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# Why learning to read is easier in Welsh than in English: Orthographic transparency effects evinced with frequency-matched tests

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ABSTRACT
This study compared the rate of literacy acquisition in orthographically transparent Welsh and orthographically opaque English using reading tests that were equated for frequency of written exposure. Year 2 English-educated monolingual children were compared with Welsh-educated bilingual children, matched for reading instruction, background, locale, and math ability. Welsh children were able to read aloud accurately significantly more of their language (61% of tokens, 1821 types) than were English children (52% tokens, 716 types), allowing them to read aloud beyond their comprehension levels (168 vs. 116%, respectively). Various observations suggested that Welsh readers were more reliant on an alphabetic decoding strategy: word length determined 70% of reading latency in Welsh but only 22% in English, and Welsh reading errors tended to be nonword mispronunciations, whereas English children made more real word substitutions and null attempts. These findings demonstrate that the orthographic transparency of a language can have a profound effect on the rate of acquisition and style of reading adopted by its speakers.

Systems that are noisy and inconsistent are harder to sort out than systems that are reliable and categorical. There is now a large body of research demonstrating that greater ambiguity in the mappings between the forms and functions of a particular language causes less successful learning because of a larger degree of competition among the cues in the learning set (Bates & MacWhinney, 1987; MacWhinney, 1987). Constructivist, emergentist, and connectionist perspectives on language acquisition emphasize that human rulelike processing of the structural regularities of language emerges from learners' lifetime analysis of the distributional characteristics of the language input (MacWhinney, 1999). Some cues are more reliable than others, and the language learner's task is to work out the most valid predictors. The Competition Model shows how Bayesian cue use can resolve in the activation of a single interpretative hypothesis from an interaction of cues, which vary in their frequency, reliability, and validity (MacWhinney, 1997).

These processes pervade all domains of language acquisition. Consider, for example, how the acquisition of grammatical gender is determined by the degree of transparency of its morphophonological marking. Brooks, Braine, Catalano, Brody, and Sudhalter (1993) demonstrated that children and adults showed better learning of the noun subclasses of artificial languages when ambiguity was reduced by there being a subset of nouns of each subclass that shared a phonological feature than in a condition in which the phonological features were less reliable cues in distinguishing the subclasses. Taraban and Roark (1996) manipulated the ambiguity in the mapping of noun forms onto genders in two sets of French nouns and showed that learning the same set of feminine nouns took longer if the nouns in the masculine class were, as a set, more ambiguous in the mappings of their noun endings onto gender. This demonstration is important because it illustrates how the presence of nontransparent marking not only affects the speed at which the nontransparent items themselves are acquired but also slows the learning of the whole system. Recent studies have simulated language-learning data using simple connectionist models that relate cues and their functional interpretations. For example, the simulations of Kempe and MacWhinney (1998) showed why the Russian case inflection system is acquired more rapidly than is that of German: even though case marking in Russian is more complex than in German, the Russian inflections are more reliable cues to sentence interpretation.

One area in which the effect of consistency of mapping has been extensively researched is that of relating symbols and their sounds in reading aloud. To the extent that readers are able to construct the correct pronunciations of novel words or nonwords, they must be able to apply sublexical rules or mappings that relate graphemes and phonemes (Coltheart, Curtis, Atkins, & Haller, 1993; Patterson & Morton, 1985) or larger orthographic units and their corresponding rimes or syllables (Ehri, 1998; Glushko, 1979; Goswami, 1999; Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995), and it is likely that it is the operation of this system that explains why regular or consistent words are read better than irregular or inconsistent words. For the case of adult fluency in English, words with regular spelling–sound correspondences (such as *mint*) are read with shorter naming latencies and lower error rates than words with exceptional correspondences (such as *pint*; Coltheart, 1978); in development, the reading of exception words (*blood*, *bouquet*) is acquired later than that of regular words (*bed*, *brandy*; Coltheart & Leahy, 1996). Similarly, in fluent performance, words that are consistent in their pronunciation in terms of whether this agrees with those of their neighbors with similar orthographic body and phonological rime (*best* is regular and consistent in that all *-est* bodies are pronounced in the same way) are named faster than inconsistent items (*mint* is regular in terms of its GPC rule, but inconsistent in that it has *pint* as a neighbor) (Glushko, 1979). The magnitude of the consistency effect for any word depends on the summed frequency of its "friends" (similar spelling pattern and similar pronunciation) in relation to that of its "enemies" (similar spelling pattern but dissimilar pronunciation) (Jared, McRae, & Seidenberg, 1990). Adult naming latency decreases monotonically with increasing consistency on this measure

(Taraban & McClelland, 1987). In development, Laxon, Masterson, and Coltheart (1991) showed that within regular words, consistent (*pink*, all *-ink*) and consensus (*hint*, mostly as in *mint*, but cf. *pint*) items are acquired earlier than ambiguous ones (*cove* versus *love*, *move*), and that within irregular words, those in deviant gangs (like *look*, *cold*, and *calm*) are acquired earlier than ambiguous ones (*love*). According to the power law of learning that relates reaction time to amount of exposure, performance converges asymptotically at high levels of practice, and thus these effects of regularity and consistency are more evident with low-frequency words than with high-frequency ones (Seidenberg, Waters, Barnes, & Tanenhaus, 1984). As with the learning of other quasiregular language domains, these effects of consistency and ambiguity of spelling–sound correspondence within language have been successfully simulated in connectionist (Harm & Seidenberg, 1999; Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland 1989; Zorzi, Houghton, & Butterworth, 1998) and exemplar-based (Ellis & Hicks, 2000) computational models.

These investigations have compared the learnability and processing of words of different degrees of spelling–sound ambiguity within a language. What about the large cross-linguistic issue: what are the effects of the overall ambiguity of a language's symbol–sound mappings on its speakers' rate of literacy acquisition? The orthographies of languages such as Finnish, Italian, Spanish, Dutch, Turkish, and German are, on the whole, much more transparent than those of opaque languages such as English and French. In transparent orthographies, the mappings from letters to sounds are consistent. In opaque orthographies, the same grapheme many represent different phonemes in different words, and, as just illustrated for English, there are many words that are irregular in terms of the default grapheme–phoneme rules. It seems likely that these language differences in overall orthographic transparency have a determining effect on rate of reading acquisition, segmental phonological awareness, reading strategy, and reading disorder. We will briefly consider each in turn.

### *Rate of reading acquisition*

Theories of reading acquisition in alphabetic languages commonly hold that there is a prolonged alphabetic stage of reading in which words are decoded on the basis of learned symbol–sound associations, and that this provides the practice that allows for the eventual development of skilled orthographic reading abilities (e.g., Ehri, 1979, 1998; Frith, 1985; Goswami, 2000; Marsh, Friedman, Welch, & Desberg, 1981). An orthographic transparency hypothesis therefore predicts that children learning to read a transparent orthography, in which sound–symbol mappings are regular and consistent, should learn to read and spell faster than those learning an opaque orthography, in which the cues to pronunciation are more ambiguous. Empirical research supports this prediction; for example, children learning to read German were more able to read their transparent orthography instantiation of pairs of translation equivalents (e.g., *Pflug–plough*) than were matched learners of English (Landerl, Wimmer, & Frith, 1997); Spanish children were able to read more of a sample of eight monosyllabic and eight disyllabic words in their language than were matched French or English children (Goswami, Gombert, & De Barrera, 1998); and Turkish children are able to read and spell with high degrees of accuracy by the end of the first grade (Öney & Durgunoglu, 1997).

### *Segmental phonological awareness*

Whereas young children are aware of the structure of spoken language at the syllable, onset, and rhyme levels, the representation of segmental information at the phoneme level seems partly dependent on learning to read an alphabetic orthography. The written graphemes provide explicit feedback that clarifies the phonemic code (Brown & Ellis, 1994; Bradley & Bryant, 1983; Ellis & Large, 1987; Goswami & Bryant, 1990; Morais, Alegria, & Content, 1987; Wimmer, Landerl, Linortner, & Hummer, 1991), and explicit focus on the representations of sounds as they are written during spelling instruction seems to push along the acquisition of explicit phoneme segmentation abilities (Ellis & Cataldo, 1990; Frith, 1985; Goswami & Bryant, 1990). This suggests that the representation of phonemic information as a consequence of the acquisition of reading should depend on the degree of consistency or ambiguity of the system of symbol–sound mappings in a language. Research has demonstrated this to be so: phonemic segmentation develops in a rapid spurt in languages such as Greek or German, in which such graphemic feedback is a reliable index of segmental phonology, and it tends to be more protracted in orthographies such as French or English, which are more ambiguous in this respect (Cossu, Shankweiler, Liberman, Katz, & Tola, 1988; Frith, Wimmer, & Landerl, 1997; Goswami et al., 1998; Goswami, Porpodas, & Wheelwright, 1997; Wimmer & Goswami, 1994). Onset-rime awareness is a predictor of reading development for English, with its relatively high degree of spelling–sound consistency at the level of rime compared to the level of the vowel phoneme, but not in German, in which phoneme awareness is a much stronger predictor (Wimmer et al., 1991; Wimmer, Landerl, & Schneider, 1994).

