
Number name systems and children’s early number knowledge: A comparison of Welsh and English speaking children

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ABSTRACT

Studies of the effect of regular number name systems on children’s counting and early arithmetical skills have traditionally involved cross-cultural comparisons. The major weakness of previous studies has been that the possible impact of wider cultural differences between the groups studied has largely been ignored. The present study resolves this problem by making comparisons within a broad cultural group and a single educational system. Welsh and English speaking 5 and 6 year olds were tested on their number sequence knowledge and arithmetical skills. Welsh speakers made fewer errors than English speakers on backward and forward sequencing tasks, and on arithmetic at age 6. A facilitatory effect for regular number name systems is supported by these data.
INTRODUCTION

International comparisons of mathematical attainment have shown that pupils in Asian countries such as Japan, China, Taiwan, Singapore and Korea achieve higher average standards with greater consistency than pupils in most western countries (Husen, 1967; Robitaille and Garden, 1989; Travers and Westbury, 1989). Many studies have sought explanations for these differences in performance and have looked for explanations in terms of differences in mathematics instruction time, class size (Reynolds et al., 1986), the content of curricula (Howson, 1988), and parental expectations (Stevenson, Azuma and Hakuta, 1989). Cultural values and the possible effects of Asian educational philosophies have also been discussed in this context (Stevenson, 1989).

In addition to the approaches mentioned above, a number of researchers have suggested that a plausible place to look for the roots of variation in mathematical attainment is in differences between languages (Nunes and Bryant, 1996). Most European languages have number word systems which, whilst having a basic base-ten system, are irregular in parts, and particularly in the ‘teens’ and decade words. In contrast, the number the word systems of some Asian languages are truly regular and can be termed ‘generative’, in that when we understand the logic of a number system, we can generate numbers we have not heard before. The learning of number-word systems involves the memorization of number words in a fixed order. Irregular, non-generative number name systems, such as English, place heavy demands on children. Children learning to count in English will need to learn all the number words up to twenty as well as the decade
numbers. Whilst adults may appreciate the derivation of irregular words such as 'twenty' from 'two ten', it is doubtful whether young children learning to count will realize this. Children are more likely to perceive 'twenty' as simply the next number word after 'nineteen' in a series which needs to be memorized.

A regular number-word system, on the other hand, involves only the numbers from one to ten, and the number pattern is then repeated using combinations of these number words up to 99. In such a system, 11 becomes the equivalent of 'ten one', 12 becomes 'ten two', 20 becomes 'two ten', 45 becomes 'four-ten-five' and so on. There is a clear and consistent use of word order to signify value. Fuson (1988) suggests that the advantage of such a logical and regular numbering system for children in the process of developing their understanding of number, lies in the emphasis on the importance of base-ten, which is continually reiterated in repeated counting. Nunes and Bryant (1996) also argue that the linguistic use of a generative number-word system facilitates an earlier grasp of number structures and that this may assist the acquisition of mathematical skills and understanding in the early years. Evidence from comparisons of American and Chinese children suggests that children using a generative number name system make fewer errors in counting and, in particular, exhibit a greater understanding of the 'decade system' and the importance of 'ten' in the counting structure (Miller and Stigler, 1987; Miura and Okamoto, 1989; Miura, Okamoto, Kim, Chang, Steere and Fayol, 1994). This understanding may provide the children with advantages while they are developing their early mathematical skills.
In the development of mathematical skills, oral counting is one of the first steps. However, the development of mathematical understanding does not begin on entry to school and continue at a steady rate throughout school years. Children develop some awareness in 'informal' mathematics long before they can write and well before the beginning of school (Aubrey, 1993; Fuson, 1988). The question of whether Asian children have a 'head start' in informal mathematical thinking has been examined by Song and Ginsberg (1987). They compared the performance of a large sample of Korean children aged 4-8 years with the data presented by Miller and Stigler (1987). They found that the performance of pre-school Korean children in mathematics was similar to that of pre-school American children. However by the age of eight, Korean children were significantly outperforming their US counterparts. They explain this in terms of early 'cognitive overload' due to the fact that Korea employs a dual system involving a less regular system (with irregular decade names) for counting and a regular number name system for reading and writing numbers. It is the regular system which dominates formal mathematics instruction. Their findings suggest that the advantages of using a regular generative number-word system emerge after the first year at school, but this does not preclude the possibility of a regular number system providing children with a base on which subsequent skill can be more easily built.

