exaggerated in infant-directed speech, and this also appears to have a learning function. The use of heightened pitch, increased duration, and exaggerated intonation appears to help babies to pick out words in the speech stream (e.g., Fernald & Mazzie, 1991). Prosodic cues also carry important information about how sounds are ordered into words when the words are multisyllabic. Therefore, by the end of the five year, infants are developing phonological representations of potential word forms that encode both lexical stress and segmental information.

The exponential increase in the number of words in the mental lexicon during the first 5 years of life poses additional challenges for phonological development. Each word has a unique phonological identity, and highly-similar words such as "back" and "bag" must be represented as distinct forms. Language-specific factors now begin to come into operation. For example, syllable structure, sonority profile, and phonological "neighborhood density" (the number of similar-sounding words to a particular target word) will all affect the development of phonological representations. These factors also affect the development of phonological awareness, which also emerges during the preschool period. Phonological awareness refers to a child's ability to detect and manipulate the component sounds that compose words at different grain sizes. For example, it is easier to become "phonologically aware" of the individual sound elements in syllables that have a simple structure (e.g., consonant-vowel or CV) than of sounds in syllables that have a complex structure (e.g., CCVCC). It is also easier to become phonologically aware of the constituent sounds in syllables when consonant phonemes are less sonorant (e.g., "at" is easier to segment than "am"). Other factors affecting the development of phonological representations are similar across languages. These include the age of acquisition of certain words, the speech-processing abilities of the child, and the "speech reading" abilities of the child (e.g., using lip-reading cues to help to distinguish sounds). As might be expected, there are some cross-language differences in the development of phonological awareness by children. There are also individual differences in the quality of the phonological representations developed by children. These individual differences turn out to be very important for the development of reading.

The Development of Phonological Awareness across Languages

The cognitive skills required for reading are usually described by the umbrella term "phonological awareness." Phonological awareness can occur at different "grain sizes." The primary linguistic processing unit is the syllable, and phonological awareness of syllables emerges first across languages. An important level of phonological awareness for literacy acquisition is awareness of "onset-rime" units. Onsets and rimes represent a grain size intermediate between syllables and phonemes. Each syllable making up a word can be decomposed into onsets, rimes, and phonemes in a hierarchical fashion. The onset-rime division of the syllable depends on dividing at the vowel. For English, words like *sing*, *sting*, and *spring* all share the same rime, the sound made by the letter string "ing." The onset of sing is /s/, the onset of sting is /st/, and the onset of spring is /spr/. These onsets make up one, two and three phonemes respectively. The rime can be divided into vowel and coda. The coda comprises any consonant sounds after the vowel. However, in many languages in the world, syllable structure is simple. Syllables are CV units. Hence for many languages, onsets, rimes, and phonemes are equivalent. Each onset and each rime in the syllable is also a single phoneme.

Prior to literacy instruction, the development of phonological awareness follows a similar developmental sequence across languages. Children first gain awareness of syllables. Syllabic awareness is usually present by around age three. Next, they gain awareness of onset-rime units. This emerges around the age of 3 to 4. Finally, children become aware of phonemes. Phoneme awareness emerges at different ages in different languages. This cross-language variation appears to depend on (1) the syllable structure of the language and (2) the transparency with which the orthography represents phonemes. It may also depend on morphology (Goswami & Ziegler, 2006).

Becoming Aware of Syllables

A number of different tasks are used across languages to measure the emergence of syllable awareness in children. Counting and tapping tasks are particularly frequent. For example, Liberman, Shankweiler, Fischer, and Carter (1974) gave American children aged from 4 to 6 years a wooden dowel and asked them to tap once for words that had one syllable (*dog*), twice for words that had two syllables (*dinner*), and three times for words that had three syllables (*president*). A criterion of six correct responses in a row was required in order for children to be accorded syllabic awareness. This criterion was passed by 46% of the 4-year-olds, 48% of the 5-year-olds, and 90% of the 6-year-olds. The 4- and 5-year-olds were prereaders, and the 6-year-olds had been learning to read for about a year.