### *Reading strategy*

Just as fluent readers' ability to read nonwords demonstrates the availability of a synthetic route to reading in which the pronunciation is assembled on the basis of known symbol–sound associations, so their ability to pronounce irregular or inconsistent words implicates the availability of a direct reading route in which the word as a whole is used to access its pronunciation. Ab initio readers sometimes treat words like pictures and learn to relate the overall word shape to the word name. This first phase of logographic reading is a natural consequence of the use of flash cards and look-and-say methods. Skilled readers, on the other hand, access pronunciation of the word as a whole on the basis of an analysis of the orthographic sequence of letters. Learners of English thus use different balances of predominance of different strategies of reading at different stages of development: they move from logographic whole-word lookup, through an alphabetic stage where phonology is assembled, to skilled reading, which is predominantly orthographic whole-word lookup, at least for high-frequency words (Frith, 1985; Marsh et al., 1981). Readers of transparent orthographies are more likely to succeed in reading by means of alphabetic reading strategies than readers of oblique orthographies, and their differential histories of success or failure may well bias the reading strategy adopted by these learners, with readers of transparent scripts being more likely to rely on alphabetic reading strategies.

Again, there is support in the literature for this. Learners of German (Wimmer & Goswami, 1994) and Spanish (Lopez & Gonzalez, 1999) are more able to read nonwords than are learners of English (Rack, Snowling, & Olson, 1992). Öney, Peter, and Katz (1997) showed that readers of Turkish are more likely to use synthetic phonology during word recognition, in that they were more affected by a spoken pseudoword prime that rhymed with the target words, than were American children – although, in support of stage theories of reading development, this disparity was greatest with beginning, second, and fifth grade readers, and diminished in college students. Finally, adherence to an alphabetic decoding strategy is likely to produce errors that are mispronunciations that do not sound like real words, whereas whole-word reading strategies are more likely to generate erroneous real-word response errors. Accordingly, Wimmer and Hummer (1990) showed that the majority of German children's reading errors were nonwords, whereas young children reading English make frequent (wrong) real-word errors (Seymour & Elder, 1986; Stuart & Coltheart, 1988).

### *Reading disorder*

Orthographically ambiguous languages such as English may be expected to pose much more of a challenge in learning the symbol–sound pairings for children who are impaired in phonological processing. Goswami (2000) argued that phonological deficits should be more associated with difficulties in learning to read opaque orthographies than transparent languages. Again, there is some evidence in support of this. Many children who are developmentally dyslexic in English have phonological-processing deficits (Ellis, 1981; Frith, 1981; Snowling, 1998; Vellutino, 1979), to the degree that Frith characterized the disorder as "a failure of alphabetic skills" (Frith, 1985, p. 324). German dyslexic children, however, show much less marked difficulties in reading nonwords, a task that indexes phonemic recoding ability (Landerl, Wimmer, & Frith, 1997), although they do show speed deficits. In contrast to English dyslexic children, Dutch dyslexics show no deficits in phonological awareness at the syllable and rhyme levels and their problems on phoneme deletion tasks do not persist into adulthood (De Gelder & Vroomen, 1991), whereas such difficulties do remain in adult English dyslexics (Bruck, 1992).

Taken together, these findings suggest that orthographically transparent languages (a) promote faster rates of reading and spelling acquisition, (b) allow faster development of phonemic awareness, (c) encourage an alphabetic reading strategy, and (d) protect, to some extent, against phonological deficits as a cause of developmental dyslexia. However, there is one long-standing difficulty in these cross-linguistic comparisons: they compare children who have learned to read different languages but who have also been taught by different teachers, in different classrooms, in different schools, using potentially different methods of instruction, and in different cultures. It is hard to control all of these potential confounds.

Britain affords an interesting contrast of written languages with the extreme opacity of English alongside the very transparent Welsh orthography, and the particular milieux of North Wales may allow more control of these instructional and cultural potential independent variables than has been possible in prior studies. The writing system of Welsh is so regular, with the mappings from graphemes to phonemes being so consistent and unambiguous, that Welsh dictionaries never include pronunciation entries for the lexis (Ball & Jones, 1984; see Williams, 1994, for a full description of the text-to-speech synthesis rules). Phonemes can be represented with either single or double letter graphemes. There are 29 letters in the Welsh alphabet, including several letter combinations (*ch*, *dd*, *ff*, *ng*, *ll*, *ph*, *rh*, *th*), which each represent one sound. As in English, vowels (*a*, *e*, *i*, *o*, *u*, *w*, *y*) can be either long or short. As shown in Appendix A, with consonant graphemes there is almost a one-to-one mapping between grapheme and phoneme, even the consonant digraphs are invariant (e.g., *ff* for /f/). The vowels are a little more problematic. Orthographic *y* may be realized as a schwa in nonfinal syllables of polysyllables; it may also represent the first nonvocalic part of a diphthong (*yw*, /iu/), or the second consonantal part of the diphthong (wy, /ui/). Welsh also permits epenthetic vowels, these being vowels that are pronounced but are not shown in the orthography. The graphemes *i* and *w* are also variable – *i* can be either a long or short vowel (/ii/, /i/), or the palatal glide /j/. The grapheme *w* is the hardest to realize, with four or five possible interpretations. Notwithstanding these few irregularities (this list is reasonably exhaustive), Welsh is a highly transparent orthography in comparison to English, in which Treiman et al. (1995) estimated that the pronunciation of vowels is only 51% consistent over different words; consider, for example, the *a* in *cat*, *call*, *car*, *cake*, and *care*.

In parts of North Wales, the two languages are spoken and read side by side. In particular, in the North East region, parents choose whether they want their child to attend English medium or Welsh medium schooling. Generally, it is monolingual English parents who choose the former and bilingual Welsh/English parents who speak Welsh in the home who choose the latter. These schools serve the same geographical catchment area, are administered by the same local education authority, and follow similar curricula and teaching approaches; the only real difference is the language of instruction. Children sent to Welsh medium primary schools are taught to read in Welsh, and they are only introduced to reading in English in Year 3, usually at 8 years old.

This situation permitted a profitable replication and extension of the work done on orthographic transparency to date. In the first place, it allowed for the assessment of effects of script in readers who are matched for geographical area and concomitant socioeconomic variation, broad instructional milieu, and educational background, factors that are not as tightly controlled in many of the studies reviewed here. In the second place, we wished to do a better job of assessing reading progress than that allowed by the use of small language samples (sometimes only 8 or 16 words) or the translation equivalent pairs that are common in the studies described here; we wanted to know just how far through the language English and Welsh readers had gone after similar time or task. Finally, we wanted to identify whether, despite their very similar methods of reading instruction, Welsh and English children adopt different strategies of reading as a consequence of the different degrees of transparency of these written orthographies.

It is difficult to compare the first language (L1) acquisition of literacy in different languages because the stimuli must necessarily be different. Some of the reviewed studies investigated whether translation equivalents are acquired equally easily in the different languages, but there is no guarantee that translation pairs are equally frequent in their respective languages. Others compared the ease with which non-words are read in the different languages, but however well this gives a measure of the generalizability of the child's reading skill, by their very definition, non-words are not items of the languages themselves. Nor, of course, is comparison of performance on standardized reading tests in different languages going to avail, because the standardizations are made with reference to large samples of readers of one language only. Instead, the answer to the question, Is it easier to learn to read in language X rather than language Y? lies in the use of well-matched reading tests in the two languages. But for what should they be matched? The tests must be carefully constructed so that the items are equally representative of language X and of language Y, and children of the same age must have had equal opportunity to experience the parallel items. Sampling theory informs us that representative samples must be randomly selected, although their accuracy can be increased by stratifying on important potential independent variables. The relevant independent variable with regard to experience is frequency. Thus, the tests should be constructed as random selections of each language's lexis that are stratified by frequency, with pairs of test items in the two languages being yoked in this regard. However, the matching process must not control any other factors, such as word length, imageability, utility, morphological complexity, syntactic role, semantic richness, orthographic complexity, sound–symbol consistency, or any other intrinsic aspect of the languages under study or their learnability. Everything to do with learning opportunity should be matched; everything to do with language should be freed to vary. Kempe and MacWhinney (1996) explained this principle and illustrated its use in the construction of matched lexical decision tests based on log frequency stratified samples from complete frequency counts of the two languages of concern in their assessment of cross-linguistic vocabulary knowledge. The rationale is based simply on input-driven perspectives of language acquisition: The learnability of an item is largely dependent upon the amount of experience a learner has of it and of its kind. Thus, if children of languages X and Y start learning to read at the same time and have roughly equivalent time-on-task, then, if the two orthographies are equally difficult to acquire, learners of similar experience should be able to read down to roughly to the same frequency level of sample test item in the two languages.