Further evidence to support the facilitatory effect of regular number name systems comes from Carpenter, Moser and Romberg (1982). They argue that only with constant reminder of the regularity of the structure, as in the Chinese and Japanese systems, does decomposition become a natural tool in the manipulation of addition and subtraction sums. In a regular counting system, the oral repetition of numbers between 11 and 99
both depends on and emphasizes the significance of place value. They report studies which suggest that decomposition as a tool is used earlier, more successfully, and with more understanding by Chinese and Japanese children than by their European and American counterparts.

The literature reviewed above suggests that the regularity or otherwise of counting systems may be directly related to the development of mathematical understanding and to subsequent mathematical attainment. However, the cross-cultural studies mentioned above suffer from a major weakness. Many factors other than language also differ between the groups studied. The children studied by Miller and Stigler (1987) and by Miura et al (1994), for example, come from cultures that are markedly different in parental expectations and child rearing practices, time spent in formal education in the early years, and classroom management. For these reasons it has been difficult to assess the strength of the effect of number-word systems on developing mathematical understanding.

Psychology has a long history of making cross-cultural comparisons of single factors whilst ignoring the impact of other aspects of the cultures under study, and the cross national study of mathematics has suffered from this methodological problem. The remedy for this lies in careful selection of the groups to be compared. An attempt can be made to assess the effect of different counting systems by comparing groups of children taught within the educational system in Wales. There are two reasons for this, one linguistic and one cultural. Firstly, Welsh, unlike English and most other European languages, has a generative number-word system, similar in its regularity to that
observed in Chinese, Japanese and Korean. Schools in Wales teach in either the medium of Welsh or English, or may have parallel streams within the same school, often sharing the same central facilities but providing education for children in the preferred language. Secondly, a study based in Wales provides the opportunity to compare the performance of children from within the same broad cultural background, and the same educational system and curriculum, but using different languages at home and as the medium of instruction.

The aim of this study was to test the hypothesis that regular number name systems provide an initial advantage to children when compared with others whose language uses a less regular system. It is likely that any differences in early number knowledge will be more marked for higher level skills. This study therefore assessed children’s ability to produce the number sequence and to count objects, as well as their knowledge of the forward and backward sequencing, and early arithmetical skills.

METHOD

SUBJECTS

Schools in Wales teach in either the medium of Welsh or English, or may have parallel streams within the same school, often sharing the same central facilities but providing education for children in the preferred language. Welsh is the sole medium of instruction in 27% of schools in Wales, with this rising to 56% in the Dyfed Education Authority area (H.M.S.O., 1995), the area chosen for the study. Dyfed Education
Authority policy is for English to be introduced to Welsh speaking schools only as children enter the junior phase around the age of 8 years. As a result of this policy, children in the first two years of school (aged 5 and 6) who come from Welsh speaking homes can be classified as Welsh speakers for whom English will be their second language. Approximately fifty percent of Dyfed primary schools use Welsh as the sole medium of instruction (Welsh Office, 1994). From those schools offering a choice of Welsh or English as the medium of instruction, five were selected for inclusion in the study, with an additional 3 schools offering education only in the Welsh language.

140 children in reception and first year classes were selected. The group comprised roughly equal numbers of reception and year one pupils, balanced by gender and language. The sample consisted of 70 pupils who were being taught through the medium of Welsh and for whom Welsh was the language spoken in the home, and 70 who were being taught through the medium of English and for whom English was the language spoken in the home. The sample comprised roughly equal numbers of boys and girls. The tests were conducted in the child’s home language by a bilingual Welsh/English speaker at the end of June in the summer term. The children in the younger age group were 5 years 0 months on average (s.d. 2.73 months), while those in the older group were 6 years 0 months (s.d. 2.42 months). Dyfed allows children to start school in the term following their fourth birthday, and as a result, summer born children may be at a disadvantage in terms of the length of time they have spent in school. The year and language groups were balanced for the proportion of summer born children.
The children’s vocabulary was tested using the British Picture Vocabulary Scale. A Welsh version was developed by the researchers. This involved the translation of B.P.V.S. items into Welsh and their subsequent back translation into English by a different bilingual Welsh-English speaker. This resulted in a test of vocabulary which permits the comparison of the raw scores of the two groups of children, to ensure that there were no significant differences between the Welsh and English speaking groups. The B.P.V.S. scores of the two language groups showed no significant differences between the Welsh speaking children (mean long form score 41.85, s.d. 10.28) and the English speaking children (mean long form score 41.72, s.d. 11.00).

