Genetica **99:** 165–172, 1997.
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Beliefs about genetic influences on mathematics achievement: a cross-cultural comparison

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Received 17 June 1996 Accepted 14 August 1996

Key words: beliefs, cultural differences, mathematics achievement, motivation

Abstract

The poor mathematics performance of children in the United States has become a topic of national concern. Numerous studies have shown that American children consistently perform worse than their counterparts in many parts of the world. In contrast, children in China, Japan, Taiwan, and other Asian countries consistently perform at or near the top in international comparisons. This paper examines possible causes of the poor performance of American children and the excellent performance of Asian children. Contrary to the beliefs of many Americans, the East Asian advantage in mathematics is probably not due to a genetically-based advantage in mathematics. Instead, differences in *beliefs* about the role of genetics may be partly responsible. Asians strongly believe that effort plays a key role in determining a child's level of achievement, whereas Americans believe that innate ability is most important. In addition, despite the relatively poor performance of their children, American parents are substantially *more* satisfied with their children's performance than Asian parents. The American emphasis on the role of innate ability may have several consequences for children's achievement. For example, it may lead children to fear making errors and to expend less effort on mathematics than their Asian counterparts. As research on genetic influences on behavior, traits, and abilities increases scientists should be careful to ensure that the public understands that genetics does not directly determine the exact level of a child's potential achievement.

Introduction

American children consistently perform very poorly in international comparisons of mathematics achievement (Garden, 1987; McKnight et al., 1987; Stevenson, Chen, & Lee, 1993). American government and business leaders have warned of the dangers of low mathematics achievement, and journals such as *Science* have published numerous articles that highlight the importance of rectifying the problem. Despite all the attention, however, there has been little if any improvement in the relative standing of American children (Stevenson, Chen & Lee, 1993). In Stevenson et al.'s (1993) words, 'A decade of heightened emphasis in the United States on mathematics and science education has had little influence on academic achievement..' (p. 53).

In contrast, children in East Asia consistently perform at or near the top in mathematics. For example, Japanese children perform better than American children even in kindergarten, and the magnitude of the differences only increases throughout the school years (Uttal, 1995; Stevenson et al., 1993). The Asian advantage is not limited to the performance of children in highly industrialized nations such as Japan. Recent research indicates that children in Mainland China also perform much better than their American counterparts (Stevenson et al., 1990).

This paper is based, in part, on research that has attempted to identify the correlates and possible causes of the poor performance of American children in mathematics. Specifically, I focus on the influence of genetics and *beliefs* about genetic influences on the performance of East Asian and American children. Although many Americans believe that Asians possess

a genetically-endowed advantage in mathematics, the research does not support this view. Ironically, however, it may be the *belief* that genetics plays an important role in determining mathematics ability that hinders Americans' performance.

The paper is organized as follows. First, I consider whether the East Asian advantage in mathematics has a genetic basis. Second, I present the results of research on the beliefs of American, Chinese, and Japanese parents and children regarding influences on mathematics achievement. Third, I consider the implications of differences in Asian and American beliefs about influences on achievement. Finally, I consider the origins of the differences in belief systems and the implications of the research for geneticists.

Can genetics explain the east Asian advantage in school mathematics?

The review presented in this section is aimed at assessing whether the East Asian advantage in mathematics achievement could have a genetic basis. At the outset, it should be noted that claims regarding group differences in cognitive abilities are extremely controversial (see Gould, 1981; Hirsch, 1975; Herrnstein & Murray, 1994; Rushton, 1994, 1995 for examples). It has been argued, for example, that attempts to classify influences on intelligence in terms of a simple nature-nurture dichotomy obscure the complex interactions that shape the development of intelligence.

It is not my intent here to enter into this controversy. Instead, I ask the following question: If we *assume*, for purposes of discussion, that claims regarding presumably innate group differences (e.g., Asian versus European descent) in cognitive abilities are valid, can these differences account for the achievement differences? That is, taken at face value, can research on differences in the intellectual abilities of East Asians and Europeans shed light on the excellent performance of East Asian children and the poor performance of American children in mathematics?

