

## Reading and spelling processes in Welsh–English bilinguals: differential effects of concurrent vocalisation tasks

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**Abstract** Theories of literacy acquisition, developed mostly with reference to English, have characterised this process as passing through a series of stages. The culmination of this process is a strategy which takes account of the complex relationship between graphemes and phonemes within a deep orthography (Frith (1985). In K. Patterson, & M. Coltheart, (Eds.), *Surface dyslexia: Neuropsychological and cognitive studies of phonological reading* (pp. 301–330). London: Erlbaum). In addition, recent studies (Arab-Moghaddam & Senechal (2001). *International Journal of Behavioural Development*, 25, 140) have found that different strategies are used to decode and produce words according to the orthographic depth of the script involved. The present studies used Welsh–English bilingual children to investigate the effect of orthographic depth on the use of phonological recoding in reading and spelling. The first experiment investigated the effects of concurrent vocalisation on spelling in English and Welsh and found that spelling in Welsh was adversely affected by this phonologically disruptive task. A second experiment found that concurrent vocalisation had a deleterious effect on reading for meaning in English and Welsh in the case of younger children, but only affected reading in Welsh in older children. Overall, these results indicate a differential involvement of phonological processes across the two languages in the tasks of reading and writing.

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## Introduction

The issue of how children learn to read and write in alphabetic systems has been the subject of considerable research which has led to a number of theories of literacy acquisition (e.g., Ehri, 1991, 1997; Frith, 1985). It is widely accepted that the development of reading and writing passes through a series of distinct phases or stages. Frith (1985) has proposed three stages of development: logographic, alphabetic and orthographic. Ehri (1991, 1997, 2003) has characterised literacy development as passing through a series of phases: the pre-alphabetic phase, the partial alphabetic phase, the full alphabetic phase and the consolidated alphabetic phase. Both views see literacy development as initially visually mediated, followed by a period of development in which children begin to apply their expanding alphabetic awareness to the tasks of reading and spelling, and eventually developing a mature orthographically-based strategy.

In the case of English orthography, research evidence is broadly supportive of the notion that reading and spelling change with age and experience of literacy instruction. Various studies have demonstrated that early reading is non-phonological in nature. For example, a study by Barron and Baron (1977) found that reading for meaning in early readers was not impaired by a concurrent vocalisation task. As this concurrent task is known to interfere with the phonological recoding of words (Bryant & Bradley, 1983), these results imply that phonological recoding was not necessary for early readers. It is also well established that pre-reading children are unable to make judgements about words at the level of the phoneme (Bruce, 1964; Liberman, Shankweiler, Fischer, & Carter, 1974; Treiman & Baron, 1981) as are illiterate adults (e.g., Morais, Cary, Alegria, & Bertelson, 1979). However, when phonemic segmentation abilities are acquired, they are a strong predictor of subsequent reading development (Muter, Hulme, Snowling, & Taylor, 1997; Nation & Hulme, 1997). There is much evidence that children make use of salient visual cues to acquire a sight vocabulary during the early period of reading development (Gough, Juel, & Roper –Schneider, 1983; Mason, 1980).

In contrast to early reading behaviour, the research evidence suggests that early spelling is phonological in nature. For example, a study by Bryant and Bradley (1980) found that there was a class of words that children could spell but not read. Typically these were regular words, with a consistent sound-spelling mapping, such as ‘cat’ and ‘bun.’ Conversely, there were also words that children could read but not spell, and these were usually irregular words such as ‘school.’ Various other studies have demonstrated a ‘regularity effect’ in early spelling, but not reading (Goswami & Bryant, 1990). More recently, a longitudinal study by Caravolas, Hulme, and Snowling (2001) found that early

spelling abilities were predicted by phonemic awareness and letter-sound knowledge. They also found that early spelling ability predicted later reading achievement, which is supportive of Frith's (1985) proposal that spelling acts as a pacemaker for the transition from the logographic to the alphabetic stages of reading development.

While the use of the phonological strategy, that is, the application of letter-sound correspondences represents a major milestone in the acquisition of literacy, it is also recognised that with increasing exposure to print, reading, and later spelling becomes orthographic in nature whereby children learn to read and spell words using their accumulated knowledge of letters and letter order in words (Ehri, 1991, 1995, 2003; Frith, 1985). There is much evidence to support this view. For example, it has been found that orthographic skills do make a contribution to predict reading performance that is independent of phonological skills (Cunningham & Stanovich, 1991; Stanovich & West, 1989). In the case of adult readers, there is also evidence that words can be recognised orthographically without any phonological conversion (Taft & van Graan, 1998).

While the research evidence does suggest a particular course of development for reading and spelling in English, it should be noted that the relationship between phonology and orthography varies across languages (Arab-Moghaddam & Senechal, 2001). Some scripts represent *transparent* or *shallow* orthographies whereby use of letter-sound rules will usually be a successful strategy in reading and spelling unfamiliar words. Other languages, including English, represent *opaque* or *deep* orthographies where the relationship between a letter and its sound is not always consistent, and in which, letter strings occur that cannot be decoded on a letter-sound basis (e.g., colonel, yacht) to yield the intended word.