This study was therefore designed to compare the rate of acquisition of orthographically transparent Welsh and orthographically opaque English using reading tests that were equated for amount of exposure. The word types that composed million token word frequency profiles for English and Welsh were sorted in decreasing frequency of occurrence and sampled so that a test word was selected that matched (roughly) every decreasing step of 10,000 word tokens. The two lists of 100 words were then used as frequency-matched test samples of written English and Welsh. The study investigated (a) whether Welsh children progressed further in reading than English children of similar reading experience, (b) whether they differed equally in reading comprehension abilities, (c) whether their reading latencies were indicative of different reading strategies, and (d) whether the two groups of learners made qualitatively different patterns of error that also indexed a difference in reading strategy.

## METHOD

### *Schools*

Six primary schools in the Wrexham area of northeast Wales agreed to participate in the study. Three of these schools were Welsh speaking and three were English speaking. They were matched on a number of variables, including their catchment areas, classroom sizes, and teaching methods, as determined by detailed interviews with the teachers.

Reading instruction in the English schools was done broadly as follows. In nursery school, children were taught the shapes of most letters of the alphabet and introduced to book use. They were read to on a daily basis, and there was emphasis on repetition and rhyming in the reading books used. In the "Reception" class, Big Books (Oxford Reading Tree; Oxford University Press) were used by all schools, with approximately 30 min per day dedicated solely to reading. These large-sized books were used when reading aloud to a whole class, with children being able to see both the written texts and the large illustrations in order to develop individual, group, and whole class reading and listening skills. Flash cards were also used to introduce individual words and to form simple sentences. Children were encouraged to take books home to read. There was much use of word building, pattern recognition, and odd-one-out games. In Year 1, the Oxford Reading Tree scheme was incorporated as a reading tool in each school and used to implement the literacy hour. Rhyme and analogy materials were used to develop phonological awareness, poetry was introduced to encourage children's awareness of rhythm and rhyme, and Jolly phonics (Jolly Learning Ltd.) was also used to helping them to develop phonological skills. Year 2 saw the final stages of the Oxford Reading Tree and some use of the First Steps Scheme (Heinemann). Approximately 30 min was spent each day on reading, mainly within groups, but children were also assessed on a one-to-one basis with their teachers. They were encouraged further to read two or three books a week at home, with their parents or guardians being asked to comment on reading development.

Reading instruction in the Welsh schools was much the same, in that it used the same materials in translation, was guided by the same curriculum, and devoted the same amount of time to the activities. The alphabet and letter shapes were introduced in nursery school. Big books were used in Reception. In Years 1 and 2, children had approximately 30 min of reading daily, with opportunities for individual, group, and class reading. The Oxford Reading Tree scheme also provided the core curriculum materials in the Welsh schools, with stages 1 through 5 being a direct translation of the English scheme, although no translations are given for the rhyme and analogy resources provided for English-speaking children. A reading corner was available in each classroom. A phonetic teaching approach was a large part of Year 1 instruction. In terms of homework, books were taken home every night, and children were expected to read at least three times a week. Diaries were used by parents and teachers to keep track of reading development. Children were also encouraged to search for information in different types of literature on particular themes which interested them.

### *Participants*

A consent form, a brief description of the study, and a questionnaire concerning language use in the child's home and their prior educational history was sent to every pupil in Year 2 in the six participating schools. The questionnaire, based on Lyon (1996), included five questions concerning the language that was mostly used when the child was in conversation with their parents or guardians, siblings, grandparents, and friends. On the basis of these returns, 20 Welsh children were selected from the Welsh primary schools and 20 English children from the English schools. There were 17 girls and 23 boys. They were either 6 or 7 years old and attended Year 2. The majority of the Welsh children spoke Welsh with their immediate family, although a few only spoke Welsh with extended family who lived in the child's home and with friends. The English children were monolingual. Children were selected to participate only if they had been exposed to reading in their L1 and if they had normal academic levels of attainment. The two groups were matched with regard their participants' exposure to reading, with the majority having only been introduced to reading at school; however, six Welsh and seven English children had received some basic prereading instruction at home prior to school entry.

English and Welsh participants were further matched on their academic levels using the results from the Key Stage 1 maths exams taken in May 1999 in Year 2. These exams were translation equivalents of the same problems, with possible grades ranging from Level 1, through Levels 2a, 2b, and 2c, to Level 3. The tests included workbooks in which each child was required to read and answer questions individually. When the maths grades were converted to a 5-point scale, the Welsh group ($M = 3.55$, $SD = 1.00$) and English Group ($M = 3.35$, $SD = 1.04$) did not differ significantly, $t(38) = 0.62$, *ns*. We take this equality to indicate that the two groups of children were broadly the same in terms of native ability and quality of schooling.

### *Materials*

The English and Welsh reading tests were each compiled by sampling words from 100 successive strata of decreasing written word frequency in the language. This ensured that both lists were closely matched on frequency levels. Word form lists were used rather than lemmas. The English test was formed by taking the word types that composed approximately 1 million token word frequency profiles for English in the CELEX Lexical Database (Baayen, Piepenbrock, & van Rijn, 1995), which estimates these written word frequencies from an analysis of the 16.6 million token Cobuild corpus. The word types were sorted in decreasing frequency of occurrence and sampled so that a test word was selected that matched, as closely as possible, every decreasing step of 10,000 word tokens. This process generated a list of 80 words, which ranged in frequency from 59,739 (*the*) down to 1 (*marigolds*). The list was then increased to 100 by adding 20 more randomly selected words with a frequency of 1 per million.

The Welsh test was formed by taking the word types that composed approximately 1 million token word frequency profiles for Welsh in the CEG corpus (Ellis, O'Dochartaigh, Hicks, & Morgan, 1999). This corpus is a word frequency analysis of just over 1 million words of written Welsh prose, based on 500 samples of 2,000 words each, selected from a representative range of text types to illustrate modern (mainly post-1970) Welsh prose writing. The sample included materials from the fields of religious writing; children's literature, both factual and fictional; nonfiction materials in fields such as education, science, and business; novels and short stories; public lectures; newspapers and magazines, both national and local; reminiscences; leisure activities; academic writing; and general administrative materials (letters, reports, and minutes of meetings). This word list was similarly sorted in decreasing frequency of occurrence and sampled so that a test word was selected that matched as far as possible every decreasing step of 10,000 word tokens, thus generating a list of 80 words that ranged in frequency of occurrence from 54,481 (*yn*) down to 1 (*achwynwr*). In like fashion to the English test, the Welsh list was made up to 100 items by adding 20 more words with a frequency of 1 per million.

The resulting reading test items can be seen in Appendix B. Figure 1 illustrates the log frequencies of the items in the two tests and shows them to be well matched in their sampling of the written word frequency profiles of the two languages. This is confirmed by the clear nonsignificance of a paired *t* test between the two lists of $\log_{10}$ frequencies (English $M = 2.058$, $SD = 1.459$; Welsh $M = 2.0678$, $SD = 1.453$; $t(99) = 0.96$, *ns*).

Although no attempt was made to control the two lists for word length, the random selection procedure resulted in there being no appreciable difference between the word lengths of the items in the two reading tests (English $M = 5.86$, $SD = 3.13$; Welsh $M = 6.00$, $SD = 3.31$; $t(99) = 0.48$, *ns*).

The lists were printed in decreasing frequency order, with 14 words appearing on the left hand side of each A4 sized page in bold, lower-case, 24-point Times font using double spacing.

### *Procedure*

Children were tested individually in a quiet room in their school by the second author, a fluent Welsh and English speaker. Each child participated in just one session of two parts.