A counting task was devised by the Russian psychologist Elkonin (1963). In this task, children are given plastic counters and are asked to use them to represent the number of syllables in words of increasing length. Treiman and Baron (1981) gave a syllable counting task to 5-year-old prereaders. For example, if the experimenter said "butter," the child had to set out two counters. Treiman and Baron (1981) also reported good syllable awareness in these prereaders. A less cognitively demanding task is the same–different judgment task. In this task, children have to decide whether two words share the same sound. Treiman and Zukowski (1991) gave children pairs of words like "hammer–hammock," and "compete–repeat," which share the first and second syllable, respectively. They found that 100% of 5-year-olds, 90% of 6-year-olds, and 100% of 7-year-olds succeeded in the same–different judgment task at the syllable level.

Similar performance levels are found in other languages. For example, Cossu, Shankweiler, Liberman, Katz, and Tola (1988) gave the tapping task to Italian prereaders aged 4 to 5 years, and to schoolchildren being taught to read aged 7 to 8 years. The children were asked to tap once for each syllable in words like "gatto," "melone," and "termometro." Syllable awareness was shown by 67% of the 4-year-olds, 80% of the 5-year-olds, and 100% of the school-age sample. Durgunoglu and Oney (1999) gave the tapping task to 6-year-old Turkish kindergartners, and performance was 94% correct at the syllable level. Hoien, Lundberg, Stanovich, and Bjaalid (1995) gave the syllable counting task to 128 Norwegian preschoolers aged 7 years. The children were asked to make pencil marks for each syllable in a word (e.g., "telephone" = 3 marks). They performed at an 83%-correct level. Counting tasks were also given to German preschoolers by Wimmer, Landerl, Linortner, and Hummer (1991) and to French kindergarteners by Demont and Gombert (1996). The German preschoolers performed at 81% correct in the syllable-counting task, and the French children performed at 69% correct. Clearly, prereading children across languages have good syllable awareness prior to receiving instruction in literacy.

Becoming Aware of Onsets and Rimes

The most widely used measure of onset-rime awareness in preschool children has been the oddity task (or odd-man-out task), which was devised by Bradley and Bryant (1978). Children listen to an experimenter saying three or four words and are asked to select the "odd word out" on the basis of either the initial sound, the medial sound, or the final sound (e.g., *bus*, *bun*, *rug*; *pin*, *bun*, *gun*; *top*, *doll*, *hop*). When Bradley and Bryant (1983) gave the oddity task to around 400 preschool English children aged 4 to 5 years, average performance was 56% correct with onsets (initial sound task) and 71% correct with rimes (medial and final sounds tasks). Both performance levels were well above chance (33% correct). The same–different judgment task can also be used at the onset-rime level. For example, word pairs like "plank–plea" share the onset, and words like "spit–wit" share the rime. In the study mentioned earlier by Treiman and Zukowski (1991), 56% of the 5-year-olds, 74% of the 6-year-olds, and 100% of the 7-year-olds made accurate onset-rime judgments. Rime awareness can also be measured by asking children to complete nursery rhymes. Bryant, Bradley, Maclean, and Crossland (1989) asked 3-year-olds to complete familiar nursery rhymes by supplying missing rhyming words, such as "Jack and Jill went up the ? [hill]." The mean score for the group was 4.5 out of 10, and only one child out of 64 could complete no nursery rhymes. Hence onset-rime awareness is also well established in young children prior to schooling.

Again, a similar developmental picture is found in other languages. Chukovsky (1963) collected a large corpus of Russian children's language games and poems, and noted that the children were fascinated by rhymes. For example, Tania, aged 2.5 years, made up the following poem:

> Ilk, silk, tilk
> I eat Kasha with milk.
> Ilks, silks, tilks,
> I eat Kashas with milks.