Recent studies have investigated the influence of the opacity of a script on the use of orthographic and phonological skills to read and spell. Wimmer and Goswami (1994) have found evidence of differential strategies for word recognition in English and German. They suggest that while children learning to read English rely on a 'direct' recognition strategy, German children make use of an assembled pronunciation strategy arrived at through the application of grapheme-phoneme correspondences. A difference in strategy is also highlighted in a study by Goswami, Ziegler, Dalton, and Schneider (2003) who argued that children learning to read in the opaque orthography of English are forced to adopt a more flexible decoding strategy involving switching between small-size units and large size units than those reading in the more transparent orthography of German who relied mainly of small-size grapheme-phoneme correspondences. Differences in reading acquisition across a range of European orthographies have also been noted by Seymour, Aro, & Erskine (2003) who found that the acquisition of reading in English takes more than double the time required in transparent orthographies such as Finnish and Italian. They have argued that the complex nature of the English orthographic system requires the establishment of a dual foundation involving both logographic and alphabetic strategies, which takes much longer to instantiate than the

single, alphabetic foundation required for successful acquisition in the shallow orthographies. There is also some recent evidence that specifically highlights differences in strategy between children learning to read in English and Welsh (Spencer & Hanley, 2003). The children learning to read in Welsh exhibited superior performance in reading words, nonwords, and in a test of phoneme awareness. Hence, it appears from this evidence that different strategies are demanded of children exposed to orthographies of varying opacity.

The studies described above are based on monolingual literacy development. Arab-Moghaddam and Senechal (2001) studied the reading and spelling performance of a group of Persian–English bilingual children. It should be noted that while English is an opaque orthography for both reading and spelling, Persian is a transparent orthography with respect to reading, but opaque with respect to spelling. The results of this study indicated that predictors of reading performance were similar in both languages: phonological and orthographic skills each made independent contributions. However, predictors of spelling ability varied across the two languages. In English, spelling was predicted by both phonological and orthographic skills, whereas spelling in Persian was predicted by orthographic skills only.

It appears from this evidence that bilingual individuals make use of different sets of strategies depending on the nature of the orthography they are using. This is in line with Geva, Wade-Wooley, and Shanny (1993) who looked at phonological and orthographic skills in a group of English speaking kindergarten children who were also learning Hebrew as a second language. In this way, they were able to compare performance in the opaque orthography of English with performance in the more transparent orthography of Hebrew. They found that while orthographic skills came to dominate the children's performance in English, phonological skills were to the fore when using Hebrew.

The purpose of the present study was to examine the involvement of phonological processes in two alphabetic orthographies of differing complexity: English and Welsh. As previously discussed, English has an opaque orthography as it is both polyphonic (it includes graphemes that can represent more than one phoneme) and polygraphic (it includes some phonemes that can be represented by different graphemes). Welsh, on the other hand has a very transparent orthography displaying a very high degree of consistency of grapheme–phoneme mapping (Spencer & Handley, 2003). Reading and writing in Welsh can be achieved by the use of grapheme–phoneme correspondence rules alone. It is, therefore, possible to predict differences in the role of phonological processes across the two languages. Given the transparent nature of the Welsh orthography, it would be expected that phonological processes would play a more dominant part in reading and spelling, compared to English in which orthographic skills would be more important.

In the literature, the role of phonological processes has been examined empirically in a number of ways, and particularly through the use of concurrent vocalisation. This task involves a participant repetitively uttering out loud an irrelevant phrase while attempting to perform a task involving reading

or spelling. It is assumed that the application of grapheme–phoneme correspondences involves sub-vocal articulation (Goswami & Bryant, 1990). Therefore, if concurrent vocalisation can be shown to disrupt performance in a given reading or spelling task, it may be inferred that phonological processes play an important function in the successful execution of that task. Conversely, the absence of an effect of concurrent vocalisation is taken as evidence that phonological processes do not play a role in that task. However, this latter assumption has been criticised by Besner (1987) who argues that it is possible to generate a phonological code from printed English which can be used for lexical access, but this code is unaffected by concurrent vocalisation. As mentioned earlier, studies by Barron and Baron (1977) and Bryant and Bradley (1983) used the technique to investigate if early reading behaviour was phonological in nature, and found that this task did not disrupt performance in a reading for meaning task. However, Kimura and Bryant (1983) did note a disruptive effect of concurrent vocalisation on reading in Japanese *Kana* script, whereas in the case of English, spelling but not reading was affected. This would again indicate the differential nature of phonological recoding for different orthographies. Phonological recoding would be necessary for reading and spelling in the *Kana* script in which each character represents a syllable. In the case of English, beginning readers would tend to read logographically but spell phonologically (Frith, 1985).

The technique of repetitively uttering an irrelevant phrase while performing a cognitive task has also been employed by researchers in the area of working memory, who refer to this task as ‘articulatory suppression.’ Typically, it has been found that articulatory suppression has a deleterious effect in tasks such as serial recall of verbal material (Baddeley, 1986). Here, the effects of articulatory suppression are explained in terms of disruption of access to the phonological loop in working memory. It is also possible to explain the effects of this technique on reading and spelling in a similar manner. It may be the case that in reading, the comprehension of an integrated text involves carrying over information from one sentence to another, and this task is performed in working memory (Glanzer, Dorfman, & Kaplan, 1981). Therefore, it could be argued that it is this process, rather than the application of a phonological recoding strategy, that is disrupted by articulatory suppression. In the case of spelling, it has been argued that rather than disrupting the application of a phonological recoding strategy, the negative effect of articulatory suppression takes place at a peripheral point in the spelling process referred to as the ‘graphemic buffer.’ This has been defined as “... a specialised working memory device ... to maintain the graphemic code in a buffer zone while the spatial identity of each letter is chosen at the next processing stage” (Caplan, 1992, pp. 209–210). Recent studies also implicate working memory in spelling output processes. In an experiment using a backward typing task under conditions of articulatory suppression, Service & Turpeinen (2001) found evidence that the graphemic buffer is used to maintain chunks of two to three letters during stimulus production.