The first part involved measuring their ability to read aloud in their language

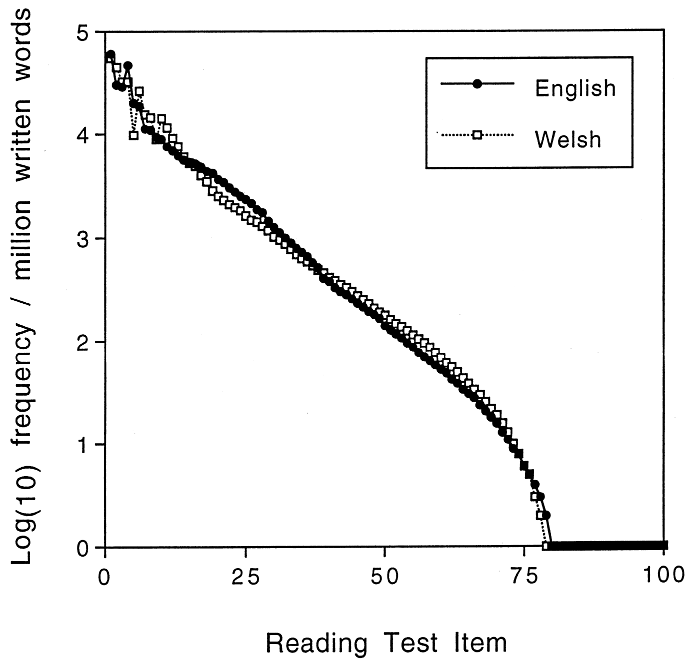


Figure 1. The matched written frequency profiles of the English and Welsh reading tests.

of schooling. Children who seemed immediately at ease were simply asked to try to read the words aloud in order that we could see how their reading was coming along; those who seemed more reticent were engaged in play with Joshua, a puppet, and were then asked if they were willing to help Joshua to remember how to read some words. They were told that they would be recorded and would need to speak loudly and clearly. A stopwatch was used to record reaction times. A piece of plain cardboard was used to cover the list, and the child was asked to move the card down when the experimenter said "next," and to read the following word immediately. If the child made no response after 15 s, the experimenter would ask him or her to try the next one. Praise was given periodically, and any appropriate self-corrections was marked as a positive response unless given beyond the 15-s point. The children were given a few practice trials until the experimenter was satisfied that they properly understood the instructions. Testing continued until the child made five consecutive errors. Errors in their tape recorded responses were later categorized for error type.

In the second part of testing, after a short break, the child had to return to the first page and try to explain the meaning of each word by giving a synonym, an explanation, or a correct usage. Individual responses were noted in writing; tape-recording was not used, nor were latencies measured. The child was asked to explain the meaning by either giving another word that means the same thing, an explanation of the meaning or, if this was too hard, a sentence showing that he or she understood its appropriate use. If at any time the experimenter was unsure whether the child understood the word, further questions were asked. Testing again continued until the child made five consecutive errors.

## RESULTS

### *Reading aloud accuracy*

The criterion cutoff of five consecutive errors was reached significantly earlier in the English children ($M = 70.1$, $SD = 13.1$) than in the Welsh children ($M = 79.8$, $SD = 15.2$), $t(38) = 2.16$, $p < .04$. The numbers of children correctly reading each word are shown in Appendix B. The Welsh words were read aloud significantly more accurately by the Welsh children than the English words were read by the English children: 61% and 52% respectively, $t(99) = 3.94$, $p < .001$. Although this 9-point difference may not seem very large, the sampling procedure ensures (as can be seen by reference to the 52nd word of the English test and the 61st word of the Welsh test) that this predicts that the average English child in our sample would be able to read down to the 716th word form type of English with a frequency of 118/million, whereas the average Welsh child would fare well over twice as well, reaching the 1,821st word form type with a frequency of 61/million.

### *Reading aloud latency*

The naming latencies for correct responses are shown in Figure 2, which plots the mean reaction times (RTs) for each frequency-matched pair of English and Welsh test items from item 1 (frequencies > 54,000 per million) down to item 100 (frequencies = 1 per million). Note that this is a graph of the main effects of frequency and language; the individual data points reflect a wide variety of other lexical influences, including word length, imageability, orthographic regularity, and sound–spelling consistency. Overall, the latencies are greater for Welsh than for English: English $M = 1.41$ s, $SD = 1.13$; Welsh $M = 1.85$ s, $SD = 1.11$; $t(82) = 2.70$, $p < .01$, and, as can be seen in Figure 2, the difference between the two groups increases as an inverse function of word frequency. Regression analyses relating latency of correct responding to $\log_{10}$ word frequency are as follows: Welsh $B = -0.40$, $SE\ B = 0.06$, $\beta = -0.54$, $F(1, 98) = 40.60$, $p < .0001$, $R^2 = 0.29$; English $B = -0.25$, $SE\ B = 0.09$, $\beta = -0.28$, $F(1, 81) = 6.97$, $p < .01$, $R^2 = 0.08$.

However, it should be remembered that there are fewer correct responses in the English group; indeed there were 17 words for which there were no correct responses for the English group (hence the *df* of 82). Thus, the Welsh function is penalized by the presence of a greater number of low-frequency data points for Welsh. Over the 30 most frequent items in the languages for which there was, on average, greater than 95% accuracy of responding in both groups, there was no significant difference in the latency of responding: English $M = 0.84$ s, $SD = 0.22$; Welsh $M = 0.90$ s, $SD = 0.20$; $t(29) = 1.22$, *ns*. Over the next 30

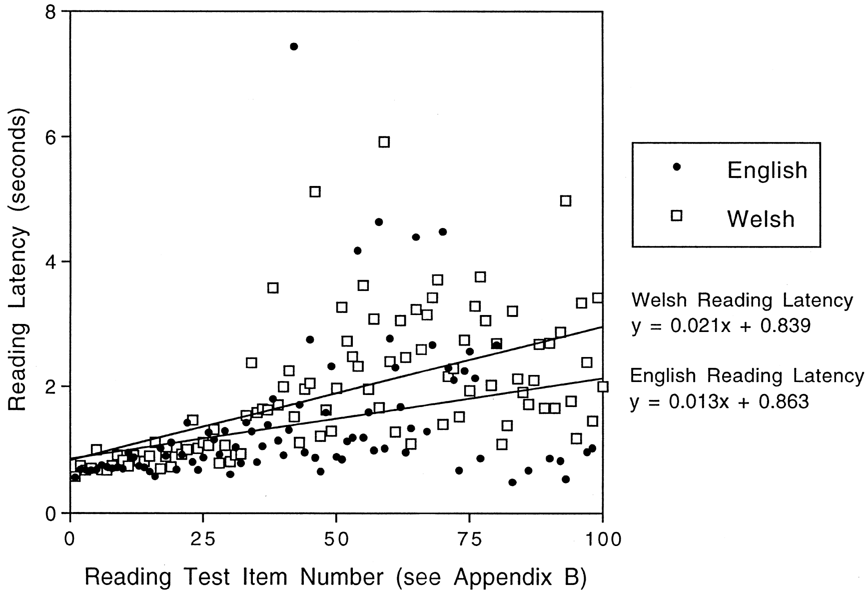


Figure 2. Reading latency for the test items correctly read aloud in English and in Welsh.

items (31–60), on which responding was 42% correct in the English group and 50% correct in the Welsh group, the latencies were still not significantly different in the two groups: English $M = 1.73$ s, $SD = 1.44$; Welsh $M = 2.25$ s, $SD = 1.14$; $t(29) = 1.45$, *ns*. It is only in the last bin of 40 items (61–100) that the latencies differed significantly: English $M = 1.734$ s, $SD = 1.13$; Welsh $M = 2.26$ s, $SD = 0.93$; $t(22) = 2.5$, $p < .05$, on the 23 word pairs where there is some correct naming in both groups, although English accuracy was only 6.8%, whereas Welsh accuracy was 17.3%.

### *Reading latency as a function of word length*

Regression analyses demonstrate that latency of correct responding is more a function of word length in Welsh, $B = 0.31$, $SE\ B = 0.02$, $\beta = 0.83$, $F(1, 98) = 228.25$, $p < .0001$, than it is for English, $B = 0.20$, $SE\ B = 0.04$, $\beta = 0.47$, $F(1, 98) = 22.56$, $p < .0001$. The RTs averaged for each length are shown in Figure 3, which shows that the relationship between length and latency is more linear in the Welsh data than the English data, and the function is much more predictable, as shown by the tighter standard errors. It is clear that reading latency is more clearly a function of word length in Welsh ($R^2 = 0.70$) than in English ($R^2 = 0.22$).