To answer this question, it is necessary to look first at what cognitive abilities underlie mathematics ability and/or achievement. Most of the research on mathematics ability is based upon a model of intelligence that is derived from the work of Vernon (1961), who emphasized both general intelligence and more specific intellectual abilities. Vernon suggested that intellectual abilities are organized hierarchically; general intelligence is at the top of the hierarchy, and the first division is between verbal and visual-spatial abilities. Verbal intelligence includes skills such as the comprehension of sentences and knowledge of vocabulary. Visual-spatial intelligence includes skills such as the mental rotation of two- or three-dimensional figures.

The search for the cognitive underpinnings of mathematics performance has not revealed a specific 'mathematics ability'. Instead, researchers have shown that mathematics performance is influenced both by visual-spatial intelligences and by verbal intelligences (Lynn, 1988). This is not surprising when one considers that the successful solution of math problems involves reasoning both about verbal and visual-spatial relations. In addition, it seems likely that different aspects of mathematics draw upon different aspects of intelligence. Solving word problems, for example, may draw particularly heavily on verbal skills, whereas solving geometry problems may draw more heavily on visual-spatial skills. In sum, just as mathematics itself is a diverse body of knowledge, so too are the cognitive abilities that are used to solve mathematical problems.

The lack of a specific mathematics ability suggests that if the Asian advantage in mathematics is genetically based, then the advantage would have to be in general intelligence or in either verbal or visual-spatial intelligences, both of which are involved in mathematical reasoning. Some researchers have claimed that the ancient ancestors of modern-day Asians faced evolutionary pressure that favored the selection of particular sets of cognitive abilities. Perhaps these pressures led to the selection of sets of abilities that help East Asians to excel in mathematics.

Three consistent differences have emerged in research comparing Asian and European intellectual abilities. The first is a slight Asian advantage in general intelligence that emerges at approximately age 8 and plateaus at less than 5 IQ points at approximately age 10 (Lynn 1987; Vernon, 1982). Before approximately age 6, Asian children score lower than children of European descent on general intelligence tests.[1]

The second set of findings concerns verbal and visual-spatial abilities. First, Asians consistently score lower than Europeans on tests measuring verbal intelligence. The difference diminishes over the middle school years; by about age 10, the Asian norm of verbal intelligence is nearly identical to the American norm. Second, by approximately age 5, Asian children consistently score higher than American or European children on visual-spatial tests. The difference remains consistent into adulthood.

Some researchers (e.g., Lynn, 1987, 1988; Rushton, 1995) have suggested that the differences in the intellectual ability characteristics of Europeans and Asians have a genetic basis. Lynn has argued that the ancient ancestors of modern-day Asians faced evolutionary pressures that led to the selection of advanced visual-spatial skills. For example, the ancestors of Asians may have had to travel farther to find food that the ancestors of Asians or Africans.

But could the observed differences in intellectual abilities account for the vast Asian advantage in mathematics achievement? The overall difference in general intelligence could, at least theoretically, play a role in the differences in mathematics achievement. However, the difference in general intelligence is quite small overall and moreover, does not begin to emerge until middle childhood or pre-adolescence. In contrast, the differences in achievement are quite large, and more importantly, emerge very early, in some cases in the preschool years (Geary, 1994; Stevenson & Stigler, 1992). In other words, Japanese and Chinese children are scoring far better than American children in mathematics, even when their general intelligence is about the same as Americans and their verbal intelligence is substantially *lower* than Americans.

One might still argue that it is the Asian advantage in spatial-visualization that accounts for the superior achievement in mathematics. Some researchers have argued that differences in visual-spatial abilities may play a particularly important role, for example, in determining sex differences in mathematics achievement (Benbow, 1988). Hence, it is not unreasonable to ask whether the fairly large Asian advantage in visual-spatial abilities might account for the observed differences.

