Author(s): Pirjo Aunio, Carol Aubrey, Ray Godfrey , Pan Luejuan, & Yan Liu

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Children's Early Numeracy in England, Finland and People's Republic of China

Pirjo Aunio[1], Carol Aubrey[2], Ray Godfrey[3] , Pan Yuejuan[4], & Yan Liu[4]

[1]Niilo Mäki Institute, Finland, [2]Warwick University, England[3] Canterbury Christ Church University, England [4] Beijing Normal University, PRC

Pirjo Aunio, Niilo Mäki Institute, P.O. Box 35, 40014 University of Jyväskylä, Finland, e-mail: pirjo.aunio@nmi.fi tel. +358-50 43 43 408

Abstract

This research investigated the similarities and differences between countries in young children's early numeracy skills related to age, culture and gender. The participants were five-year-old children from Beijing (People's Republic of China), England and Finland. The rationale for the cross-cultural comparison originates from the research results with older children showing that Asian children outperform children from America or Europe, and from the lack of such information concerning younger children. The results showed that in all locations the older children performed better than the younger children. Cultural differences were found: young children from Beijing outperformed those from England and Finland in overall early numeracy performance, as well as in sub-tests for understanding of quantities and relations (i.e. relational skills) and counting skills. Finnish children had better scores than English children in the whole early numeracy scale and in the relational scale. The results are discussed in relation to culture, instruction in preschools and learning support at home, as well as the effects of language characteristics. The culture's appreciation of and approach to mathematics learning in early childhood is a plausible explanation for the cross-cultural differences found in this study.

Keywords: early numeracy, cross- cultural comparison, preschoolers, gender effects

Children's early numeracy

Literature on children's early mathematical skills uses varying terminology to refer to core developments. These include basic number skills (Geary, 1994), preparatory arithmetic skills (Schopman, Van Luit, and Van de Rijt 1996), concepts of numbers and counting (Fuson 1988), informal mathematical knowledge (Ginsburg et al. 1997), number module (Butterworth 1999), and number sense (Dehaene 1997). Despite different theoretical emphases, all these terms refer to the skills that children acquire and display, before formal schooling begins, and that are essential for learning mathematics at primary school. The development of early numeracy includes a growing awareness of the number words used in the culture, and of the different ways in which these number words can be used to represent quantitative reasoning and aid in problem-solving situations (Geary 1994). The research reported here examines the early numeracy of children aged five years from Finland, England and China in terms of their age, gender, and culture.

Bryant and Nunes (2002) have suggested that the basis for children's early mathematical development is logical thinking, the teaching of conventional counting systems, and a meaningful context for learning mathematics. Research on logical principles (see Smith 2002 for an introduction) has shown that the development of mathematical thinking is about children's growing abilities to make relational statements (e.g., learning what it means that a number is equal to or more than another number), in other words to compare, classify, and understand one-to-one correspondence and seriation. Being able to detect one-to-one correspondence and to seriate is essential for understanding cardinality and ordinality, and this in turn is important for understanding the number-word sequence (Bryant 1996). The ability to compare two sets numerically is a vital aspect of conservation ability and related forms of numerical reasoning (e.g., Sophian 1998), while the ability to classify is a fundamental element of mathematical reasoning in general (Smith 2002).

The relevance of the conventional counting system is especially emphasised by those who consider whole-number-sequence skills to be the foundation of mathematical thinking (Fuson 1988; Gelman and Gallistel 1978). Such views have distinguished six developmental stages in acquiring counting skills during early childhood: primary understanding of amounts, acoustic counting, asynchronic counting, synchronic counting, resultative counting and shortened counting (Case 1996; Fuson, 1988; Van de Rijt, Van Luit, and Pennings 1999). Primary understanding of amounts emerges at around two years of age when children show knowledge of how the different number-words refer to a different number of objects, but at this stage only very basic discrimination of amounts is possible. When they are at the acoustic counting stage, around the age of three, children can say number-words, but not in the correct order, and they do not necessarily begin with one: it is as if they are reciting a nursery rhyme. When children reach the asynchronic stage, around the age of four, they are able to say number-words in the correct order and to point to objects, but the words and pointing are not coherent. Six months later, at the synchronic stage, children are able to recite number-words and to mark the counted objects correctly, by pointing at or moving the objects, for instance. The resultative counting stage emerges around the age of five, when children are able to say number-words correctly starting with one, and understand that countable objects should be marked once and that the last said number-word indicates the number of objects in a set. Furthermore, at this stage they understand that number-words form a growing series in magnitude, meaning that the bigger one refers to a bigger amount. During the shortened counting stage, at around five-and-a-half years of age, they are able to recognize the figure five, for instance, and can continue counting upwards from that. Thus their ability to operate with the number-word-sequence for whole numbers, and to use this in problem solving, increases substantially during these developmental shifts. From the developmental point of view, as Rittle-Johnson and Siegler (1998) suggested, conceptual understanding (i.e., understanding logical principles) sometimes precedes and sometimes follows procedural competence (i.e., the emergence of counting skills). It is the timing, frequency and quality of children's exposure to mathematical concepts and procedures that forms the key factor contributing to the emergence of their skills. Early development, the time before primary school, is thus an important phase of the mathematical skills developments as, for instance the longitudinal studies ((Aunola et al. 2004; Desoete and Grégoire 2006) have demonstrated that children differ in their mathematical skills when they enter primary school, and that the difference between weak and well achieving children grow by grade. Cultures, meaning for example their values, language and numerical system, have been found to support the children's mathematical learning in various ways (e.g., Saxe,1991; Miura et al. 1993).