### *Reading comprehension*

Notwithstanding the Welsh children's greater accuracy in reading words aloud, it was the English children who showed superior word comprehension. The English

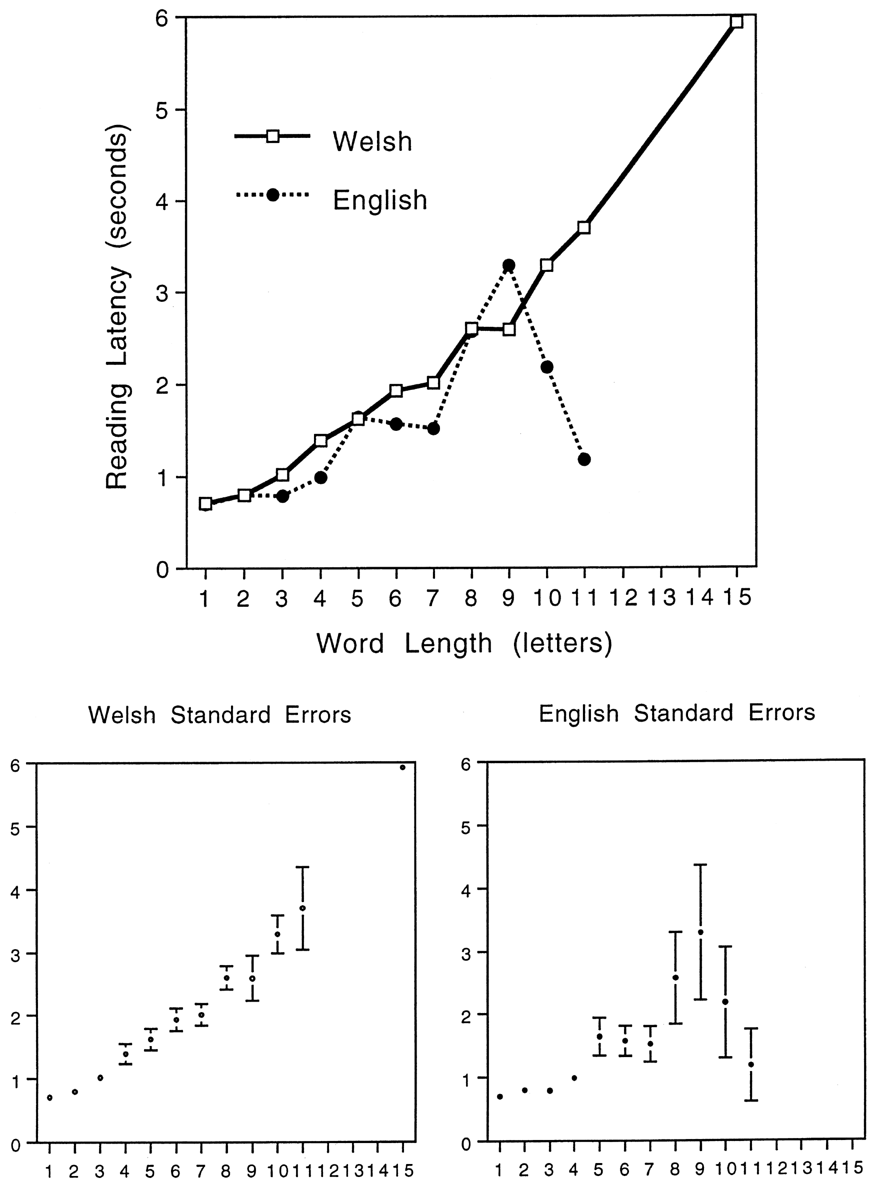


Figure 3. Reading latency as a function of word length for words correctly read aloud in Welsh and in English.

Table 1. *Classification of the reading errors made by the Welsh and English children*

| | Welsh | | | English | | |
|---|---|---|---|---|---|---|
| Error type | *N* | Column % | Haberman standardized residuals | *N* | Column % | Haberman standardized residuals |
| Null response | 52 | 13.7 | –3.5[a] | 112 | 30.8 | 3.5[a] |
| Whole word substitution | 92 | 24.3 | –3.3[a] | 163 | 44.8 | 3.4[a] |
| Other attempt (nonword) | 235 | 72.5 | 5.4[a] | 89 | 24.5 | –5.5[a] |
| Total | 379 | | | 364 | | |

*Note:* $\chi^2(2, N = 743) = 107.25$, $p < .00001$.
[a]Haberman standardized residuals > 2.

children gave accurate definitions for 45% of the words, compared to the Welsh children's 36%: by subjects, $t(38) = 2.96$, $p < .005$; by items, $t(99) = 3.23$, $p < .001$. Thus, the English children could read aloud only a little beyond their comprehension level, with a reading-aloud:reading-comprehension ratio of 1.16, whereas the shallow orthography of Welsh allowed Welsh children to read aloud far more words than they could comprehend, at a ratio of 1.68.

### *Reading errors*

Recall that the reading test was discontinued after the child made five consecutive errors. This procedure resulted in the 20 English children making a total of 364 errors and the Welsh children, 379.

These errors were first classified into three categories: null response within 15 s, whole-word substitutions, and "other" attempts that resulted in nonword responses. The number of items in each cell can be seen in Table 1. This classification demonstrated that the English children made a large number of null responses and that these formed a larger proportion of their errors than they did the Welsh children's errors (31 vs. 14%). The English children also had a greater tendency to make whole word substitution errors (45 vs. 24%) of the kind illustrated in the following examples: *complete* "computer," *there* "three," *babandod* "babanod," or *amserau* "camerau." The Welsh children's errors tended to be the third, "other" type. This different pattern of errors types in the two language groups is highly significant, $\chi^2(2, N = 743) = 107.25$, $p < .0001$, with the Haberman's standardized residuals in each cell exceeding 2.0.

What "other" kinds of error response are made? It is common in reading error classification to try to distinguish between what might be visually driven errors and what are more clearly mispronunciations (see the examples of error classification systems in Coltheart, Patterson, & Marshall, 1987, and Funnell, 1999). However, such distinctions are more difficult to apply to errors made when reading an orthography which is highly consistent in its grapheme–phoneme correspondences and where the error transcriptions concomitantly tend to look like the stimulus which prompted them to the same degree as they tend to sound like it, and there is no clear-cut boundary between mispronunciations and look-alike errors. For this reason we took a slightly different tack in the further analysis of these errors.

Appendix C lists the Welsh and English errors that were generated by two example stimulus words of each length, where available. An inspection of such examples suggested that the Welsh errors were rather longer and more complete attempts to represent the sounds in the stimulus word than were the English errors. Analyses of the complete corpus of errors confirmed this. The average length of the Welsh error transcriptions ($M = 6.16$, $SD = 3.51$) was significantly greater than for the English error transcriptions ($M = 4.31$, $SD = 3.65$), $t(741) = 7.04$, $p < .001$. This remains the case if we remove the null responses (Welsh $M = 7.16$, $SD = 2.67$; English $M = 6.35$, $SD = 2.58$), $t(571) = 3.64$, $p < .001$. The Welsh errors also tended to be closer to the stimulus; that is, the transcribed responses tended to represent a greater proportion of the letters of the intended word (Welsh $M = 0.86$, $SD = 0.17$; English $M = 0.82$, $SD = 0.19$), $t(571) = 2.80$, $p < .005$. A more stringent measure of this notion is the degree of overlap between the transcribed error and the stimulus in terms of letters correct in absolute serial position. The non-null errors in Welsh were also closer to the intended stimuli on this measure than were the English ones (Welsh $M = 4.05$, $SD = 2.26$; English $M = 3.14$, $SD = 2.07$), $t(571) = 4.94$, $p < .001$.

## DISCUSSION

Our first question concerned whether Welsh children progressed further in reading than English children with similar reading experience. The data clearly demonstrate this to be true: the Welsh children were able to read aloud significantly more of their reading test than the English children. Performance on the test items, when extrapolated back to the million-word corpora that they reflected, demonstrated that after roughly 2 years of reading instruction, Welsh children could read aloud approximately 61% of the written word tokens of their language, a coverage that is generated by the 1,821 most frequent word types in Welsh. In contrast, English children at the same stage of development could read the word types that comprised only 52% of the written English tokens, a coverage generated by the 716 most frequent word types. The control of subject potential independent variables among subjects afforded by the context of this study strongly implicates that these differences are a result of the orthographic transparency of Welsh and the orthographic ambiguities of English.