The oddity task has been given to prereaders in a variety of languages. When Wimmer, Landerl, and Schneider (1994) tested German kindergartners, group performance was 44% correct with onsets and 73% correct with rimes. Wimmer *et al*. used sets of four words in order to increase task difficulty for these older children (German children do not go to school until age 6). Ho and Bryant (1997) gave Chinese 3-year-olds a rhyme-oddity task and found that performance was 68% correct. Hoien *et al*. (1995) gave their Norwegian preschoolers a match-to-sample rhyme task in which children had to select one picture out of three that rhymed with a target picture. Performance was 91% correct. Finally, Porpodas (1999) devised a Greek version of the oddity task. He reported that first-grade 7-year-old children in Greece scored 90% correct. As with syllables, therefore, cross-language data suggest that pre-reading children across languages have good onset-rime awareness prior to receiving instruction in literacy.

Becoming Aware of Phonemes

This developmental picture of cross-language consistency does not hold for the development of phoneme awareness (Ziegler & Goswami, 2005). This is not particularly surprising, as the phoneme is not a natural speech unit. The concept of a phoneme is an abstraction from the physical stimulus. For example, the "a" phoneme in "bag" and "back" is not exactly the same physical sound. In natural speech, acoustic features such as voicing determine phonetic differences (such as the difference between /p/ and /b/). Via prototype formation, the brain groups some similar but nonidentical sounds (called allophones) as the phoneme /b/ and many other similar but nonidentical sounds as the phoneme /p/. This grouping depends on acoustic features. The mechanism for learning about the abstract unit of the phoneme seems to be learning about letters. Letters are used to symbolize phonemes, even though the physical sounds corresponding, for example, to the vowel in "bag" and "back" are rather different. This means that the development of phoneme awareness depends in part on the consistency with which letters symbolize phonemes. It also depends on the complexity of phonological syllable structure. Accordingly, there is cross-language divergence in the rate of development of phonemic awareness.

These cross-language differences in the development of phoneme awareness have been shown using a variety of cognitive tasks. One popular task has been phoneme counting. This is often used as a comparison task to syllable counting. For example, Wimmer *et al*. (1991) used a phoneme counting task in their German study, Demont and Gombert (1996) used a phoneme counting task in their French study, and Hoien *et al*. (1995) used a phoneme counting task in their Norwegian study. The German preschool children performed at 51% correct, the French preschool children performed at 2% correct, and the Norwegian kindergartners performed at 56% correct. Durgunoglu and Oney (1999) used a phoneme tapping task in their Turkish study, and the Turkish children performed at 67% correct. The Italian children studied by Cossu *et al*. (1988) were also given a phoneme tapping task. In their study, the criterion was reached by 13% of the 4-year-olds and 27% of the 5-year-olds. In English, as in French, phoneme counting tasks are typically performed rather poorly. For example, Liberman *et al*. (1974) reported levels of 0% correct for their 4-year-olds, and 17% correct for their 5-year-olds.

Clearly, the children in these different cross-language studies are already showing some language-specific variation in the ease with which they can identify individual phonemes in words. However, these different samples were not matched for any cognitive variables, and the words that they were asked to analyze were not matched either. Nevertheless, these differences by language become even more marked as children are taught to read. For example, in Cossu *et al*.'s Italian sample, 97% of the school-aged children were able to tap out phonemes. In contrast, in Liberman *et al*.'s American sample, phoneme tapping was at 70% correct when the children had been learning to read for about a year. Studies of English-speaking first-grade children by Tunmer and Nesdale (1985) and of second-grade children by Perfetti, Beck, Bell, and Hughes (1987) report comparable success levels (of 71% and 65%, respectively). Children learning to read other transparent languages typically score at levels more comparable to those of the Italian children. In studies using the phoneme counting measure, Turkish first-graders scored at 94% correct, Greek first-graders at 100% correct, and German first-graders at 92% correct (Durgunoglu & Oney, 1999; Harris & Giannouli, 1999; Wimmer *et al.*, 1991). In contrast, French children are more similar to English-speaking children. In their study, Demont and Gombert (1996) reported that by the end of first grade, group performance in the phoneme counting tasks was at 61% correct. Clearly, phoneme awareness develops at different rates in children who are learning to speak and read different languages.