As can be seen from the above, a similar task has been utilised in two different research contexts which will be referred to as the ‘working memory’ and the ‘phonological recoding’ approaches. The present research took as its starting point the ‘phonological recoding’ approach and used the term ‘concurrent vocalisation’ to refer to the task of repeatedly vocalising an irrelevant syllable. However, the relevance of both approaches is considered when interpreting the findings.

The present study investigated the spelling and reading performance of a group of Welsh–English bilingual children at different developmental stages under conditions of concurrent vocalisation. On the basis of Frith’s (1985) characterisation of the development of spelling and reading, it would be expected that the younger children would make use of phonological recoding for the task of spelling and reading in English and hence performance in these tasks should be impeded by concurrent vocalisation. On the other hand, if the older children have made the transition to reading and spelling orthographically, concurrent vocalisation should have no adverse effect on performance as this task is thought to only disrupt use of the phonological code.

However, findings such as those of Arab-Moghaddam & Senechal (2001) suggest that children can use different strategies according to the nature of the orthography to which they are exposed. In the case of the present study, the orthography of Welsh is transparent. With just a few exceptions, there is a high degree of consistency between graphemes and phonemes, and use of the phonological code will typically be a successful strategy for reading and spelling in this language. If children (regardless of age) do tend to rely more on phonological than orthographic skills for reading and spelling in Welsh, then there should be pronounced deleterious effects of concurrent vocalisation here.

## Experiment I: method

### Participants

Thirty children from a Welsh language school in Pontypridd took part in this study. The children were identified as being equally fluent in English and Welsh on the basis of tests carried out by the school and their current school work. The school’s primary language for instruction in all subjects is Welsh. However, the school is situated in an area of South Wales that is predominantly English speaking, so the children who attend this school are required to function as fluent bilinguals on an everyday basis. English literacy is taught in this school as a second language. Prior to testing, each child was informally interviewed to elicit information about the home language environment. These interviews indicated that all of the children spoke English as their first language. However, it was found that all children were supported in speaking Welsh at home but only 16 of the 30 children had parents who were fluent Welsh speakers. Informal observation of the children by the tester indicated

that they regularly engaged in ‘code switching’ in their everyday language behaviour. Two groups of children were tested: 15 year ‘Twos’ with a mean age of 7 years and 2 months (8 males and 7 females), and 15 year ‘Sixes’ with a mean age of 11 years and 3 months (6 males and 9 females). It was confirmed by the teachers that none of the children selected for inclusion in the study had been diagnosed with reading or any other educational difficulties.

### Spelling tests

The tests were specially constructed for the purposes of this study. They consisted of a set of 63 English and a set of 63 Welsh words. Both sets comprised words of one, two and three syllables, with equal numbers at each length. The words for the spelling tests were assembled in consultation with the childrens’ teachers, and selected on the basis that they were all words that would be familiar to the children. A specially constructed test was considered preferable over existing standardised spelling tests due to the necessity of balancing the English and Welsh words in terms of number of syllables and familiarity. With these requirements in mind, it was not possible simply to translate an existing English language test into its Welsh equivalent. Some of the Welsh words used in the spelling tests were the translation equivalents of English words (e.g., *llaeth*—milk); however direct translation equivalents did not always fit into the same syllabic length category (e.g., *ffenester*—window). Where literal translation equivalents were not appropriate, alternatives were chosen from similar categories with which the children were familiar (e.g., *sun*—*haf* [summer]). See Appendix 1 for a list of test items.

### Design and procedure

The words for the tests were spoken to the children by the researcher, and administered under three experimental conditions: a ‘Silence’ condition whereby the children were simply required to write down the words to dictation with no concurrent task; a ‘Concurrent Vocalisation’ condition in which the children were required to utter aloud an irrelevant syllable (“la...la...la...”) whilst writing the words to dictation; a ‘Tapping’ condition in which the children had to tap a finger of their free hand whilst writing down the words to dictation. The tapping condition was used to control for the possibility that any decrement in performance under concurrent vocalisation simply reflected the attentional demands of doing two tasks at once. If this was the case, then a similar decrement should also be observed in the tapping condition. All of the children were exposed to each condition. Words were presented in groups of twenty-one, each group consisting of seven items of each syllabic length for each language. Children were tested individually with the order of presentation of each group of words counterbalanced across experimental conditions to ensure that each subset of words was rotated through each of the concurrent task conditions. There were brief rest periods between conditions. The children were told that they were going to be asked

to spell some words. At the beginning of the concurrent vocalisation condition the experimenter would say “During this group, I would like you to say, “la...la...la...” while you are writing the words”. At the beginning of the tapping condition, the experimenter would say, “During this group I would like you to tap your finger while you are writing the words.” The tester actively monitored the conduct of the concurrent task conditions to ensure that both tapping and vocalisation were performed in a continuous and uniform manner by the children. This monitoring indicated that all of the children performed the tasks as required. Children were required to produce the exact spelling for each word—they were scored as ‘correct’ or ‘incorrect’—and the total number of correct spellings split by language, task and length was obtained for each child.