The next question asked whether there were associated differences in reading comprehension abilities. We found no such differences. Indeed the English children could comprehend more of the words than could the Welsh children. It seems, therefore, that the lexical comprehension abilities of these young children were determined by factors other than reading ability and that their reading comprehension was tapping lexical knowledge that had been achieved elsewhere, through spoken language use. Although it is certainly the case that for adults, a large part of their vocabulary is achieved through reading (e.g., Anderson, Wilson, & Fielding, 1988; Ellis, 1994; Stanovich & Cunningham, 1992), these Year 2 children seem still to have been at the stage of "learning to read" rather than "reading to learn." A typical 6-year-old child has acquired the meaning of some 14,000 different lexical items (Nagy & Herman, 1987) and thus understands far more words in the spoken language than he or she can read. Nevertheless, given the eventual importance of reading as a source of vocabulary and of a wide range of other knowledge and skills (Stanovich, 1986) – as Stanovich and Cunningham (1992) put it: "whatever cognitive processes are engaged over word or word-group units (phonological coding, semantic activation, parsing, induction of new vocabulary items) are being exercised hundreds of times a day. It is surely to be expected that this amount of cognitive muscle-flexing will have some specific effects" (p. 51) – it therefore seems likely that any factor that affects the rate of reading acquisition and the success with which children become literate in a language will also have some effects on the skills that are a consequence of reading. However, it remains for these proposals to be properly tested in older Welsh and English readers. Meanwhile, our data show that the Welsh children were able to read aloud further beyond their comprehension levels (168%) than were the English children (116%). The final remaining question with regard to comprehension abilities was why the Welsh children comprehended less than the English children. We believe that this is a consequence of bilingualism. The English children were predominantly monolingual, but in the northeast corner of Wales it would be rare indeed for a Welsh-speaking child to be so: the Welsh children were monoliterate but bilingual. Spoken English pervades the culture, and a normative assessment in the streets and media availability of this area would suggest that, in contrast to other areas in the heartlands of Northwest Wales, English is the dominant language. Lexical development in any one of the languages of bilingual children is typically slower than that in a comparable monolingual (Ben-Zeev, 1977; Kirsner, Lalor, & Hind, 1993; Rosenblum & Pinker, 1983). This again is a simple consequence of reduced time on task; taken as a whole, the lexical development of bilingual children is as good as, or better than, that of monolinguals (Pearson, Fernandez & Oller, 1993).

The final issues concerned whether differences in orthographic transparency had resulted in the two groups' having adopted different reading strategies: we looked for evidence relating to this matter from RTs and error patterns. There was some confirmatory evidence, in that the Welsh children had longer average correct RTs than the English children, but this conclusion was qualified by the observation that the Welsh children were successfully attempting less frequent words than the English children. Naming latency is a function of frequency (Forster & Chambers, 1973), and the Welsh children's RT functions reach further down the frequency band. The latencies for well-known words in the first 30 most frequent test items in the two languages did not differ significantly. This is a by-items result, which parallels the by-grades fluency-by-strategy interaction of Öney et al. (1997), discussed previously. The error patterns suggest that the longer Welsh RTs as a whole came from performance on items that were novel to the child but which he or she nevertheless attempted to pronounce by synthesis.

What is clear is that there is a much more linear relationship between successful word-naming time and word length in the Welsh children ($R^2 = 0.70$) than in the English children ($R^2 = 0.22$). This linear relationship is exactly what would be predicted if pronunciation were assembled by means of a left-to-right parse of the graphemes which constitute each word, with concomitant look-up of the corresponding phonemes – the more graphemes there are to process, the longer will be the assembly time. The fact that the English children are less affected by word length, with RTs actually declining for words over eight or nine letters long (Figure 3), suggests that they are less likely to attempt to construct pronunciations by the application of a symbol–sound synthetic route and instead tend to use other cues to read aloud.

The different nature of the reading errors in the two groups confirms this potential difference in read-aloud strategies. The English readers were more prone to null attempts, indicative of a lack of ability to successfully synthesize the pronunciation and to make more erroneous real-word substitutions, again showing deviance from a purely synthetic assembly strategy. An inspection of the types of read word errors that they made (in Appendix C) shows that these substitutions are, on the whole, visually similar to the targets, and it thus appears that the English children tend to produce whole-word pronunciations (i.e., lexical retrieval) on the basis of a partially visual analysis of the reading stimuli. Welsh readers, in contrast, tend to produce longer errors, which tend to successfully represent more of the stimulus. They also tend less to be lexically driven and more to be simple mispronunciations. It thus appears that Welsh children's errors reflect their reliance on an alphabetic decoding strategy. It is this strategy that allows their decoding so far to outstrip their comprehension.

When we undertook this empirical work, we did not know of other research that addressed these issues in Welsh. Since that time, the findings of Spencer and Hanley (1998) came to our attention. Working with 5- to 6-year-old children in Denbighshire, North Wales, these researchers showed that Welsh children were better able than their English peers to read both nonwords and translation-equivalent words. The Welsh readers also performed better on phonemic awareness tasks, although the English children performed significantly better than the Welsh readers on tests of auditory rhyme detection. This finding echoes those of Goswami et al. (1997, 1998) and Wimmer, Landerl and Schneider (1994) on the comparisons of English with other orthographically transparent languages, such as German, Spanish, and Greek: the nature of the orthography affects the development of phonological awareness, with exposure to languages that are orthographically transparent promoting phonemic awareness and exposure to languages in which the sound–symbol regularity lies at the onset-rime levels promoting the development of phonological awareness at these levels instead. In solving a problem, learners find and exploit the regularities at whatever level helps them to achieve their task, and as they practice, their representations and strategies become tuned to that particular problem. Learning to read is a particular case of competitive learning, in which human rulelike processing of the structural regularities of language emerges from learners' lifetime analysis of the distributional characteristics of the language input.

Despite their common functions and diachronic evolution, there are minor differences between languages with regard to their learnability and utility. These are the differences that permit investigations of linguistic relativity (Gumperz & Levinson, 1996; Slobin, 1996). The core belief of linguistics, that all languages are basically equally effective, is worth holding to. Nevertheless, there are demonstrable small differences. In the example of Welsh, its orthographic transparency makes it easier to learn to read and spell, but its rich diversity of mutations is hard to acquire and its number names make it nonoptimal for digit-span tasks, especially in comparison to the rapidly articulated Cantonese digit names (Ellis & Henneley, 1980; Hoosain, 1987). It is swings and roundabouts.

One way of exploring these effects cross-linguistically, as has been done for within-language effects, is to investigate the regularities that arise when simple learning models, as instantiated in computer programs, are exposed to different written languages. Ellis and Hicks (2000) developed a two layer, exemplar-based model of reading and spelling acquisition, termed Chunker, which learns by associative chunking within orthographic and phonological domains and associative mapping between them. Its learning rate and on-line processing function reflect human short-term memory constraints. Chunker's acquisition of literacy when exposed to frequency-representative 5-million word samples of English, German, Welsh, and Dutch under supervised and unsupervised learning conditions demonstrates sensitivity to within-language and cross-linguistic word frequency, word length, letter sequence and phonotactic regularity, lexicality, and orthographic and sound–spelling transparency. Chunker explains over 75% of the variance of within-language human performance on standardized tests such as the Wide Range Achievement Test. Cross-linguistically, early comparisons of Welsh and English show that, during exposure to the first representative 1 million word tokens of English or Welsh, in the course of learning, Chunker correctly synthesizes twice as many correct pronunciations in Welsh as it does in English. We are now using Chunker as a *lector rasus*, a metrical learner for comparing the difficulty of the world's alphabetic scripts.

One profound implication of the thesis that language shapes the language learner is that we might be able to see these effects as molded in the plastic of the readers' functional neuroanatomy. Paulesu et al. (2000) presented the first demonstrations of such effects of orthographic transparency on brain function. In a series of behavioral experiments, Italian undergraduate readers were found to show faster word and non-word recognition than English readers. In two subsequent PET studies, the Italian readers showed greater activation in the brain's left superior temporal regions, which have been associated with sublexical phonology. In contrast, and for nonwords in particular, English readers showed greater activations in the left posterior inferior temporal gyrus and anterior inferior frontal gyrus, areas that have been associated with the lexical/semantic aspects of word naming.

Although such brain-scanning work remains to be done with Welsh readers, the behavioral data seem clear. Our findings, along with those of Spencer and Hanley (1998), demonstrate that the consistency of spelling-to-sound patterns in Welsh allows children to more rapidly crack the Welsh alphabetic code, causing rapid reading acquisition that is biased toward a strategy of letter–sound decoding. Superior phonological awareness at the segmental phonemic level comes as a consequence of this written exposure. Conversely, there is a cost to the ambiguity of the English orthographic code; children learn this code more slowly, and it fails to generalize well to other words. English children acquire phonological awareness at the level at which phonology and orthography relate most clearly – at the onset and rhyme levels – and young English children are less likely to concentrate purely on alphabetic reading and more likely to use visual cue-driven access to whole-word phonology. It is simply harder to plough through the tough dough of English orthography (Powers, 1997). Finally, we believe that these results demonstrate the utility of frequency-matched reading tests in cross-linguistic literacy research.