MEASURES

Number Knowledge

In the practice of oral counting, three basic criteria need to be satisfied. These are that counting displays the use of a one-to-one relationship; that a stable order is maintained; and that the last number counted may be used as a description of the whole (Fuson, 1991). Only when these basic criteria are satisfied may it be assumed that there is any understanding of the significance of counting. In order to assess the counting skills and number knowledge, children were assessed in 5 ways:

1. **Counting**
   
   Children were asked to “count as high as you can, start with one..”

2. **Object Counting**

   Children were asked to count identical counters spread on the table. The instructions were “Now I want you to count these for me. I need to know how many there are. Count out loud.”
3. **Counting-on**

Children were invited to count on having been presented with two numbers in sequence. The instructions were “Now we’re going to do some counting. I’m going to start and you can finish, so if I say ‘one’, you would say ‘two’. Let’s have a go.” The numbers presented to the children were: 1, 2 ..., 18, 19..., 10, 11..., 4, 5..., and 28, 29....

4. **Number knowledge - forward sequencing**

Children were asked “What comes after ....” and given a number. The numbers were 3, 9, 17, 39, 92 and 89.

5. **Number knowledge - backward sequencing**

Children were asked “What comes before ....” and given a number. The numbers were 2, 6, 13, 17, 71 and 100.

**Arithmetic**

Arithmetical ability was tested using the Arithmetic sub-test from the Wechsler Intelligence Scale for Children (W.I.S.C.). For the Welsh speaking children this test was translated and back-translated into Welsh for checking before administration. The W.I.S.C. items can be subdivided into two groups. Items 1-4 (count items) present children with problems which may be solved by counting the display in front of them. Item 5 and subsequent items (arithmetic items) are word problems presented with no visual cue.

**RESULTS**
The means for each age and language group for the highest number counted to in sequence (both with and without objects to count) are displayed in Table 1 along with the mean number of errors made while counting. Analysis of counting errors is usually made based on a number of trials, while the data presented here are based on a single trial in each of the two conditions. An analysis of the errors children made revealed that more children taught through the medium of English (33 pupils) omitted one or more numbers during their counting than children taught through the medium of Welsh (24 pupils). This difference was significant at the one per cent level. Miller and Stigler (1987) observed patterns of errors that differed between their American and Chinese groups children. Analysis of the counting errors made by the children in the current study showed low frequencies of ‘made up’ numbers in both language groups, with 5 Welsh speakers and 6 English speakers making up number words. There were no discernible differences between Welsh and English speakers in the types of made up numbers or the nature of the omissions made whilst counting, although it is interesting to note that the 2 children who omitted the numbers from 14 to 39 (making the phonological error of skipping from 13 to 40), were both English speakers. While the means in Table 1 indicate a slight advantage for Welsh speaking children over English speaking children for each of the tasks, no further statistical analysis was performed due to the possibility that these counting tasks were not sufficiently rigorous measures of the children’s counting ability.

Table 1: Object counting and spontaneous counting by age and language group.
<table>
<thead>
<tr>
<th></th>
<th>5 year olds</th>
<th>6 year olds</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Welsh n=37</td>
<td>English n=36</td>
</tr>
<tr>
<td></td>
<td>Welsh n=33</td>
<td>English n=34</td>
</tr>
<tr>
<td>Object counting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(highest no.)</td>
<td>mean 22.92</td>
<td>mean 20.61</td>
</tr>
<tr>
<td></td>
<td>s.d. 8.38</td>
<td>s.d. 8.82</td>
</tr>
<tr>
<td></td>
<td>mean 32.09</td>
<td>mean 30.06</td>
</tr>
<tr>
<td></td>
<td>s.d. 6.15</td>
<td>s.d. 6.98</td>
</tr>
<tr>
<td>Object counting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(errors)</td>
<td>mean 1.70</td>
<td>mean 2.69</td>
</tr>
<tr>
<td></td>
<td>s.d. 2.60</td>
<td>s.d. 3.21</td>
</tr>
<tr>
<td></td>
<td>mean 0.36</td>
<td>mean 0.41</td>
</tr>
<tr>
<td></td>
<td>s.d. 0.70</td>
<td>s.d. 0.74</td>
</tr>
<tr>
<td>Counting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(highest no.)</td>
<td>mean 22.43</td>
<td>mean 19.50</td>
</tr>
<tr>
<td></td>
<td>s.d. 9.87</td>
<td>s.d. 11.97</td>
</tr>
<tr>
<td></td>
<td>mean 39.39</td>
<td>mean 37.82</td>
</tr>
<tr>
<td></td>
<td>s.d. 12.78</td>
<td>s.d. 13.98</td>
</tr>
<tr>
<td>Counting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(errors)</td>
<td>mean 1.24</td>
<td>mean 3.19</td>
</tr>
<tr>
<td></td>
<td>s.d. 1.88</td>
<td>s.d. 3.76</td>
</tr>
<tr>
<td></td>
<td>mean 0.48</td>
<td>mean 0.80</td>
</tr>
<tr>
<td></td>
<td>s.d. 0.80</td>
<td>s.d. 2.28</td>
</tr>
</tbody>
</table>