Cross-national differences in mathematical skills

Cross-cultural comparisons of preschoolers' mathematical skills have shown that the mathematical performance of Asian children is better than that of their non-Asian peers (Ginsburg et al. 1997; Huntsinger et al. 1997; Miller et al. 1995; Zhou et al. 1999; Zhou, Peverly, and Lin 2005; see Song and Ginsburg 1987 for contrasting results). For example, young Chinese children consistently outperform their Western peers in abstract and object counting, concrete and mental addition and subtraction, and in the use of sophisticated strategies in mathematical problem solving. Differences in language (cf. Fuson and Kwon 1992; Zhou and Boehm 2001), teaching and learning environments (Stevenson, Lee, and

Graham 1993; Zhou, Peverly and Lin 2005; Yang and Cobb 1995), and cultural and societal issues (Campbell and Xue 2001; Caplan, Choy, and Whitmore 1992; Jose et al. 2000; Stevenson et al. 1993; Tuss and Zimmer 1995; Zhou and Boehm 2001) have been considered to be factors underlying superior mathematical performance in Asian children. These cross-cultural comparisons of mathematical performance have mainly focused on children aged six years and above. There are two sets of studies investigating the early numeracy skills of children aged between four and seven-years in Europe and Asia.

The European studies (Godfrey et al. 2000; Torbeyns et al. 2002; Van de Rijt et al. 2003) following longitudinal research procedures, found no evidence for any differences between early numeracy scores of the different cultural samples, namely between Dutch, English, Flemish and Slovenian children, other than those that could be accounted for in terms of the different ages or length of schooling of the children. Another set of cross-cultural comparisons on early numeracy have been conducted with Finnish and Chinese children (Aunio, Niemivirta et al. 2006), children from Finland, Hong Kong and Singapore (Aunio et al. 2004) and children from China, Finland, and Singapore (Ee, Wong, and Aunio 2006). Results from these studies show that the Asian children have better early numeracy than Finnish children, and that the children in Singapore scored higher than did children in Hong Kong or China. Although Asian children’s superior counting skills have often been explained by the fact that the Chinese number sequence system makes it easy to learn to count (Fuson and Kwon 1992) and understand the place-value system (Miura et al. 1993), these studies did not support such a conclusion, as for instance there were no differences in performance between English speaking children in Singapore and Hong Kong on the one hand and Chinese speaking children in Hong Kong (see also LeFevre, Clarke and Stringer 2002).

While there has been growing interest towards the young children's early numeracy skills, we know very little about cross-cultural differences in such skills. Towse and Saxton (1998) suggest that one approach to understanding cross-cultural differences in mathematics is to study such skills before formal teaching at school has begun.

Gender differences

There are contradictory research results relating children's mathematical performance to gender. Some research suggests that girls and boys possess identical primary numerical abilities (Dehaene 1997; Nunes and Bryant 1996). The researchers analysing the English National Curriculum Key Stage 1 measurements (children aged four to seven years) have mostly reported girls outperforming the boys in basic arithmetic (Demie 2001; Gorard, Rees, and Salisbury 2001; Strand 1997, 1999). More precisely Strand (1999) reported that girls performed better than boys at the age of four years (baseline measurement) and at the age of seven (Key Stage 1 standard assessment), but that boys made more progress than girls between the two measurement times. Carr and Jessup (1997) reported that in their first school year, boys and girls may use different strategies for solving mathematical problems, but that there is no difference in the level of their performance. These somewhat paradoxical results originate most likely from different study designs, as an emphasis on outcome measures tends to hide some important factors like the quality of child's strategy choice. Gender differences in numerical skills at preschool age have attracted very little research attention (Torbeyns et al. 2002; Van de Rijt et al. 2003), and it would therefore be worthwhile to check such differences in children's early numeracy.

The aim of the study

In this study we aimed to compare the early numeracy of children around five-years old in two countries (Finland and People's Republic of China) who have not followed formal teaching in mathematics at all and in one (England) have followed it for less than half a year.

This study will increase current knowledge, first by providing knowledge of children's early numeracy at a point of time when in some countries formal mathematics teaching begins. Secondly, it will give a fuller picture of the situation in Europe as we compare Finnish and English children who have not previously been compared. The early teaching tradition in Finland is different to that in England, as Finnish children follow an early childhood education that emphasizes social development rather than academic teaching. Primary schooling begins at the age of seven years in Finland. English children, on the other hand, start primary school before the age of five years. This research focuses on differences and similarities in children's early numeracy performance related to age, culture and gender.

Method

Participants

The structure of the sample is shown in Table 1. There were 354 children whose performance was measured once with the Early Numeracy Test (ENT; Van Luit, Van de Rijt, and Pennings 1994) in three countries. The Finnish sample was formed by taking all children aged 54 – 66 months (4 year 6 months and 5 years 6 months) from the Finnish norm sample collected for the Finnish ENT (Van Luit, Van de Rijt, and Aunio 2006). The sample in England was taken from the data set originally collected for the European cross-national comparison with longitudinal data (Van de Rijt et al. 2003). As the Finnish and Chinese children had all used form A of the ENT, those English children who had used forms B or C were omitted from this analysis. In China, the stratified sampling was used to select five districts of different economic and educational development (two of them advanced in economy, one of them advanced in education, one moderate in both aspects and one lagged in both aspects). Then two preschools in each district and two classrooms in each preschool were randomly sampled. In each classroom, teachers were first asked to classify the boys and girls into three groups according to their maths development, and then to select randomly one boy and one girl on each level to participate in the study. The stratified sampling strategy for the English and Finnish sample has already been reported (ibid).