## Results

The results were analysed using a 2 (age groups)  $\times$  2 (languages)  $\times$  3 (concurrent tasks)  $\times$  3 (word length) mixed factorial ANOVA. This analysis revealed significant main effects of language ( $F_{1,28} = 4.39$ ,  $P < .05$ ), age ( $F_{1,28} = 19.77$ ,  $P < .001$ ), concurrent task ( $F_{2,56} = 48.83$ ,  $P < .001$ ), and word length ( $F_{2,56} = 57.31$ ,  $P < .001$ ).

Inspection of means in Table 1 indicates that spelling performance in Welsh was superior to English; that Year 6 (11 year old) children exhibited superior spelling performance compared to Year 2 (7 year old) children, as would be expected given that the same spelling test was administered to both groups; spelling performance was most accurate under conditions of silence, with a decrement under conditions of concurrent tapping and least accurate under conditions of concurrent vocalisation; shorter words were more accurately spelt than longer words. A planned contrast on the concurrent task factor indicated a significant linear trend across the three presentation conditions ( $F_{1,29} = 82.59$ ,  $P < .01$ ). A series of paired  $t$ -tests with Bonferoni corrections to the significance levels indicated that spelling performance in the tapping condition was significantly lower than in the silent condition

**Table 1** Mean number of correct spellings as a function of age, language, length and task. (Standard deviations in parentheses)

| Age             | Silence     |             | Tapping     |             | Concurrent vocalisation |             |
|-----------------|-------------|-------------|-------------|-------------|-------------------------|-------------|
|                 | English     | Welsh       | English     | Welsh       | English                 | Welsh       |
| 7-year olds     |             |             |             |             |                         |             |
| One syllable    | 3.40 (1.80) | 4.40 (2.10) | 3.13 (1.73) | 4.13 (2.50) | 3.53 (1.55)             | 3.13 (2.72) |
| Two syllables   | 2.67 (1.80) | 3.80 (1.80) | 2.87 (2.03) | 3.33 (1.91) | 1.73 (1.16)             | 1.80 (1.52) |
| Three Syllables | 1.93 (1.49) | 2.93 (2.10) | 2.07 (1.62) | 1.53 (1.55) | 1.47 (1.55)             | 0.53 (0.74) |
| 11-year olds    |             |             |             |             |                         |             |
| One syllable    | 6.00 (1.93) | 5.90 (1.16) | 5.80 (2.18) | 5.60 (1.59) | 6.07 (1.16)             | 5.13 (1.50) |
| Two syllables   | 4.60 (2.30) | 5.67 (1.80) | 4.20 (2.21) | 6.00 (1.56) | 3.87 (2.33)             | 4.13 (1.74) |
| Three syllables | 2.80 (1.90) | 5.60 (1.88) | 2.87 (1.64) | 5.13 (2.10) | 2.20 (2.10)             | 3.07 (2.37) |

Note: Maximum possible score in each cell is 7

**Table 2** Mean correct spellings as a function of language and concurrent task. (Standard deviations in parentheses)

|         | Silence     | Tapping     | Concurrent vocalisation |
|---------|-------------|-------------|-------------------------|
| English | 3.52 (0.28) | 3.49 (0.29) | 3.15 (0.24)             |
| Welsh   | 4.72 (0.30) | 4.29 (0.29) | 2.97 (0.30)             |

Note: Maximum possible score in each cell is 7

( $t(29) = 2.66$ ,  $P < .05$ ), spelling performance in the concurrent vocalisation condition was significantly lower than in the silent condition ( $t(29) = 9.09$ ,  $P < .05$ ), and also significantly lower than in the tapping condition ( $t(29) = 6.36$ ,  $P < .05$ ). From these comparisons it can be concluded that although the concurrent tapping task did significantly affect performance relative to the silent condition, it had less of an effect than the concurrent vocalisation condition and therefore that concurrent vocalisation had an effect on processing over and above the distraction caused by a secondary task.

A significant task by language interaction was also observed ( $F_{2,56} = 21.79$ ,  $P < .001$ ). Inspection of Table 2 reveals that the deleterious effects of concurrent vocalisation were more pronounced in the case of spelling in Welsh. A series of paired  $t$ -tests with Bonferroni corrections revealed that in the case of spelling in Welsh, when compared to the control condition, performance was significantly lower in the tapping condition ( $t(29) = 3.11$ ,  $P < .05$ ), and in the concurrent vocalisation condition ( $t(29) = 11.72$ ,  $P < .05$ ). However, a comparison of the tapping and concurrent vocalisation conditions indicated that spelling accuracy was significantly reduced when asked to repeat irrelevant words ( $t(29) = 8.09$ ,  $P < .05$ ). In the case of English spelling, a series of paired  $t$ -tests with Bonferroni corrections indicated no significant differences between the control and tapping conditions ( $t(29) = .511$ ,  $P > .05$ ), the control and concurrent vocalisation conditions ( $t(29) = 2.60$ ,  $P > .05$ ) and the tapping and concurrent vocalisation conditions ( $t(29) = 2.02$ ,  $P > .05$ ).

There was a significant age by language by length effect ( $F_{2,56} = 13.69$ ,  $P < .001$ ). This interaction was further analysed using a series of  $t$ -tests with Bonferroni corrections to the significance levels. In the case of younger children spelling performance did not differ significantly between English and Welsh in the case of one syllable words ( $t(14) = .98$ ,  $P > .05$ ), two syllable words ( $t(14) = .98$ ,  $P > .05$ ) or three syllable words ( $t(14) = .27$ ,  $P > .05$ ). In the case of older children there was no significant difference in performance between English and Welsh words of one syllable ( $t(14) = 1.22$ ,  $P > .05$ ). However, in the case of two syllable words, performance was significantly lower in English compared to Welsh ( $t(14) = 3.69$ ,  $P < .05$ ) and in the case of three syllable words performance was also significantly lower in English compared to Welsh ( $t(14) = 4.83$ ,  $P < .05$ ). Inspection of Table 3 indicates that in the case of the younger children, spelling performance declined with increasing length for both languages, while in older children, spelling performance in Welsh was unaffected by increasing length, but declined with increasing length in the case of English.