Table 2 shows the means, standard deviations and coefficients of variation for the remaining measures. The W.I.S.C. Arithmetic raw score is presented along with its two components, the counting items and the arithmetic items. The 6 year old Welsh speakers had low standard deviations for counting-on and W.I.S.C. count items when compared with the English 6 year olds. For number knowledge and the W.I.S.C. count items the dispersal of the English scores was greater than the dispersal of the Welsh scores, (as shown by the larger coefficients of variation). It is widely recognized that mathematical attainment among English speaking pupils is characterized by a
relatively large variation and a long tail of under-achievement and it is possible that this feature is beginning to be apparent here.

Of the three number knowledge tasks, the test of knowledge of backward sequencing was the most difficult and the counting-on task the most easy. A multivariate analysis of variance (MANOVA) was conducted to examine the differences between the language and age groups. Analysis of the number knowledge tests indicated significant interactions between age group and test \[F (2,135) = 8.40, p < 0.001\], language group and test \[F (2,135) = 8.09, p < 0.001\] and a significant three way interaction between age group, language group and test \[F (2,135) = 3.28, p < 0.05\]. It was only for the counting-on task that Welsh speakers showed no advantage.

Inspection of the components of the backward and forward sequencing tasks indicated that English speaking children had more difficulty with the numbers before 13 and 17 than Welsh speakers. Producing the number before 71 showed an age effect but no language effect. Welsh children were more likely to succeed than English children when asked to produce the number following 39 and 17.

Analysis of variance on the W.I.S.C. Arithmetic sub-test showed an age by language interaction \[F (1,136) = 5.18, p < 0.025\], and subsequent analysis indicated that Welsh children outperformed English speaking children on the arithmetic items at age 6, but not at age 5. The counting items showed only main effect for age \[F (1,136) = 13.36, p < 0.001\] and for language \[F (1,136) = 3.93, p < 0.05\], and no age by language interaction.
Table 2: Number knowledge (correct responses to counting-on, forward and backward sequencing questions) and W.I.S.C. arithmetic by age and language group.

<table>
<thead>
<tr>
<th></th>
<th>5 year olds</th>
<th>6 year olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Welsh n=37</td>
<td>English n=36</td>
</tr>
<tr>
<td>Counting mean</td>
<td>3.32</td>
<td>3.47</td>
</tr>
<tr>
<td>on s.d.</td>
<td>1.13</td>
<td>1.32</td>
</tr>
<tr>
<td>Forward mean</td>
<td>2.95</td>
<td>2.14</td>
</tr>
<tr>
<td>sequencing mean s.d.</td>
<td>1.22</td>
<td>1.20</td>
</tr>
<tr>
<td>Backward mean</td>
<td>2.59</td>
<td>1.89</td>
</tr>
<tr>
<td>sequencing mean s.d.</td>
<td>1.46</td>
<td>1.43</td>
</tr>
<tr>
<td>W.I.S.C mean</td>
<td>2.96</td>
<td>2.85</td>
</tr>
<tr>
<td>Count items mean s.d.</td>
<td>1.00</td>
<td>1.17</td>
</tr>
<tr>
<td>W.I.S.C. mean</td>
<td>1.46</td>
<td>1.56</td>
</tr>
<tr>
<td>Arithmetic items s.d.</td>
<td>0.96</td>
<td>0.94</td>
</tr>
<tr>
<td>W.I.S.C. mean</td>
<td>4.59</td>
<td>4.61</td>
</tr>
<tr>
<td>Arithmetic subtest s.d.</td>
<td>1.55</td>
<td>1.84</td>
</tr>
</tbody>
</table>

DISCUSSION

The results reported here support the hypothesis that regular, generative number name systems provide children with an advantage in the early stages of developing their number knowledge. Although the counting-on task showed no clear differences between the two language groups, the backward and forward sequencing tasks did indicate an advantage for Welsh over English speaking children, suggesting that the
young English speakers were still consolidating their knowledge of the number sequence, and the teen words in particular. The largest differences between the Welsh and English speaking children were largely in skills which demanded a well developed knowledge of the number sequence. Whilst 5 year old English speaking children are still struggling with forward sequencing, by the age of 6 there are no significant differences between the groups. As one might expect from the hierarchy of difficulty of the tasks, backward sequencing shows language effects in both age groups, suggesting regular number name systems provide a small advantage while number knowledge skills are being acquired.