Table 1 approximately here

Instruments

In this study the Early Numeracy Test (ENT; Van Luit, Van de Rijt, and Pennings 1994) was used to assess young children's early numeracy. Its structure is shown in Table 2 and item examples given in Appendix 1. The test is based on a developmental perspective, and aims to tap several aspects of young children's numerical and non-numerical knowledge of quantity. Although the ENT is assumed to yield a unidimensional measure of children's early numeracy (Van de Rijt et al. 1999), previous studies (e.g. Aunio, Niemivirta, et al. 2006; Aunio, Hautamäki, et al. 2006) have shown that, the ENT also provides two closely related subscales measuring slightly different aspects of children's early numeracy. The first four sections of the instrument relate to the logical principles often identified as the key factors underlying children's understanding of quantities and relations (i.e. relational skills) (Piaget

1966), and the rest of the test focuses more explicitly on the use and understanding of numbers (i.e., counting skills) (Fuson 1988; Gelman and Gallistel 1978). Analysing the data in terms of a single scale, two subscales (relational and counting) and eight topics can reveal different aspects of a comparison between cultures.

Table 2 approximately here

The ENT includes 40 items. The test is given individually and takes about 30 minutes for a child to complete. The child is given one point for a correct answer and zero for a wrong answer, the maximum being 40 points (Van de Rijt et al. 1999).

The original Dutch instrument was translated into Finnish and its psychometric properties tested in the norm study (Aunio, Hautamäki, et al. 2006). The English ENT was provided by the authors of the Dutch ENT, and the accuracy of the translation has been checked by British researchers in the field, and used in European studies (e.g., Aubrey and Godfrey 2003; Van de Rijt et al. 2003). The instrument had previously been translated into Chinese, and the translation-back-translation procedure was used for a study with Mainland Chinese children (Aunio, Niemivirta, et al. 2006). The cultural suitability of the instrument in all languages was ensured by consulting several native-speaking experts in the field.

Procedure

The test was administered to children by trained fieldworkers from their own school (in Beijing and Finland) or from outside fieldworkers (in England), usually in a separate quiet room with chairs and a table. In all countries there were three test administrators. The administrator presented the questions and provided the test materials (pictures, cubes, paper and pencil) to the child according the instruction for each item. The tasks are presented verbally and the child is asked to point the correct answer. There are also tasks in which the child is required to answer verbally. In addition, there are some tasks in which the child uses the given material to solve the question by himself.

Data analysis

Before carrying out a detailed comparison, data from the national samples were analysed to examine the psychometric properties of the ENT when taken as a single scale, two related scales or eight separate topic scales. Confirmatory Factor Analysis (CFA) was used to assess construct comparability among the three languages, and used the chi-square (χ^2), the Comparative Fit Index (CFI) (cut-off value >.95), and the Root Mean Square of Error Approximation (RMSEA) (cut-off value < .06) (Hu and Bentler, 1999; Yu and Muthén, 2002) as model-fit indicators. The Mplus program was used for the Confirmatory Factor Analysis due to its advantage in operating with dichotomous variables (Muthén and Muthén, 1998-2004). Following this, statistical models were constructed for scores' dependence on age, country, and gender at the level of: total scores, numerical and relational scores; and individual topic scores.

Results

Preliminary analysis

The purpose of the preliminary data screening was to use variance-covariance matrixes to find the items that would disrupt the psychometric use of the test. Table 3 lists items that had correct answers from more than 95% or less than 5% for boys, girls and all children in each of the national samples. In the Chinese total sample and for boys and girls separately there were five items with very high facility (over 95%). For the Finnish children there were far fewer high facility items and for the English children there were none. One question had a very low facility for Finnish children and rather more were found difficult by the English sample. There was no consistency of high- or low-facility items between countries and, whereas for some methods of analysing the data from a particular subsample very high or very low facilities might cause problems, including items where one set of children did very well or very poorly, this finding strengthens rather than undermines the main comparison between countries. Consequently all items were carried forward into the main analysis.

Table 3 approximately here

Further analyses were carried out in order to ensure that the results obtained from the measurements in the three languages were comparable, hence a confirmatory factor analysis was conducted to test the construct equivalence across languages. In the one-factor solution, all of the items were set to load on a single latent factor, while in the two-factor and the eight-factor models, items were grouped as shown in Table 2. To ensure unambiguous scaling, the parameter for one item for each latent factor was fixed at one. In the two-factor model, the latent factors were allowed to correlate. All of the key parameters, factor loadings, item thresholds, and factor variances were constrained to be equal across the languages (i.e., fully invariant models were used). The indices for the model fit are summarised in Table 4.

Confirmatory Factor Analysis (CFA).

Table 4 approximately here

Confirmatory Factor Analysis gives support for using either two-factors or eight-factors model, however eight-factors model seems to fit most of the data slightly better than the rest of the models (see Table 4). The Cronbach's alphas to check the internal consistency of the scales included in one-factor, two-factors and eight-factors models in separate samples are shown in Table 5.

In all samples the total (one-factor), relational and counting scales (two-factors) models showed acceptable reliability in excess of .70 and were clearly suitable for further analysis. There were only a few subscales in the eight-factors model that showed this level of reliability and even these were not as reliable in all samples; so some lack of precision was to be expected in further analysis of these scores. In other words, we worked also with the eight-factor model including all items despite the reliability problems as we wanted to provide readers with the possibility to compare our findings with other European studies on the topic (Godfrey et al. 2000; Van de Rijt et al. 2003).

Cross-cultural comparisons

Overall comparison of the three national samples in terms of total ENT scores revealed a pattern consistent with previous studies. When mean total scores were plotted against age in months (Figure 1 (a)), the Chinese sample clearly outperformed the two European samples.