**Table 3** Mean correct spellings as a function of age, language and word length. (Standard deviations in parentheses)

| Age             | Language    |             |
|-----------------|-------------|-------------|
|                 | English     | Welsh       |
| 7-year olds     |             |             |
| One syllable    | 3.36 (0.38) | 3.89 (0.48) |
| Two syllables   | 2.42 (0.47) | 2.98 (0.40) |
| Three syllables | 1.82 (0.39) | 1.67 (0.43) |
| 11-year olds    |             |             |
| One syllable    | 5.96 (0.38) | 5.56 (0.48) |
| Two syllables   | 4.22 (0.47) | 5.29 (0.40) |
| Three syllables | 2.67 (0.39) | 4.60 (0.43) |

Note: Maximum possible score in each cell is 7

A significant task by length interaction was observed ( $F_{4,112} = 6.18, P < .001$ ). A series of *t*-tests with Bonferroni corrections to the significance levels indicated that in the case of one-syllable words, performance did not differ significantly between the control and tapping conditions ( $t(29) = 1.44, P > .05$ ), the control and concurrent vocalisation conditions ( $t(29) = 2.26, P > .05$ ) and the tapping and concurrent vocalisation conditions ( $t(29) = 1.08, P > .05$ ). In the case of two syllable words, performance did not differ significantly between the control and tapping conditions ( $t(29) = .46, P > .05$ ), but performance in the concurrent vocalisation condition was significantly lower compared to the control condition ( $t(29) = 7.75, P < .05$ ) and the tapping condition ( $t(29) = 6.38, P < .05$ ). In the case of three-syllable words, performance did not differ significantly between the control and tapping conditions ( $t(29) = 2.32, P > .05$ ), but spelling performance was significantly lower in the concurrent vocalisation condition compared to the control condition ( $t(29) = 6.64, P < .05$ ) and the tapping condition ( $t(29) = 5.89, P < .05$ ). From Table 4, it appears that concurrent vocalisation had a more pronounced effect as the length of words increased, though the absence of a 3-way task by length by language interaction suggests that this effect was comparable for both languages. All other interactions were non-significant.

## Discussion

The results of this study indicate that while spelling of English words is marginally affected by concurrent vocalisation, performance in Welsh drops sharply under such conditions. It appears that concurrent vocalisation is more disruptive in the case of the more transparent orthography of Welsh. A priori it would seem plausible, in terms of cognitive economy, to assume that basic output strategies for spelling would be transferable across different languages. However, the results of this study indicate that this may not be the case. If basic output strategies were the same across languages, then one would expect the effects of concurrent vocalisation to be the same for both English and Welsh. The findings reported here would suggest that participants are making

**Table 4** Mean correct spellings as a function of task and word length. (Standard deviations in parentheses)

|                 | Silence     | Tapping     | Concurrent vocalisation |
|-----------------|-------------|-------------|-------------------------|
| One syllable    | 4.93 (0.26) | 4.67 (0.30) | 4.47 (0.29)             |
| Two syllables   | 4.18 (0.29) | 4.10 (0.29) | 2.90 (0.26)             |
| Three syllables | 3.32 (0.24) | 2.90 (0.24) | 1.85 (0.29)             |

*Note:* Maximum possible score in each cell is 7

greater use of the phonological code when spelling in Welsh. Use of such a strategy would be adaptive for spelling in a language in which there is a clear correspondence between phonology and orthography.

Further evidence that spelling strategies vary across languages of different orthographic depth is indicated by the differential effects of word length. Here, older and more proficient spellers continue to spell Welsh words accurately, even as length increases, while a decrement in performance is observed for spelling in English. However, in the case of younger spellers, spelling accuracy declines in both languages with increasing word length.

Another finding from this study shows that concurrent vocalisation has differential effects according to word length, irrespective of language. Spelling of longer words is more affected by concurrent vocalisation than spelling of shorter words. It seems to be the case that there is a greater reliance on phonological processes as word length increases. This appears to hold true across both age and language. Similar findings were reported by Service and Turpeinen (2001) who proposed that there was a greater involvement of phonological working memory for spelling longer words. Working memory is seen here as helping the speller to keep a “track of progress” through the word.

Overall, the results of this experiment demonstrate some differences in the processes used for spelling in English and in Welsh. The deleterious effects of concurrent vocalisation for spelling in Welsh, regardless of the age of the children indicates that here spelling is phonological in nature, thus demonstrating differences in the manner in which words are spelt according to the orthographic depth of the script.

## Experiment 2: Method

### Participants

Forty-five children from a Welsh language school in Cardiff took part in this study. The school’s primary language for instruction in all subjects is Welsh. However, this school is situated in a predominantly English-speaking area. So the children who attend this school are required to function as fluent bilinguals on an everyday basis. A brief structured interview with the children indicated that all of the children spoke English as their first language, but were supported in speaking Welsh at home. Twenty-four of the children had parents

who were fluent Welsh speakers. As with the group tested in the first experiment, informal observation of the children by the tester confirmed that the children regularly engaged in code switching in their everyday conversations. Two groups of children were tested: 24 year ‘Twos’ with a mean age of 7 years and 6 months (14 females and 10 males), and 22 year ‘Sixes’ with a mean age of 10 years and 4 months (10 females, 12 males). It was confirmed by the teachers that none of the children selected for inclusion in the study had been diagnosed with reading or any other educational difficulties.