Longitudinal Connections between Phonological Awareness and Reading

Despite this cross-language variability, preschool differences in phonological awareness predict reading and spelling development across languages. This has been shown most convincingly by longitudinal studies. These studies measure phonological awareness prior to school entry and then explore whether individual differences in phonological awareness predict children's performance in standardized tests of reading and spelling 2 to 3 years later. In order to measure whether there is a specific connection between phonological awareness and progress in literacy, other cognitive variables such as individual differences in intelligence or in memory must also be measured. These variables can then be controlled in longitudinal analyses seeking to establish a connection between phonological awareness and reading.

One of the first longitudinal studies of this nature was reported by Lundberg, Olofsson, and Wall (1980), who gave 143 Swedish children a range of phonological awareness tests in kindergarten. The tests used included syllable blending, syllable segmentation, rhyme production, phoneme blending, phoneme segmentation, and phoneme reversal. Predictive relationships between these tests and reading attainment were then measured in the second grade. Lundberg *et al*. reported that both the rhyme test and the phoneme tests were significant longitudinal predictors of reading. Another longitudinal study was reported by Bradley and Bryant (1983), using English children, who administered the oddity task to 400 preschool children at ages 4 and 5 years; they then tested the same children when they were aged (on average) 8 and 9 years. At follow-up, the children were given standardized tests of reading, spelling, and reading comprehension, and their performance was adjusted for age and I.Q. Bradley and Bryant reported significant correlations between performance on the oddity task at ages 4 and 5 and reading and spelling performance 3 years later. When the effects of I.Q. and memory were removed in multiple regression equations, the oddity task accounted for up to 10% of unique variance in reading. Similar results with English-speaking samples have been reported by a number of other research groups. For example, Baker, Fernandez-Fein, Scher, and Williams (1998) measured nursery rhyme knowledge in 39 kindergarten children and reported that it was the strongest predictor of nonword decoding and word identification skills measured in second grade. Rhyme knowledge at time 1 and at time 2 accounted for 36% and 48%, respectively, of unique variance in nonword decoding and word identification. The second strongest predictor of reading at time 2 was letter knowledge, which accounted for an additional 11% and 18% of the variance in each measure, respectively.

A German replication of Bradley and Bryant's study was reported by Wimmer *et al.* (1994). They followed up 183 German kindergartners who had received the oddity task at age 6 (in kindergarten) one year later (at first grade), and again 3 years later. When the German children were 7 to 8 years old (the same age as the English children in Bradley and Bryant's study), performance in the oddity task was only minimally related to reading and spelling progress. However, at the 3 year follow-up, when the children were aged (on average) 9 years 9 months, Wimmer *et al*. reported that rime awareness (although not onset awareness) was significantly related to both reading and spelling development. The Norwegian preschoolers studied by Hoien *et al*. (1995) were also followed longitudinally. When reading was tested in first grade, it was found that syllable, rhyme, and phoneme awareness all made independent contributions to variance in reading. The Chinese preschoolers studied by Ho and Bryant (1997) were also followed longitudinally. These 100 children were given the rime oddity task when they were 3 years old, and their progress in reading and spelling was assessed two years later. Phonological awareness was found to be a significant predictor of reading even after other factors such as age, I.Q., and mother's educational level had been controlled.