When the randomness in the raw data was smoothed out by linear regression (Figure 1(b)) the pattern is even clearer. Progression with age appeared to be about the same in all three samples, but the Chinese children were on average about a year ahead of the Finnish, who in turn were about half a year ahead of the English.

Figure 1 about here

Only in the case of Finnish children was there any evidence for a difference in performance between boys and girls, girls outperforming the boys. The best model was:

Total ENT score =	15.8	(0.6)
	+ 0.64 x age in months above 60	(0.1)
	+ 2.5 for Finnish boys	(1.0)
	+ 5.9 for Finnish girls	(1.1)
	+ 12.6 for Chinese children	(0.8)

Standard errors for the coefficients are shown in the right. The model accounts for about half the overall variance in scores (adjusted $R^2 = .49$).

The pattern for relational scores, shown in Figure 2 is very similar to that for total scores, except that the gap between Finnish and Chinese children was equivalent to about half a year and the gap between English and Finnish equivalent to about a year. Once again there was no evidence for a gender effect except in Finland. The best model was:

Relational score =	9.3	(0.3)
	+ 0.32 x age in months above 60	(0.05)
	+ 3.1 for Finnish boys	(0.5)
	+ 4.8 for Finnish girls	(0.5)
	+ 6.0 for Chinese children	(0.8)

Figure 2 about here.

For numerical scores, as shown in Figure 3(b), the performance of Finnish and English children is virtually indistinguishable. Chinese children appeared to be about twenty-two months ahead of English children and Finnish boys and seventeen moths ahead of Finnish girls. The best model was:

Counting score =	6.4	(0.3)
	+0.32 x age in months above 60	(0.06)
	+1.3 for Finnish girls	(0.6)
	+6.9 for Chinese children	(0.5)

Figure 3 about here

In terms of the eight topic scores, the patterns of age and gender differences were varied. Since in many cases the distribution of scores on the 0-5 scale was so far from normal that ordinary linear regression was inappropriate, ordinal logistic regression was used consistently throughout. In none of the models was any gender difference evidenced in the English sample. English children aged 60 months were, therefore, taken as the baseline group and the parameters shown in Table 6 indicate how far other children differed from this. The parameters are on the log (odds) scale. For example in the comparison model the overall value for a Finnish girl aged 58 months would be 2.25 (as a Finnish girl) – 0.26 (as being two months below 60 months), which makes 1.99. This indicated that the model calculates the odds on a Finnish girl of this age surpassing any particular score for comparison to be about 7.3 times as great as those for an English child of 60 months.

Table 6 about here

Progress with age appears to have been very similar for all topics and there was no evidence that it differed between national samples. Gender differences were almost entirely confined to Finnish children. As suggested by the analysis of overall relational and numerical scores, the superiority of Finnish children over English is clearly seen only for the four relational topics. Figures 4 and 5 show this in relation to two topics, Comparison and Resultative Counting, the underlying distributions of scores as estimated in the ordinal regression models at 56 and 64 months. At one extreme, the scores for comparison showed gender differences in each of the three cultures and show Chinese pupils clearly outperforming Finnish children, who clearly outperformed the English. The scores for Resultative Counting showed no gender differences and little detectable difference between the two European samples.

Figures 4 and 5 approximately here

Discussion

The focus of this research was to investigate the similarities and differences in young children's early numeracy skills related to age, culture and gender. The results show that age was related to the children's early numeracy performance, as the older children had better performance than the younger children. However, we need to bear in mind that the children were all between 4 to 5 years, so the age range was small, and results might be different in other age groups. There were cultural differences in this age group: the children in China outperformed those in England and Finland in overall early numeracy performance, as well as in relational and counting scales. Finnish children had better scores in the whole early numeracy scale and in relational tasks than the English children. There was no difference between Finnish and English children in the counting scale. The gender differences were found only among the Finnish children, as the girls performed better than boys in the relational tasks. Cross-cultural comparison studies with school-age children have approached the differences in children's skills in relation to issues originating from curriculum, teaching and learning ways, and cultural values and beliefs (Leung, Graf, and Lopez-Real 2006). The same topics can be discussed also here as possible explaining factors.

First, we take the differences between Asian and European children. We studied the performance of children aged four to five years found in preschools in China and Finland, and the English children had just begun their formal schooling. None of the children had experienced formal mathematical teaching for a long time (i.e. In China and Finalnd none and in England maximum six months period of teaching early mathematics), making the effects of curriculum quite minor. We think that the variation in children's performance originated from the children's exposure to the mathematics learning across cultures, not only in the preschool but also at home. Informal mathematics tends to be very culturally dependent (Geary 1994).

It can be that the success of Chinese children is related to the way that educators, parents, and the society as a whole, appreciate mathematical knowledge. Knowledge of mathematics is important and highly valued in the Chinese society, where children are expected to practice and learn it. This affects also the preschool teaching that can be seen as a systematic approach to the topic. At first, the logic of the subject is obeyed, for example, in the case of number knowledge, the children are expected to learn first the cardinal meaning of numbers and, then the ordinal meaning of numbers. Next, teaching is aimed at helping children understand the fundamental relationship embodied in the mathematics knowledge and skills. For example, related to number knowledge, educators would help children to learn the conservation of number and classification by number, and transformation of two numbers in the seriation.