## APPENDIX A

*Welsh pronunciation*

| | Explanation | Example | IPA |
|---|---|---|---|
| a (short) | As in English *cat* | Mam | /a/ |
| a (long) | As in English *car* | Tad | /aː/ |
| b | As in English | Mab | /b/ |
| c | As in English *car*-always hard-there is no *k* in Welsh | Ci | /k/ |
| ch | As in English *loch* | Chi | /x/ |
| d | As in English | Dim | /d/ |
| dd | As in English *the* | Ddoe | /ð/ |
| e (short) | As in English *pen* | Pen | /ɛ/ |
| e (long) | As in English *bear* | Pêl | /eː/ |
| f | As in English *violin*-there is no *v* in Welsh | Afal | /v/ |
| ff | As in English *off* | Ffilm | /f/ |
| g | As in English *grand* | Gêm | /g/ |
| ng | As in English *sing* | Ngêm | /ŋ/ |
| h | Always sounded | Haul | /h/ |
| i (short) | As in English *pin* | Bin | /i/ |
| i (long) | As in English *peel* | Cinio | /iː/ |
| (j) | Borrowed from English | Jac-y-do | /dʒ/ |
| l | As in English | Lwc | /l/ |
| ll | Place tongue to say *ll* of tall and then blow | Lle | /ɬ/ |
| m | As in English | Maneg | /m/ |
| n | As in English | Ni | /n/ |
| o (short) | As in English *pop* | Bol | /o/ |
| o (long) | As in English *more* | Llo | /oː/ |
| p | As in English *pen* | Pop | /p/ |
| ph | As in English *physical* | Phen | /f/ |
| r | As in English *red* but trilled in Welsh as in Spanish and Italian | Roced | /r/ |
| rh | Aspirated – place tongue to say *r* and blow | Rhosyn | /r̥/ |
| s | As in English *sit* | Sosban | /s/ |
| si | As in English *ship* | Siarad | /ʃ/ |
| t | As in English | Te | /t/ |
| th | As in English *thing* | Cath | /θ/ |
| u (short) | As in English *pin* | Pump | /i/ |
| u (long) | As in English *seen* | Du | /ɨ/ |
| w (short) | As in English *took* | Cwm | /u/ |
| w/ŵ (long) | As in English *moon* | Dŵr cwrw | /uː/ |
| | Occasionally as a consonant | Gwlad | /w/ |
| y | Has two sounds *ee* or *i* in the final syllable or in words of one syllable and *uh* in the preceding one(s) | Dyn Bryn | /iː/ /i/ |
| | | Mynydd | /ə/ |

## APPENDIX B

*English and Welsh reading tests*

| English word | Word freq. rank order | Word freq./ million | *n*/20 Correctly read aloud | Welsh word | Word freq. rank order | Word freq./ million | *n*/20 Correctly read aloud |
|---|---|---|---|---|---|---|---|
| The | 1 | 59,739 | 20 | Yn | 1 | 54,481 | 19 |
| Of | 2 | 30,106 | 17 | Y | 2 | 44,909 | 20 |
| And | 3 | 28,705 | 20 | I | 3 | 32,498 | 20 |
| A | 4 | 46,615 | 20 | A | 4 | 32,323 | 20 |
| To | 5 | 19,942 | 20 | o | 6 | 26,411 | 20 |
| In | 6 | 18,464 | 20 | Ar | 7 | 15,544 | 20 |
| It | 7 | 11,144 | 20 | Ei | 8 | 14,589 | 20 |
| I | 8 | 11,045 | 20 | Yr | 10 | 14,186 | 17 |
| Is | 9 | 9,435 | 20 | Ac | 11 | 11,498 | 20 |
| He | 10 | 8,828 | 20 | Oedd | 12 | 9,736 | 20 |
| That | 12 | 7,513 | 20 | Bod | 13 | 9,173 | 20 |
| With | 15 | 6,966 | 20 | Mae | 14 | 8,878 | 20 |
| Be | 16 | 6,214 | 20 | Am | 15 | 7,618 | 20 |
| At | 18 | 5,584 | 20 | Ond | 17 | 5,961 | 19 |
| Was | 20 | 5,417 | 20 | Eu | 20 | 5,190 | 15 |
| Not | 24 | 5,099 | 18 | Fel | 22 | 4,873 | 19 |
| This | 26 | 4,734 | 20 | Â | 25 | 4,005 | 20 |
| By | 27 | 4,337 | 19 | Ni | 28 | 3,476 | 20 |
| From | 29 | 4,172 | 20 | Ôl | 32 | 2,815 | 17 |
| We | 32 | 3,615 | 20 | Nid | 37 | 2,511 | 20 |
| There | 35 | 3,353 | 17 | Dim | 42 | 2,311 | 20 |
| If | 38 | 3,006 | 19 | Iawn | 47 | 2,080 | 19 |
| As | 41 | 2,767 | 20 | Mawr | 53 | 1,937 | 20 |
| Out | 45 | 2,526 | 17 | Fy | 59 | 1,818 | 15 |
| Them | 49 | 2,347 | 19 | Trwy | 66 | 1,607 | 13 |
| Has | 53 | 2,118 | 20 | Nhw | 73 | 1,481 | 18 |
| Then | 58 | 1,881 | 20 | Rhaid | 81 | 1,426 | 19 |
| Now | 63 | 1,726 | 17 | Chi | 89 | 1,274 | 20 |
| People | 69 | 1,461 | 17 | Meddai | 98 | 1,180 | 20 |
| Any | 76 | 1,263 | 15 | Plant | 108 | 1,030 | 19 |
| Don’t | 83 | 1,134 | 20 | Bach | 119 | 948 | 20 |
| Over | 91 | 1,007 | 17 | Eto | 131 | 875 | 20 |
| Never | 100 | 896 | 19 | Dwy | 144 | 779 | 9 |
| Going | 110 | 799 | 19 | Blwyddyn | 160 | 697 | 18 |
| How | 121 | 732 | 18 | Nifer | 176 | 630 | 17 |
| Same | 133 | 660 | 13 | Pethau | 194 | 587 | 19 |
| Though | 147 | 576 | 4 | Arno | 213 | 535 | 17 |
| Himself | 163 | 508 | 19 | Cyfarfod | 234 | 488 | 12 |
| Much | 201 | 403 | 20 | Bore | 257 | 453 | 20 |
| Seen | 222 | 376 | 18 | Newid | 282 | 416 | 19 |
| Moment | 246 | 333 | 12 | Dosbarth | 309 | 392 | 20 |
| Political | 272 | 300 | 1 | Cwmni | 338 | 357 | 16 |
| Itself | 301 | 281 | 19 | Union | 370 | 330 | 14 |
| I’ll | 332 | 258 | 19 | Ambell | 404 | 305 | 18 |
| Education | 366 | 233 | 3 | Gellid | 441 | 276 | 15 |
| Use | 403 | 213 | 16 | Gweithredu | 482 | 254 | 11 |
| Particular | 443 | 196 | 1 | Siwr | 525 | 230 | 8 |

APPENDIX B (*continued*)