From this brief survey of studies, it is clear that individual differences in phonological awareness predict individual differences in reading attainment in all languages so far studied. Ho and Bryant's data show that this relationship between phonology and reading acquisition is equally strong for children who are learning to read nonalphabetic scripts (see also Siok & Fletcher, 2001). Because the children in these studies are preschoolers, the measures of phonological awareness used tend to be syllable, onset, and rime measures. However, once children are learning to read, individual differences in phoneme awareness also become predictive of individual differences in literacy attainment (Ziegler & Goswami, 2005). A similar cross-language picture emerges for developmental dyslexia. Deficits in phonological awareness predict developmental dyslexia across all languages so far studied, but the manifestation of developmental dyslexia varies with the language that the child is learning to read (see Ziegler & Goswami, 2005, for a detailed cross-language survey). For example, in most European orthographies dyslexia is diagnosed on the basis of poor spelling rather than poor reading. Children with dyslexia who are learning to read transparent orthographies can become accurate decoders, although decoding remains very slow and effortful for these children, making them functionally dyslexic.

Phonological Awareness and Reading: Psycholinguistic Grain Size Theory

Theoretically, we (Ziegler & Goswami, 2005; 2006) have proposed that there are at least two language-dependent reasons for the cross-language variation that is found in reading acquisition and in developmental dyslexia. One is the phonological structure of the syllable. As noted earlier, syllables can be simple (CV) or complex (CCVCC). For many of the world's languages, the most frequent syllable type is CV. Languages like Spanish, Italian, Finnish, and Turkish contain predominantly CV syllables. In other languages, like English and German, syllable structure is more complex. The most frequent syllable type in English is CVC, with this structure accounting for 43% of monosyllables (e.g., "cat," "dog," "soap") (De Cara & Goswami, 2002). There are also many CCVC syllables (15% of monosyllables, e.g., "trip" and "spin"), CVCC syllables (21% of monosyllables, e.g., "fast" and "jump"), and some CCVCC syllables (6%, e.g., "trust"). Although a language like German has fewer monosyllables overall (approximately 1,400 compared to approximately 4,000 for English), phonological structure is similar. German has syllables with complex onsets, like "Pflaume" and syllables with complex codas like "Sand."

For languages like Italian and Spanish, onset-rime segmentation of the syllable is usually equivalent to phonemic segmentation. An Italian child who segments an early-acquired word like "Mamma" at the onset-rime level will also arrive at the phonemes comprising this word (e.g., /m/ /a/ /m/ /a/). Only 5% of English monosyllables follow the CV pattern (see De Cara & Goswami, 2002; examples are "go" and "see"). For languages like English and German, onset-rime segmentation is usually not equivalent to phoneme segmentation. For words like "dog," "spin," "jump," and "crust" both onsets and rimes can contain clusters of phonemes. Accordingly, another cognitive step is required to reach the phoneme level. Complex onsets like "sp" and complex rimes like "ust" must be segmented further. Other phonological factors will also contribute to the cross-language ease or difficulty of becoming aware of phonemes. For example, languages differ in the sonority profile of their syllables. Vowels are the most sonorant sounds, followed in decreasing order by glides (e.g., /w/), liquids (e.g., /l/), nasals (e.g., /n/), and obstruents or plosive sounds (e.g., /p/). Whereas the majority of syllables in English end with obstruents (almost 40%), the majority of syllables in French either end in liquids or have no coda at all (almost 50%).

The second important factor in explaining cross-language differences in phonemic awareness is orthographic transparency. Languages like Greek, German, Spanish, and Italian have a one-to-one mapping between letters and sounds. In these languages, letters correspond consistently to one phoneme. Languages like English have a one-to-many mapping between letters and sounds. Some letters or letter clusters can be pronounced in more than one way, for example, *O* in "go" and "to," *EA* in "speak" and "steak," and *G* in "magic" and "bag" (Berndt, Reggia & Mitchum, 1987; Ziegler, Stone & Jacobs, 1997). It is easier for a child to become aware of phonemes if one letter consistently maps to one and the same phoneme. It is relatively difficult to learn about phonemes if a letter can be pronounced in multiple ways (see Ziegler & Goswami, 2005, 2006, for more detailed arguments).