On the contrary, in Finnish society, good preschool education is centred on children's own activities and play, and it does not emphasize academic learning objectives (Ministry of Social Affairs and Health 2002; Ojala and Talts 2007). In kindergarten (6-year-olds) mathematics learning is based on everyday activities in which the mathematical concepts are introduced for children (National Board of Education, 2000). In Finland, children start their primary school in the autumn of the year that they have their seventh birthday. During their first year at school, children are expected to learn to operate with number words (National Board of Education, 2004). Ojala (2000) reports that Finnish parents share the viewpoint of preschool educators that social skills are the most important skills to be learnt between the ages of 3 and 5 years. Both Finnish parents and early childhood educators put less emphasis on pre-academic skills (see also Hujala-Huttunen 1996).

In England between three and five years, children follow a play-based curriculum, but there are also key numeracy goals that include counting, recognising numerals, and relating addition and subtraction to operations on small quantities of objects, as well as using the language of size, shape and measurement and practical problem-solving.

The interesting fact is that even though children start primary school at age seven in China and Finland and at age five in England (i.e the official start of formal teaching), preschool education cross-nationally takes obviously different roles in supporting children's learning in early numearcy skills.

Cultural values also steer how parents support their children’s learning, what kind of activities they do and which kind of books they read. Phillipson and Phillipson (2007) reported that in Hong Kong, parents’ expectations for children’s achievement in mathematics were good predictors for the children’s school performance. On the contrary, the family’s socio-economical status has not been found to be an efficient or stable variable in explaining cross-national or cultural differences in mathematics (Tzouriadou, Barbas, and Bonti 2002; Zhou, Peverly and Lin 2004). The “one child policy” in China has been suggested as one reason for Chinese children’s good academic performance, as they receive extraordinary attention from their parents and grand parents (Jiao, Ji and Jing 1996; Zhou and Boehm 2001). It could be that in our study also the only child status of Chinese children explains some of their good performance. It is obvious, that if we want to understand how different family factors (e.g., parental behaviour, communication) affect children’s learning we cannot rely solely on two potential indicators but we need to investigate the effects more thoroughly. This is as big a challenge for cross-cultural comparisons as it is for studies conducted within a single culture.

Language is often introduced as an explanation in mathematical cross-national studies involving children from East Asia. As argued by some scholars (Fuson and Kwon 1992), the systematic number words in the Chinese language facilitate children’s understanding of numbers, counting and the underlying ten-base structure, all of which make basic computation faster and more accurate. The English and Finnish number-word sequence, in contrast, is nonsystematic, thus linking the acquisition of counting skills with rote learning and making it more prone to errors. However, more recent studies have argued that the benefits of the language for counting development are limited (LeFevre, Clarke, Tamara, and Stringer 2002; Cheng and Lorna 2005). Thus language is not quite so likely to explain the results in this study, as only some of the items required using counting words and only a few items involved numbers bigger than ten.

Second, we examine the differences between West and North Europe. Overall, children from the three cultures did not appear to have a similar pattern of development. There is some indication that very early exposure to numerical instruction may account for differences in number skills in the English context but not the differences in relational skills or the high performance by Finnish girls. Whilst Case (1996) suggested that the development of number sense is a dynamic combination of progress in general and specific skills, general skills may also be influenced by teaching. Differences in preferred activities and/or opportunities to engage in these tasks by boys and girls in early childhood could lead to different experiences and different patterns of development of number. It could be that too early an emphasis on specific number skills that is not combined with general number skills as may occur in the English context, disturbs the reciprocal relationship between the two and the overall development of competence. It seems to be that broader approach to the mathematics skills learning is more beneficial.

Third, we examine the gender differences in the Finnish sample. In general gender differences in mathematics achievement are well reported among the older children, but fewer studies have included younger children in their gender comparisons. The rationale for our analysis of gender patterns is that we do not know enough about when gender differences in mathematics start to emerge, nor do we know why they emerge when they do. One interesting finding is that Finnish girls outperformed boys in relational skills (i.e., classification, comparison, seriation and one-to-one correspondence). What makes it most interesting is that this kind of gender difference in early numeracy skills has been found only among the Finnish children (Aunio, Niemivirta et al. 2006; Torbeyns et al. 2002; Godfrey et al. 2000). As it was also found in the bigger Finnish samples including children from 4 to 8 years old, it is not likely to be coincidence (Aunio, Hautamäki, et al. 2006). Our result is in line with other Finnish studies providing the evidence that some gender differences that favour girls emerge at the beginning of primary school (Hautamäki et al. 2001; Ojala and Talts 2007). This is one interesting starting point for the later studies both inside Finland and cross-cultural.

Limitations

Our interpretations are restricted by some limitations of the study. First of all, we concentrated only to the children's performance. The data concerning the learning environment at preschool and home would have given us valuable information on interpreting the results. The points raised in the discussion part of this study, provide the direction for the future research focused on early numeracy development in different countries and cultures. More importantly, however, samples were not nationally representative and were thus prone to different sources of bias. For example, we only had two urban preschools represented in the Chinese sample, which – due to the considerable differences between rural and urban life in China – possibly resulted in somewhat biased outcomes. Had the sample included rural children, who rarely even have access to preschool education, we would have expected somewhat different results.

Implications for the practice and research

Children acquire several mathematics skills before primary school. Some cross-cultural studies results, like the results in our study, imply that children may be exposed to different discourses and practices and have different opportunities to develop these early numerical skills. Informal instruction, at home and in preschool, is important in the early years, that is to say that, the richness and meaningfulness of the learning environment is important for building the base for lather mathematics learning. This conclusion is supported by the results of longitudinal studies which show that those who have low numerical skills before primary school keep struggling with mathematics also in primary grades (Aunola et al. 2004; Desoete and Grégoire 2006). To help provide meaningful early childhood mathematics education, researchers should focus on helping educators to develop effective teaching strategies, a deeper understanding of the topic and a better sense of the challenges children face in learning early numeracy (see also Zhou, Peverly and Lin 2005).