| English word | Word freq. rank order | Word freq./ million | *n*/20 Correctly read aloud | Welsh word | Word freq. rank order | Word freq./ million | *n*/20 Correctly read aloud |
|---|---|---|---|---|---|---|---|
| Short | 487 | 181 | 15 | Cylch | 575 | 210 | 17 |
| Information | 535 | 165 | 6 | Helpu | 629 | 191 | 18 |
| Rate | 589 | 141 | 9 | Cariad | 687 | 178 | 18 |
| Find | 650 | 129 | 15 | Cefais | 750 | 163 | 18 |
| Thought | 716 | 118 | 12 | Cymuned | 820 | 149 | 9 |
| Arms | 790 | 106 | 14 | Cymharu | 894 | 138 | 12 |
| Found | 871 | 96 | 15 | Croes | 975 | 127 | 13 |
| Complete | 961 | 87 | 12 | Cefnogaeth | 1,063 | 116 | 8 |
| Costs | 1,061 | 78 | 9 | Coeden | 1,159 | 105 | 17 |
| Top | 1,171 | 71 | 17 | Gwragedd | 1,267 | 95 | 11 |
| Progress | 1,292 | 65 | 4 | Llinell | 1,384 | 87 | 18 |
| Quick | 1,424 | 59 | 13 | Cenedlaetholdeb | 1,513 | 78 | 3 |
| Protection | 1,569 | 54 | 2 | Medr | 1,658 | 69 | 13 |
| Accident | 1,728 | 49 | 4 | Ynghynt | 1,821 | 61 | 4 |
| Typical | 1,907 | 43 | 2 | Ardderchog | 2,004 | 56 | 12 |
| Cheap | 2,106 | 39 | 12 | Daliai | 2,206 | 50 | 10 |
| Title | 2,330 | 34 | 7 | Tei | 2,433 | 44 | 12 |
| Enterprise | 2,581 | 31 | 8 | Goblygiadau | 2,689 | 39 | 5 |
| Cheque | 2,861 | 28 | 0 | Dwsin | 2,982 | 34 | 12 |
| Procedure | 3,177 | 24 | 2 | Awgrymir | 3,318 | 30 | 4 |
| Poetry | 3,539 | 21 | 5 | Caeodd | 3,703 | 26 | 8 |
| Perception | 3,956 | 18 | 0 | Cyfeiriwyd | 4,154 | 22 | 3 |
| Acute | 4,442 | 16 | 4 | Amserau | 4,682 | 19 | 6 |
| Restraint | 5,010 | 13 | 0 | Awgrymog | 5,307 | 16 | 5 |
| Monetary | 5,686 | 11 | 3 | Datblygwyd | 6,063 | 13 | 1 |
| Sound | 6,490 | 9 | 7 | Trefol | 6,980 | 10 | 9 |
| Bliss | 7,457 | 8 | 5 | Prydyddion | 8,127 | 8 | 4 |
| Outrage | 8,661 | 6 | 6 | Segurdod | 9,596 | 6 | 3 |
| Echoing | 10,163 | 5 | 3 | Babandod | 11,553 | 5 | 1 |
| Blind | 12,102 | 4 | 5 | Melltithio | 14,403 | 3 | 5 |
| Attache | 14,748 | 3 | 0 | Grymuster | 18,821 | 2 | 6 |
| Cryptic | 18,700 | 2 | 0 | Moliannau | 26,853 | 1 | 7 |
| Marigolds | 25,687 | 1 | 3 | Achwynwr | 37,472 | 1 | 3 |
| Precipitously | >25,687 | 1 | 0 | Pechai | >37,472 | 1 | 3 |
| Gourmet | >25,687 | 1 | 0 | Pegiau | >37,472 | 1 | 6 |
| Guitars | >25,687 | 1 | 1 | Esgeulusai | >37,472 | 1 | 2 |
| Punctuated | >25,687 | 1 | 0 | Maindy | >37,472 | 1 | 5 |
| Distinctively | >25,687 | 1 | 0 | Ymyriadau | >37,472 | 1 | 4 |
| Subtraction | >25,687 | 1 | 1 | Socedi | >37,472 | 1 | 5 |
| Occurrences | >25,687 | 1 | 0 | Nodweddwyd | >37,472 | 1 | 4 |
| Resignedly | >25,687 | 1 | 0 | Troisai | >37,472 | 1 | 2 |
| Disgusted | >25,687 | 1 | 0 | Rhifais | >37,472 | 1 | 6 |
| Governorship | >25,687 | 1 | 1 | Gweinydd | >37,472 | 1 | 4 |
| Architecturally | >25,687 | 1 | 0 | Ddi-amod | >37,472 | 1 | 5 |
| Fiercer | >25,687 | 1 | 1 | Ymneilltuad | >37,472 | 1 | 2 |
| Nightingale | >25,687 | 1 | 1 | Tanseiliwyd | >37,472 | 1 | 4 |
| Antechamber | >25,687 | 1 | 0 | Torgest | >37,472 | 1 | 3 |
| Moron | >25,687 | 1 | 0 | Talwch | >37,472 | 1 | 6 |
| Militaristic | >25,687 | 1 | 0 | Gogledd-gorllewinol | >37,472 | 1 | 4 |
| Slung | >25,687 | 1 | 1 | Trwmbal | >37,472 | 1 | 4 |

APPENDIX B (*continued*)

| English word | Word freq. rank order | Word freq./ million | *n*/20 Correctly read aloud | Welsh word | Word freq. rank order | Word freq./ million | *n*/20 Correctly read aloud |
|---|---|---|---|---|---|---|---|
| Maxims | >25,687 | 1 | 1 | Dychwela | >37,472 | 1 | 3 |
| Marquees | >25,687 | 1 | 0 | Cywydd-un-cwpled | >37,472 | 1 | 1 |
| Moped | >25,687 | 1 | 1 | Treigla | >37,472 | 1 | 5 |

*Note*: Included are item frequency and rank order in the language and the number of children out of the 20 in that language group who correctly read the word aloud.

## APPENDIX C

*A sample of English and Welsh reading errors*

| Target | Response |
|---|---|
| | English errors |
| Of | Off, off, off |
| If | I've |
| Not | On, want |
| How | Who, who |
| Rate | Rat, rat, rat/e/, rat, right, rat, right, right, right, rat |
| Same | Sum, sami, sum, sam, #, some, sam |
| There | This, #, three |
| Never | Near |
| People | #, Peace, # |
| Though | Thought, #, #, through, through, thought, through, thought, #, through, thought, through, thought, through, thought, #, through |
| Thought | Through, #, #, fought, thawght, through, through |
| Typical | #, Tymi, typpicial, tipical, #, tiplics, #, #, typal, typri, typ/ical, typical, #, # |
| Complete | Come, computer, computer, completeted, colours |
| Accident | Acdents, adult, #, #, acdit, #, #, act/dut, acicadant, acting/accdent, adint, ast, # |
| Political | #, #, Pink, pola, poltac, #, #, polital, #, #, #, politic, polluska, poltical, #, polical, #, poker, #, pull |
| Education | #, #, Adam, equcuition, #, #, #, #, #, elephant, e/du/cat/ion, introduction, introduction, ediction, #, #, # |
| Particular | Particle, #, peter, particle, #, #, perticular, #, #, #, paintical, particle, paticlar, #, particle, #, printercal, #, pair |
| Protection | Project, #, protecation, #, #, prolinc, #, politian, protecnut, #, production, protestine, #, pretty, # |
| Information | Informance, #, #, imitation, informative, informed, informatin, inform, #, informanate, informative, #, #, # |
| Occurrences | O/curr/ances |

APPENDIX C (*continued*)

| Target | Response |
|---|---|
| | English errors |
| Militaristic | Miltarastic |
| Precipitously | #, Preciptly, #, #, # |
| Distinctively | Disfinct, #, # |
| Architecturally | Actually |
| | Welsh errors |
| Eu | I, ei, ei, ei |
| Fy | Fi, fi, fi, fi, fi |
| Nhw | Nihw, Huw |
| Dwy | Dwi, dwi, dwi, dwyn, dyw, drwy, drwy, dyw, dwi, dwi, dwi |
| Trwy | Trwyn, #, trwyn, #, trwyn, tr/w/y/, triw |
| Siwr | S/i/wr, s/i/wr, s/i/w/r/, si/wr, s/i/w/r, s/i/w/r/, s/i/wr, s/i/w/r, s/i/w/r/, s/i/w/r/, siswrn, s/i/wr |
| Cylch | Clych, c/y/lch, cwch |
| Croes | Croesoi, croesi, croesi, craoes, cres, croeso, cross |
| Gellid | Gallid, gelldi, gallid, gallid, gallynt |
| Cefais | Ceffis, cufas |
| Cymharu | Cym/ha/ru, cam, cymroi, cymharai, cymhariau, cymharau, cymheri, cymhearu |
| Ynghynt | Yngynt, yngynt, yngynt, #, yngynt, #, yngyntaf, ynganynt, #, yngynt, yngynt, yngynt, yn/caint, ynddynt, yngynt |
| Awgrymir | Angrymir, awgrymi, awgrymi, #, awgrym, #, awgrymer, awgrimir, anghywir, awgrymaw, awgrimir, awgrimir, awgrym |
| Gwragedd | Gwreigedd, garwedd, gwaedd, cwrcedd, #, gw/rag/edd, gwagedd, gwraigedd |
| Cmyharu | Cym/ha/ru, cam, cymroi, cymharai, cymhariau, cymharau, cymheri, cymhearu |
| Ymyriadau | Ymyrio, ymraidu, ymuriadu |
| Gweithredu | Gweithi, gweiddid, gweithed, gweithiad, #, gw/i/thredu, gwaithredu, gweiddi, gwethredu |
| Cefnogaeth | Cefnaeth, cyfnogaeth, #, cefn/nogaeth, cefynogaeth, #, cefnogath, cefn/gaeth, cenfogaeth, caffnogaeth, cyfnogaeth, cynogaeth |
| Goblygiadau | Gwyblygiadau, gebygiadau, gobygiadau, #, goblyiadau, #, gobeithiadi, gwblyiadau, gwybodladau, goblygiadu, goblyg, #, gobligiadau |
| Ymneilltuad | Ymneilltad, ymneu, ymnellutuad, ymneilltucod |
| Cywydd-un-cwpled | Cywyddyncw., cy.uncwmpled, cywuddu.c., cynwyddu.c., ciwbedd.u.cwp. |
| Gogledd-gorllewinol | #, Gogedd-gorlew |

*Note:* #, no response within 15 s; /, distinct pause and failure to subsequently blend. Nonword transcriptions in English written using English spelling to sound norms; nonword transcriptions in Welsh written using Welsh spelling to sound norms.

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