This theoretical analysis predicts that children learning to read in languages like Italian and Spanish should find it easiest to become aware of phonemes. They are learning languages with predominantly CV syllables, so that onset-rime segmentation and phonemic segmentation are equivalent, and their written language consistently represents one phoneme by one letter. Children learning to read in languages like German should have a more difficult time, because spoken syllables are complex in structure. Nevertheless, German has a one-to-one mapping from letter to sound, facilitating the process of becoming aware of phonemes. Children who are learning to read in languages like English and French should have the most difficult time. These children are learning languages with a complex syllable structure and an inconsistent orthography. The cross-language comparisons discussed above confirm that it takes children longer to learn about phonemes in languages like English and French compared to languages like Italian and Spanish. As shall be discussed next, cross-language data on early reading acquisition also show that learning to decode efficiently takes longer in languages like English and French compared to languages like Spanish, German, and Italian.

Learning to Decode in Different Languages

These two factors of syllable structure and orthographic transparency also lead to cross-language differences in the rate at which children acquire reading skills. The children who acquire decoding skills most rapidly are those who are learning to read spoken languages with simple (CV) syllables and consistent letter-sound correspondences. Finnish, Italian, Greek, and Spanish children all learn to read very rapidly once they go to school and receive direct instruction in grapheme–phoneme correspondence. Graphemes are alphabetic units that make a single sound, for example, the phoneme /f/ can be represented by the grapheme "ph." Children who are learning to read spoken languages with more complex syllable structure, but nevertheless largely consistent letter-sound correspondences, also learn to read rapidly. German, Swedish, Dutch, Norwegian, and Icelandic children provide good examples. Children who are learning to read spoken languages with phonologically complex syllables and with inconsistent letter–sound correspondences acquire decoding skills rather more slowly, such as Portuguese, Danish, and English children. English children make the slowest progress because English orthography has a rather high degree of inconsistency in symbol–sound mappings, and these inconsistencies occur for both reading and spelling (i.e., from orthography to phonology, and from phonology to orthography). Children who are learning to read English need to develop decoding strategies at a variety of grain sizes (e.g., whole-word strategies, rhyme analogy strategies and grapheme–phoneme recoding) (Ziegler & Goswami, 2005, 2006).

A striking illustration of the cross-language variability in the efficiency with which children acquire grapheme–phoneme recoding strategies during the first year of being taught to read comes from a study reported by Seymour, Aro, and Erskine (2003). They compared real word and nonword reading by children who were learning to read one of 14 European Union languages at the same time point during the first year of reading instruction. These first-grade children varied in age across the different E.U. countries, but they were chosen so that all were attending schools using "phonics" based (grapheme–phoneme based) instructional programs (Seymour *et al.*, 2003). The age differences were unavoidable, as (for example) children in England and Scotland begin school at age 5, whereas Scandanavian children begin school at age 7. The word and nonword items used were matched for difficulty across the languages, and the data are shown in Table 1. As can be seen, the efficiency of grapheme–phoneme recoding approached ceiling level during the first year of teaching for most of the European languages. Children learning to read languages like Finnish, German, Spanish, and Greek were decoding both words and nonwords with accuracy levels above 90%. In contrast, children learning to read French (79% and 88% correct), Danish (71% and 63% correct) and Portuguese (73% and 76% correct) were less-efficient readers, reflecting the reduced orthographic consistency of these languages. The children learning to read in English showed the slowest rates of acquisition, reading 34% of the simple words and 29% of the simple nonwords correctly. When followed up a year later, these children were achieving levels of 76% for real words and 63% for nonwords, still short of the early efficiency shown by the Finnish and Germans (Seymour *et al.*, 2003).