The comparison in this study between the Chinese, English and Finnish children suggests that the children's culture begins to affect children's mathematics learning very early on, and that cultural differences are already in place at four and five years of age. The data also suggest that the approach implemented in English early childhood education at the time of data collection (i.e. focusing on specific number skills quite narrowly) was not necessarily the most beneficial approach for young children's early numeracy skills development in general.

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Appendix 1

A description of the ENT item groups according to Van de Rijt et al. (1999) and Van Luit et al. (1994)

(1) Comparison**.** This aspect is about the use of concepts in making comparisons between two non-equivalent cardinal, ordinal and measurement situations. The child has to demonstrate an understanding of concepts in drawings of order relations. *A sample item (4): Here are some Indians. Can you point out the Indian who has fewer feathers than the one you see here?*

(2) Classification. These tasks require the grouping of objects in a class on the basis of one or more features. *A sample item (6): Look at these squares. Can you point out the square with five blocks but no triangles*?

(3) Making Correspondence. This group includes tasks that measure children's understanding about one-to-one relationships of simultaneously presented objects. Overt and covert indicating tasks (e.g., moving blocks, drawing lines, pointing) are necessary in responding to the one-to-one correspondence items. *A sample item (12): (The child has 15 blocks) The administrator shows a drawing representing two dice with showing 5 and 6. Then the administrator asks: Can you put as many blocks on the table as are shown on the dice here?*

(4) Seriation. This aspect refers to dealing with discrete and ordered entities. *A sample item (19): (The child has a paper and pencil). Here are some dogs. Each dog is going to fetch a stick. The big dog is going to fetch a big stick and the small dog is going to fetch a small stick. Can you draw lines from all of the dogs to the sticks that they fetch?*

(5) Using Number Words. These tasks are about the ability to use number words in the number-word sequence up to 20. Number words must be produced forwards and backwards. *A sample item (23): Count further from 9 to 15*

(6) Synchronous and Shortened Counting. This aspect refers to the counting of objects in organised and unorganised arrangements by pointing. *A sample item (28): The administrator puts 20 blocks on the table in an unorganised manner. The child is required to count the blocks. The child is allowed to point to the blocks with his/her finger or to move them.*

(7) Resultative counting. These tasks require accurate counting and last-word response: pointing is not allowed. Most questions are of the kind: How many Xs are there? *A sample item (33): The administrator puts 15 blocks on the table in three rows of five with some space between them, and asks: How many blocks are there? The child is not allowed to point to the blocks with his/her finger or to move them.*

(8) General Knowledge of Numbers. This aspect refers to the application of numeracy in daily life situations, which are represented in drawings. *A sample item (38): The administrator points to a picture of eight chickens and says: A farmer has eight chickens. He buys two more. The administrator then points to the picture with two chickens and continues: How many chickens does the farmer have now? Show the square with the right answer. The administrator points to the row of squares at the bottom of the paper*.

Table 1. The sample

Country	Girls	Boys	Children	Mean age	Age range	Standard deviation of ages
China	61	59	120	61.6	54-66	3.2
England	56	62	118	59.5	54-66	3.5
Finland	52	64	116	60.7	53-66	3.3
Total	169	185	354	60.6	53-66	3.4

Note. Age in months

Table 2. Structure of Early Numeracy Test

Subscale	Topic	Item Numbers
Relational scale	Comparison	1-5
	Classification	6-10
	Correspondence	10-15
	Seriation	16-20
Counting scale	Counting words	21-25
	Structured counting	26-30
	Resultative counting	31-35
	General number knowledge	36-40

Table 3. Items with extreme facilities

Country	Children	Items with facility <95%	Items with facility < 5%
China	Girls	3,5,6,7,11	-
	Boys	3,5,6,7,11	-
	All	3,5,6,7,11	-
England	Girls	-	20,24,25,29,30,35
	Boys	-	25
	All	-	20,24,25,29,30
Finland	Girls	3,6	35
	Boys	-	35
	All	6	35

Table 4. Model fit indices for alternative CFA in different subsamples

			1 factor	2 factor	8 factor
Whole sample	CFI		0.98	0.98	0.97
	WRMR		1.06	1.01	0.96
	RMSEA		0.05	0.04	0.04
	Chi Square		1307.54	1192.28	273.29
		df	740	739	178
		p.	0.0000	0.0000	0.0000
Girls	CFI		.96	0.97	0.96
	WRMR		1.04	1.02	0.96
	RMSEA		0.06	0.06	0.06
	Chi Square		1244.36	1203.69	154.09
		df	740	739	102
		p.	0.0000	0.0000	0.0007
Boys	CFI		0.97	0.98	0.96
	WRMR		1.03	0.98	0.93
	RMSEA		0.06	0.05	0.05
	Chi Square		1233.60	1115.61	160.27
		df	740	739	112
		p.	0.0000	0.0000	0.0019
Chinese	CFI		0.95	0.95	0.96
	WRMR		0.95	0.94	0.91
	RMSEA		0.05	0.05	0.04
	Chi Square		60.81	61.58	58.94
		df	48	47	48
		p.	0.1015	0.1072	0.1338
English	CFI		0.88	0.89	0.92
	WRMR		0.96	0.95	0.91
	RMSEA		0.05	0.05	0.04
	Chi Square		69.83	67.88	61.87
		df	54	54	51
		p.	0.0724	0.0971	0.1417
Finnish	CFI		0.88	0.90	0.93
	WRMR		1.03	0.99	0.93
	RMSEA		0.07	0.06	0.06
	Chi Square		120.24	111.23	101.01
		df	76	76	75
		p.	0.0009	0.0057	0.0243