### Reading tests

A reading comprehension test was employed. This was specially designed for the purposes of this study. It comprised short passages of text on subjects likely to be familiar to 7–11 year olds (e.g. trip to cinema, outing or club camp). The passages were matched for length (consisting of between 128 words and 137 words) and number of items to be remembered (e.g. amounts of money, colours and numbers). There were six factual questions along with each piece of text (e.g. “Who does Susan go ice skating with?”). There were six passages in all, three in English and three in Welsh. Prior to carrying out the main experiment, the six passages were piloted on another group of children in the same school to ensure that the passages were all of comparable difficulty both within and between languages. The results here indicated that no passage was consistently more difficult than any of the others. This type of task was selected as it has been established that reading for meaning is usually unaffected by concurrent vocalisation (Baron & Barron, 1977; Besner, 1987). If it could be demonstrated that reading for meaning in Welsh is adversely affected by this task, then there would be good grounds for assuming the differential involvement of phonological processes.

### Procedure

All children were tested individually. As in experiment 1, the reading tests were administered under three experimental conditions of silence, concurrent tapping and concurrent vocalisation, the order of which was counterbalanced. The six passages were rotated across these conditions. It should be noted that participants were only required to engage in concurrent tasks while reading the passage. After reading each passage, the children were presented with six written questions and were required to answer as many of the six questions as possible. They were required to produce the exact, factual answer to each question and each response was scored as ‘correct’ or ‘incorrect.’ The total number of correct answers, split by language and task, was obtained for each child. The administration of the comprehension tasks was self paced, with the children indicating when they had finished reading, and completed answering questions in each case.

## Results

The data were analysed using a 2(language)  $\times$  3(concurrent task)  $\times$  2(age) mixed factorial ANOVA. The results indicated significant main effects of language ( $F_{1, 43} = 21.65$ ,  $P < .001$ ), concurrent task ( $F_{2, 86} = 19.08$ ,  $P < .001$ ) and age ( $F_{1, 43} = 16.14$ ,  $P < .001$ ).

Inspection of means in Table 5 indicates that performance was superior in the English version of the reading task. Performance declined under conditions of concurrent vocalisation compared to silence and concurrent tapping. A planned contrast on the concurrent task factor indicated a significant linear trend across the three presentation conditions ( $F_{1, 45} = 85.23$ ,  $P < .01$ ). A series of paired  $t$ -tests with Bonferoni corrections to the significance levels indicated that reading performance in the tapping condition was significantly lower than in the silent condition ( $t(46) = 2.87$ ,  $P < .05$ ), reading performance in the concurrent vocalisation condition was significantly lower than in the silent condition ( $t(46) = 6.24$ ,  $P < .05$ ), and also significantly lower than in the tapping condition ( $t(46) = 3.58$ ,  $P < .05$ ). These comparisons indicate that although the concurrent tapping task did significantly affect performance relative to the silent condition, it had less of an effect than the concurrent vocalisation condition and therefore that concurrent vocalisation had an effect on processing over and above the distraction caused by a secondary task. The year Six children performed better than the year Two children. As with Experiment 1, this latter result was to be expected as the same test was administered to the two age groups. However, despite this, the means in Table 3 indicated that this difference was not due to any floor or ceiling effects, as there appears to be an acceptable amount of variability in the performance of the two age groups.

There were no significant two-way interactions. However, a significant three-way interaction was observed between the variables ( $F_{2, 86} = 3.24$ ,  $P < .05$ ). It appears that in the case of Year Two children, concurrent vocalisation had a deleterious effect on performance in both English and Welsh, whereas in the case of Year Six children, concurrent vocalisation only had a deleterious effect on performance in Welsh. A series of  $t$ -tests with Bonferroni corrections indicated that in the case of younger children reading English, performance in the tapping condition was not significantly different from performance in the silent condition ( $t(23) = 1.14$ ,  $P > .05$ ), indicating

**Table 5** Mean reading performance (number of correct answers) as a function of age, task and language. (Standard deviations in parentheses)

| Age          | Silence     |             | Tapping     |             | Concurrent vocalisation |             |
|--------------|-------------|-------------|-------------|-------------|-------------------------|-------------|
|              | English     | Welsh       | English     | Welsh       | English                 | Welsh       |
| 7-year olds  | 4.13 (0.24) | 3.33 (0.28) | 3.79 (0.31) | 2.83 (0.26) | 2.25 (0.25)             | 2.38 (0.28) |
| 11-year olds | 4.66 (0.25) | 4.73 (0.29) | 4.54 (0.31) | 3.99 (0.27) | 4.48 (0.25)             | 3.48 (0.28) |

Note: Maximum possible score in each cell is 6

little effect of a secondary task. Performance in the concurrent vocalisation condition was significantly worse than the tapping condition ( $t(23) = 3.73$ ,  $P < .05$ ) and the silent condition ( $t(23) = 3.73$ ,  $P < .05$ ). These results demonstrate a clear deleterious effect of concurrent vocalisation in English that is not attributable to secondary task demands.