Turning to the components of the W.I.S.C Arithmetic sub-test, the interaction between age and language may be explained by the possibility that 6 year old English speakers were still consolidating their number knowledge and unable to cope well with items requiring more than simple counting skills. These findings are particularly interesting given the recent work on word problems by Miura, Okamoto, Kim, Fayol, Steere, Vlahovic-Stetic and Suomala (1996) which suggests that Japanese and Korean children do not outperform Swedish or American children on word problems in first grade. They argue that the advantages conferred by number name systems may be restricted to computational problems., however their word problems were more complex than those used in the current study. Our finding that the word problem section of the W.I.S.C. Arithmetic sub-test showed an advantage for Welsh speakers gives support to the suggestion that regular number name systems may confer advantages more lasting than the ability to count with fewer errors, but it is possible that this advantage may be limited to simple word problems. In other words, small improvements in number
sequence knowledge may have an effect on the use to which that number knowledge is put, as long as the computation problem is not swamped by the difficult of interpreting its context.

Although the language effects described here are small, they are consistent, and remarkable given the very great similarities between the two cultures. Children’s counting was not subjected to the repeated testing required to gather samples of errors suitable for more rigorous analysis, and this may explain the lack of differences in the nature of the errors made by the two groups. However, some caution is required in interpreting the results as the strongest evidence for an advantageous effect of a regular, generative number system. Unlike comparisons of Asian and European language groups, this study is weakened by the likelihood that the Welsh speaking children were exposed to both Welsh and English number name systems, through the medium of television and play with other children. It is possible that the advantage shown by the Welsh speaking children was attenuated by exposure to two systems. Kim and Okamoto (1996) note that for Korean children it is their knowledge of the regular number name system which correlates with subsequent understanding of place value, and not their knowledge of the irregular system. Further research is needed to investigate the number experience of Welsh speaking children and to look in more detail at the effect of number name systems on children’s understanding of number, and in particular of place value.

Language systems used for counting are only one facet in developing mathematical understanding. Although both the ability to count orally and to understand the
underlying principles are fundamental to the development of wider mathematical understanding, there are arguably many influential factors which should be considered when attempting to explain differences in attainment. These include cultural differences, differing perceptions of the value of education, social differences, differences in teaching methods, classroom practice, teacher expectation, hours of study, classroom organization, input from parents, and so on. The evidence from this and other cross cultural studies suggests that we must add differences in counting systems to the list, but with an awareness that these differences are only a small part of the attempt to understand children’s early number knowledge and understanding.
REFERENCES


Educators have been concerned about the problems of the irregularities of the English number name system for many years. The following comes from a teaching text published in 1898:

“A child, for example, who has realised that thirteen (etymologically the ‘e’ of ‘eleven’ is one, and the ‘tw’ of ‘twelve’ is two, but this could not be made intelligible to young children) is 3+10, fourteen 4+10, fifteen 5+10, etc., will have no difficulty in remembering the words, and the order of the words, thirteen, fourteen, fifteen etc. Similarly, if he has realised that twenty is 2 x 10, thirty 3 x 10, forty 4 x 10, etc., he will have no difficulty in remembering the words and the order of the words twenty, thirty, forty etc.”


The Department for Education and Employment has overall responsibility for education in England and Wales. The requirements of the National Curriculum apply equally in both countries, but in Wales the assessments at the four Key Stages may be conducted either in English or Welsh. In 1992, out of the 36,886 pupils assessed at Key Stage 1 (i.e. age 7), some 7,000 were given tasks through the medium of Welsh (Welsh Office 1992, p. 3). There was some difference in performance between those pupils assessed in maths through the medium of Welsh and those assessed through the medium of English. For example, the respective percentages of pupils attaining maths scores in the highest two bands were 88 per cent for those being taught through the medium of Welsh and 78 per cent for those being taught through the medium of English. This indicates a slight advantage for the Welsh speaking children over the English speaking children.

Welsh language television and radio programming is not as varied or extensive as English language broadcasting.