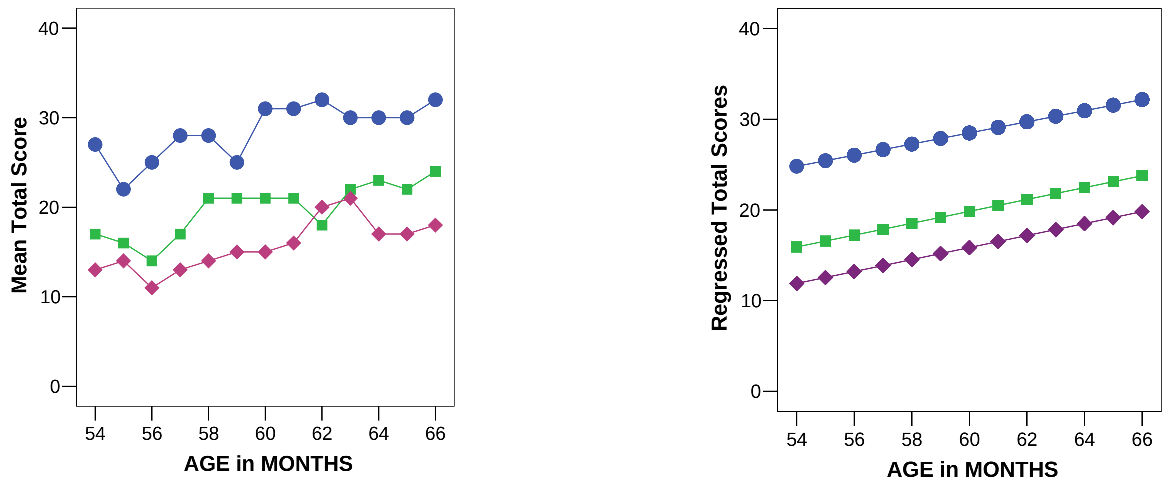
Table 5. The reliability coefficients in scales

Scales	All children	Girls	Boys	Chinese	English	Finnish
Total	.92	.92	.92	.88	.84	.88
Relational	.84	.85	.83	.75	.73	.77
Counting	.88	.87	.89	.82	.73	.84
1-5	.57	.63	.51	.28	.48	.56
6-10	.54	.58	.49	.37	.46	.42
11-15	.62	.65	.59	.56	.47	.59
16-20	.73	.74	.72	.69	.52	.55
21-25	.74	.73	.75	.50	.47	.70
26-30	.61	.57	.65	.58	.38	.53
31-35	.69	.71	.66	.57	.56	.58
36-40	.54	.47	.59	.40	.09	.47

Table 6. Parameters from best ordinal regression models for each of the eight ENT topic scores.

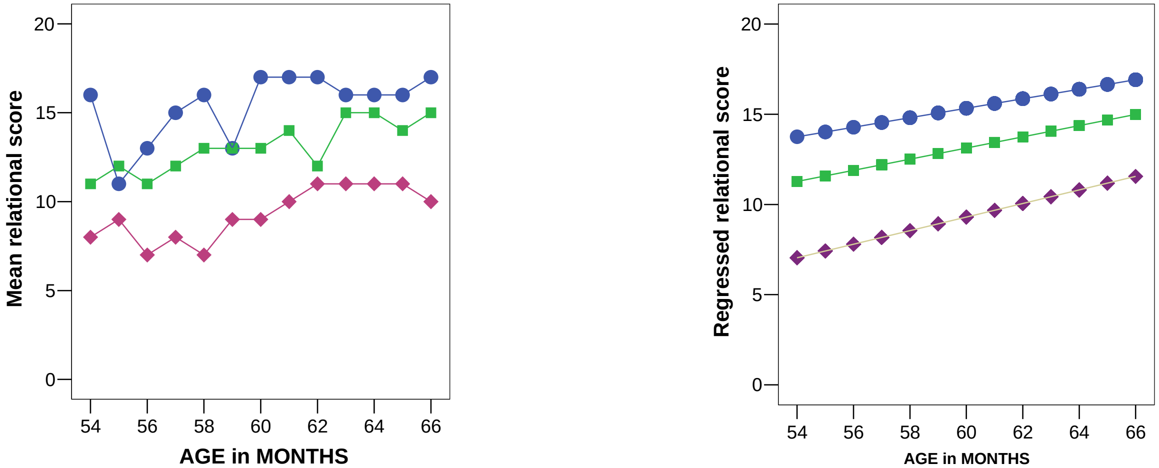
Scales	**Age in months above 60**	**Chinese girls**	**Chinese boys**	**Finnish girls**	**Finnish boys**
Comparison	0.13 *(0.03)*	2.34 *(0.28)*		2.25 *(0.36)*	1.28 *(0.30)*
Classification	0.12 *(0.03)*	2.14 *(0.27)*		2.05 *(0.33)*	1.10 *(0.29)*
Correspondence	0.11 *(0.03)*	1.84 *(0.26)*		1.80 *(0.31)*	0.87 *(0.28)*
Seriation	0.11 *(0.03)*	2.85 *(0.28)*		1.49 *(0.25)*	1.49 (0.25)
Counting words	0.10 *(0.03)*	2.92 *(0.26)*		0.73 *(0.28)*	-
Structured counting	0.12 *(0.03)*	2.52 *(0.25)*	1.96 *(0.29)*	0.97 *(0.29)*	-
Resultative counting	0.15 *(0.03)*	1.93 *(0.26)*		-0.56 *(0.24)*	-0.56 *(0.24)*
General number knowledge	0.13 *(0.03)*	2.27 *(0.25)*		-	1.07 *(0.27)*