The results for Welsh fall in the same direction but appear less clear-cut. Performance under tapping is not significantly worse than under the silent condition ( $t(23) = 1.54$ ,  $P > .05$ ), indicating little effect of a secondary task. Concurrent vocalisation leads to significantly worse performance than silence ( $t(23) = 3.46$ ,  $P < .05$ ), but the vocalisation-tapping difference fails to reach significance ( $t(23) = 1.81$ ,  $P > .05$ ). This pattern suggests that there is a small contribution of a secondary task effect to the vocalisation-tapping difference. However, since this effect is not in itself sufficiently powerful to reach significance, part of the vocalisation-silence difference must be due to the effect of vocalisation over and above that of a secondary task.

In the case of older children reading English, a series of  $t$ -tests with Bonferroni corrections indicated no significant differences between performance in the silent and tapping conditions ( $t(22) = .36$ ,  $P > .05$ ), the tapping and concurrent vocalisation conditions ( $t(22) = .143$ ,  $P > .05$ ) and the silent and concurrent vocalisation conditions ( $t(22) = .56$ ,  $P > .05$ ). However, in the case of performance in the Welsh version of the task, the results mirrored the performance of the younger children. There was no significant difference between the silent and tapping conditions ( $t(22) = 1.73$ ,  $P > .05$ ), and no significant difference between the tapping and concurrent vocalisation conditions ( $t(22) = 1.74$ ,  $P > .05$ ), but performance under conditions of concurrent vocalisation was significantly worse than in the silent condition ( $t(22) = 3.99$ ,  $P < .05$ ). Hence, it appears to be the case that when reading in Welsh, concurrent vocalisation adds significantly to the effects of a secondary task on comprehension.

Although reading performance in English was generally superior, a  $t$ -test with Bonferroni correction indicated that in the case of younger children there was no significant difference between reading in English and Welsh under conditions of concurrent vocalisation ( $t(23) = 1.31$ ,  $P > .05$ ). In the case of older children, reading performance under conditions of concurrent vocalisation was significantly lower in Welsh than in English ( $t(23) = 3.32$ ,  $P < .05$ ).

## Discussion

As in the first experiment, there was a significant main effect of age, with older children performing better overall than younger children. This is to be expected when the same test is administered to two different age groups, and the observed difference here can be regarded as trivial. A more interesting finding, however, was the overall superiority of performance when reading in English. This may be considered surprising given that the children were attending a school in which Welsh was the first language. However the wider language environment in which the school was located was predominantly

English-speaking. Therefore, this result may simply reflect the effects of the wider language environment in which the children were living, and the general effects of exposure to English. Concurrent vocalisation did have a deleterious effect on performance in general, but the three-way interaction between age, task and language indicated that in younger children it affected reading in both languages while in the older children it only had an adverse effect on reading in Welsh. This may indicate that younger children rely on a phonological strategy when reading for meaning in both English and in Welsh. This supports Frith's (1985) view that younger children make use of a phonological strategy for reading in English, and also extends it to the Welsh orthography. However, the differential effects of concurrent vocalisation on reading in English and in Welsh as a function of age suggests that older children only use a phonological strategy for reading in Welsh but not in English. The findings with regard to English are again supportive of Frith's (1985) view as it would be expected that older children have moved on to reading using an orthographic strategy. On the other hand, the deleterious effects of concurrent vocalisation on reading in Welsh suggests that older children continue to rely on a phonological strategy for reading in this orthography. The lack of an effect of concurrent vocalisation on a reading for meaning task in English is also in accordance with the views of Besner (1987) who argues that it is possible to derive a phonological code for reading which is not affected by this task. However, the finding of an effect in the case of reading in Welsh may indicate differential effects across languages. Reading in a language which has a transparent orthography may proceed with the use of an articulatory code that can be interfered with by concurrent vocalisation (Katz & Feldman, 1983).

## General discussion

The results of these studies indicate that a task which disrupts the use of the phonological code has differential effects on reading and spelling performance in English and Welsh, languages which employ orthographies of different depth. This is in line with Arab-Moghaddam and Senechal's (2001) finding that bilingual individuals will vary the strategy they use for reading and writing according to the orthographic depth of the script.

The deleterious effects of concurrent vocalisation appear to be most pronounced in the spelling production task in Welsh, where children are able to depend on the consistency of grapheme–phoneme correspondences to construct correct responses. This would imply that in the case of spelling in Welsh children are relying more on the use of phonological processes. The less pronounced effects on spelling in English would indicate that children are less reliant on phonological processes in this task. Indeed, the research evidence suggests that this would be the case in a deep orthography such as English where orthographic strategies are considered to be more useful (Ehri, 1991, 1997; Frith, 1985).

The above results clearly indicate that concurrent vocalisation disrupts the use of phonological processes. Traditionally, the effects of concurrent vocalisation in beginning readers and spellers have been implicated in the disruption of the use of an alphabetic strategy as such a process is assumed to be articulatory in nature (Bryant & Bradley, 1983; Kimura & Bryant, 1983). However, the precise nature of the processes which have been disrupted is not clear. Another possible explanation for the deleterious effects of concurrent vocalisation on spelling may relate to the involvement of working memory. Recent evidence from Service & Turpeinen (2001) suggests that concurrent vocalisation disrupts spelling performance of adults in the shallow orthography of Finnish. They found that in a backwards spelling task, increasing word length resulted in performance becoming more vulnerable to the effects of concurrent vocalisation. They explained these findings by suggesting that longer words require the use of working memory to assemble the correct representation. These results were mirrored by the performance of the older children in the present study in Welsh. In the baseline condition spelling accuracy was unaffected by increasing word length while concurrent vocalisation caused a progressive diminution in performance as the stimuli got longer. Hence, if Service and Turpeinen (2001) are correct, the results of the current research would suggest that bilingual children when spelling in Welsh make use of an output strategy involving the use of working memory.