TABLE 1. Data (% Correct) from the Cross-Language Study of Grapheme–Phoneme Recoding Skills for Monosyllables in 14 European Languages

Language	Familiar Real Words	Nonwords
Greek	98	97
Finnish	98	98
German	98	98
Austrian German	97	97
Italian	95	92
Spanish	95	93
Swedish	95	91
Dutch	95	90
Icelandic	94	91
Norwegian	92	93
French	79	88
Portuguese	73	76
Danish	71	63
Scottish English	34	41

[a]Adapted from Seymour, Aro, and Erskine (2003).

The problems experienced by the English children are not surprising in terms of the cross-language observations made earlier. The English children were learning a symbol system with inconsistent correspondences at the phoneme level, and they also had to match these symbols to phonemes that were embedded in complex syllables. In fact, the learning problem facing beginning readers across orthographies can be analyzed systematically using psycholinguistic grain size theory (see Ziegler & Goswami, 2005, 2006, for more detail). Ziegler and Goswami argue that, in general, there are more developmental similarities than differences across languages. Beginning readers across languages are faced with three problems: availability, consistency, and the granularity of symbol-to-sound mappings.

The availability problem reflects the fact that not all phonological units are accessible prior to reading. As we have seen, phonemes in particular may be inaccessible to prereaders. Furthermore, phonemic awareness develops at different rates in different languages, depending on orthographic consistency. The grain sizes that are most accessible prior to reading (syllables and onset-rimes) frequently do not correspond to the visual symbols used to represent phonology. Hence there may be a mismatch between the grain size represented by the orthography and the phonological grain sizes of which the child is aware. The severity of the mismatch will depend on the phonological and orthographic characteristics of the language. For example, a Japanese child, who is learning visual symbols that represent syllables (an early-developing grain size), should be at an advantage compared to an English child, who is learning letters that represent phonemes (a later-developing grain size, at least for languages where onset-rime units are not equivalent to phonemes).

Next, the consistency problem refers to the fact that the alphabet represents phonemes with more transparency in some languages than in others. As we have seen, Italian, Greek, and Spanish are all highly consistent in their spelling–sound correspondences. For these languages, one letter makes only one sound for reading. English, Danish and French are markedly less consistent in their spelling–sound correspondences, as, in reading, one letter can make multiple sounds. Although sound–spelling consistency can vary across languages as well (e.g., "feedback inconsistency," where one sound pattern has multiple spellings as in "hurt," "skirt," "Bert"), in terms of initial reading acquisition it is "feedforward inconsistency" (from spelling to sound) that appears to be the most influential in slowing development. English has an unusually high degree of "feedforward" inconsistency. This creates problems for beginning readers in English, who have to decode words like "though," "cough," "through," and "bough."

Finally, the granularity problem refers to the fact that there are many more orthographic units to learn when access to the phonological system is based on bigger grain sizes as opposed to smaller grain sizes. That is, there are more words than there are syllables, there are more syllables than there are rimes, there are more rimes than there are graphemes, and there are more graphemes than there are letters. Ziegler and Goswami (2005, 2006) argued that reading proficiency in a particular language will depend on the resolution of all three of these problems. For example, children learning to read English must develop whole-word recognition strategies in order to read irregular words like "cough" and "yacht," they need to develop rhyme analogy strategies in order to read irregular words like "light," "night," and "fight," and they need to develop grapheme–phoneme recoding strategies in order to read regular words like "cat," "pen," and "big." In contrast, for many other languages, children only need to develop grapheme–phoneme recoding strategies in order to become highly skilled readers.

Conclusions

Learning to read in different languages depends on phonological awareness. During language acquisition, most children develop phonological awareness of syllables and of onset-rime units via the speech-processing skills that yield acoustic features and phonotactics and by processing prosodic cues such as duration and stress. However, there are variations between languages in syllable structure and in orthographic transparency which lead to cross-language divergence in the rate at which phonemic awareness is achieved and to cross-language divergence in the rate at which decoding skills develop. A way of describing the factors that determine the development of reading in different languages is offered by psycholinguistic grain size theory (Ziegler & Goswami, 2005, 2006).

Conflicts of Interest

The authors declare no conflicts of interest.

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