Note. - indicates that there was no evidence for any differences between this group of children and the baseline group



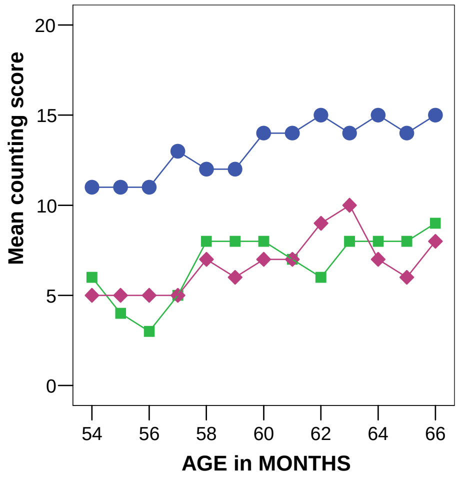
(a) **(b)**

Figure 1. Mean total ENT scores by age and country (a) from raw data and (b) smoothed by linear regression. China Finland England



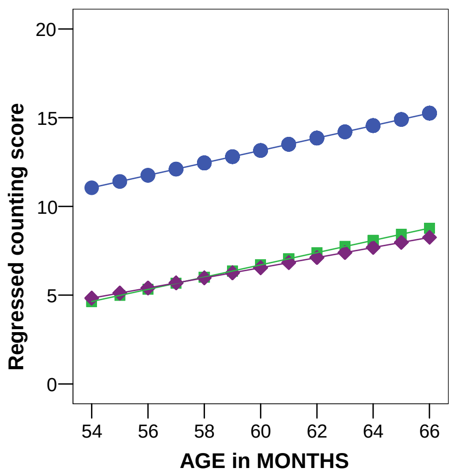
(a) (b)

Figure 2. Mean relational scores by age and country (a) from raw data and (b) smoothed by linear regression. ○ China □ Finland ◇ England



Mean counting score
20
15
10
5
0
54
56
58
60
62
64
66
AGE in MONTHS

(a)

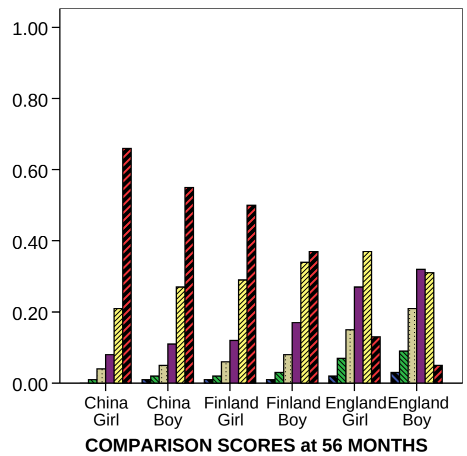


Regressed counting score
20
15
10
5
0
54
56
58
60
62
64
66
AGE in MONTHS

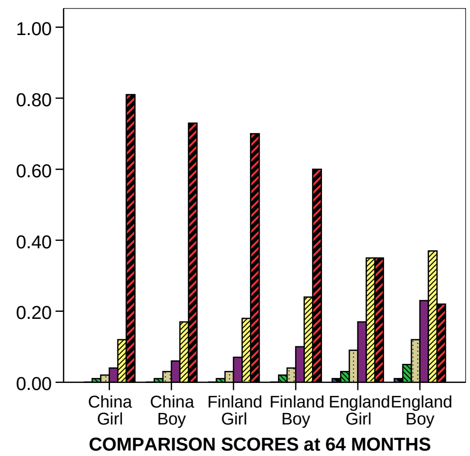
(b)

Figure 3. Mean counting scores by age and country (a) from raw data and (b) smoothed by linear regression.

China Finland England

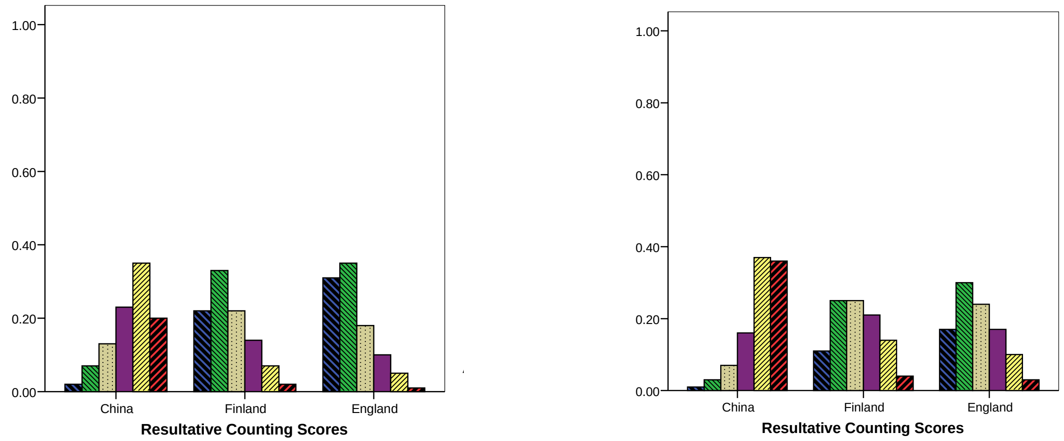


(a)



(b)

Figure 4. Distribution of comparison scores by gender and country (a) at 56 months (b) at 64 month, smoothed by ordinal logistic regression 0 1 2 3 4 5



(a) **(b)**

Figure 5. Distribution of resultative counting scores by country (a) at 56 months (b) at 64 month, smoothed by ordinal logistic regression 0 1 2 3 4 5