The two types of explanation for the effects observed here presume disruption at different levels of the process of spelling. In the reading and spelling literature, researchers using ‘concurrent vocalisation’ (e.g., Bryant & Bradley, 1983) have explained the effects of this in terms of disruption of a speech-like process of applying an alphabetical strategy to spell. However, where similar techniques have been applied in a working memory context under the name of ‘articulatory suppression.’ (e.g., Service & Turpeinen, 2001) the findings have been explained in terms of the disruption of the representation of the word in phonological short-term memory.

It is clear that concurrent vocalisation does have a disruptive effect on spelling. The results of the present study suggest that it was the application of a phonological recoding strategy that was disrupted. If concurrent vocalisation was disrupting a working memory process, then it should have deleterious effects in both languages. However, the fact that its effects were most pronounced in the transparent orthography of Welsh, when children were more likely to be using a phonological strategy to spell suggests that this was not the case.

The outcomes from the reading for meaning task support the view expressed by Ehri (1991) and Frith (1985) that children’s reading progresses from a phonological strategy involving use of grapheme–phoneme correspondences to a more sophisticated orthographic strategy whereby children begin to recognise letter strings which “...can be used to create by recombination an almost unlimited number of words” (Frith, 1985, p. 308). However, the results also indicate some difference in strategy according to the orthographic depth of the script being read. Whilst concurrent vocalisation

disrupted the reading performance of younger children in both languages, indicating the use of a phonological strategy, older children's performance was only disrupted when reading in Welsh. This would indicate that older Welsh–English bilingual children continue to rely on a phonological strategy when reading the more transparent script of Welsh, but are less reliant on this for the opaque English orthography.

As in the case of spelling, an alternative explanation for the effects of concurrent vocalisation in reading can also put forward, in this case in terms of the carrying over of information from one sentence to another in working memory (Glanzer et al., 1981). It could be argued that it was this process with which concurrent vocalisation interfered, rather than the process of phonological recoding. However if this was so, one would expect deleterious effects of this task in both languages irrespective of the age of the children and this was clearly not the case. Here, the effects of concurrent vocalisation seem to be specific to the use of a phonological strategy.

The present studies indicate that the processes involved in reading and writing not only vary across languages of different orthographic depth, but may also vary within the individual when operating in different languages. It appears that phonological strategies persist in an appropriate orthographic environment offering the individual an adaptive means of decoding and production. However, in the case of deeper orthography, reading and spelling must be mediated by processes which can take into account the more complex relationship between graphemes and phonemes.

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## Appendix 1: Spelling test words (Experiment 1)

English—One syllable:

Chair, Hair, Bed, Dog, Sky, Clock, Cat, Nose, Fire, Frog, Moon, Boat, Book, Shoe, Ring, Milk, Coat, Wall, Sun, Spoon, Floor.

English—Two syllables:

Button, Music, Perfume, Curtain, Party, Ruler, Pencil, Basket, Picture, Table, Wardrobe, Rubber, Window, Pillow, Mummy, Jumper, Ankle, Poster, Toothbrush, Shopping, Jacket.

English—Three syllables:

Bicycle, Elephant, Photograph, Chocolate, Cardigan, Banana, Computer, Gymnastics, Superman, Radio, Kangaroo, Lollipop, Calendar, Dungarees, Umbrella, Wallpaper, Strawberry, Potato, Anorak, Assembly, Container.

Welsh—One syllable:

Cath, Ci, Llaeth, Pen, Cloc, Ceg, Ty, Chwaer, Llun, Gardd, Beic, Gwlad, Haf, Llyfr, Braf, Het, Ffeil, Mawr, Sgarf, Haul, Trwyn.

Welsh—Two syllables:

Ysgol, Mochyn, Blodyn, Cartref, Ceffyl, Cariad, Esgyd, Bwyta, Wyneb, Chwarae, Bachgen, Tocyn, Golau, Gwydr, Enw, Menyn, Glanhau, Llygad, Carped, Coeden, Gwyliau.

Welsh—Three syllables:

Pysgota, Presennol, Tudalen, Teledu, Ofnadwy, Prifathro, Athrawes, Llythren, Ymosod, Ffenestr, Gwahanol, Nadolig, Adeilad, Corfforol, Naturiol, Anifail, Ysbwriel, Ysbyty, Tywysog, Ystafell, Cwningen.

## Appendix 2: Sample reading test (Experiment 2)

Sample English passage

On Saturday Rebecca and Claire spent the morning in Cardiff choosing some clothes to buy with their birthday money. They both wanted a pair of jeans, so they went to Top Shop where Claire bought a pair of black jeans costing £30 and Rebecca bought a pair costing £25. They both had £5 left so they decided to go to the cinema to watch ‘Batman’. After buying their tickets which cost £2.50 each, they bought some popcorn and a large coke to drink. When they got inside they were told to sit anywhere in the blue seats. The film lasted 1 h and 30 min. They both enjoyed the film very much. Rebecca and Claire then went to Macdonalds where they waited for Claire’s parent to pick them up.

1. When did Claire and Rebecca go to Cardiff?
2. What did they both buy?
3. How much did Claire spend in the shop?
4. What film did they go and see?
5. Did they enjoy the film?
6. Who picked them up?

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