Again, however, the answer appears to be no, at least not in the lower grades. The Asian advantage in visual-spatial abilities does not appear until middle childhood, well after the achievement differences. This does not mean that the achievement differences, particularly in middle and high school, could not be partly attributable to the differences in visual-spatial reasoning. However, it seems unlikely that these account for all or even a substantial portion of the observed achievement differences (see Lynn, 1988). In sum, whether or not one accepts the claim that there are genetically-based differences between Asians and Europeans in cognitive ability, these differences cannot in themselves explain the early appearance of very large differences in mathematics achievement.

Additional research on the correlates of low, medium, and high levels of mathematics achievement in Japan, Taiwan, and the United States supports the claim that intellectual ability differences alone cannot account for the cross-national achievement differences. Uttal, Lummis and Stevenson (1988) created an achievement test of mathematics that was based on concepts to which children in all three countries had been exposed. The researchers also included several measures of intellectual abilities. As expected, in all three countries, there was a strong, positive relation between scores on the tests of intellectual abilities and children's levels of achievement; smarter children in all three countries performed better on the math test, and less intelligent children performed worse. More importantly, however, there were substantial cross-national differences in the *absolute* levels of mathematics achievement that were associated with a given intelligence score. Consider, for example, a child of average intelligence in Japan. Relative to other Japanese children, this child's mathematics achievement score would probably be near the middle of the distribution of scores. However, relative to American children, this same child would be considered an outstanding achiever. Similarly, the mathematics achievement score of an American child of average intelligence was in the bottom quartile of the distribution of Japanese achievement scores.

Uttal et al.'s (1988) results highlight two key points. First, in any culture, intellectual ability may set limits on the expected level of achievement in mathematics or any school subject. Second, the level of achievement of American children is very far from these limits. Rather than revealing an 'Asian gene' for mathematics, the international comparisons demonstrate that we are instead failing to realize the intellectual potential of American children.

In sum, although many researchers have observed differences between Asians and Europeans in patterns of cognitive abilities, these differences cannot account for the pattern of observed achievement differences in mathematics. In fact, some researchers (e.g., Lynn, 1988) have suggested that just the opposite is true: Young Asian children excel at mathematics *despite* intellectual ability characteristics that could be construed as favoring children of European descent. For example, Lynn has argued that Japanese schooling may help young children to *overcome* some of the intellectual ability characteristics (e.g., relatively low verbal ability) that might hamper their academic progress.

Beliefs about influences on mathematics achievement

Research on the beliefs of students, mothers, and teachers in China, Japan, Taiwan, and the United States has revealed several important cross-national differences. Most of the information on parents' and children's beliefs comes from an ongoing series of studies conducted by Harold Stevenson and colleagues at the University of Michigan (Stevenson et al., 1990; Stevenson & Stigler, 1992). The research began by developing culturally-fair tests of mathematics achievement. The tests were administered to thousands of children in the Asian countries and in several cities in the United States. In addition, hundreds of mothers and students were interviewed; most of the results presented in this section come from these interviews.

The American belief in the importance of innate ability was revealed in mothers' and children's responses to a large variety of questions. Regardless of how we phrased the questions, American mothers and children consistently expressed the belief that genetics matters most. Steen (1987) has summed up the situation well: 'Americans more than any other people attribute success in mathematics to innate ability rather than to hard work'. (p. 302)

Mothers' beliefs

Many different kinds of questions were used to assess mothers' beliefs. In an initial study, mothers in Japan, Taiwan, and the United States were asked about four factors that can influence a child's achievement: effort, natural ability, the difficulty of the schoolwork, and luck or chance. Mothers were asked to assign points to the different factors. The mothers were told that they had a total of 10 points, and that one point should be assigned to the factor that they considered to be least important. The mothers were free to divvy up the remaining 9 points in any way among the remaining influences. American mothers assigned significantly fewer points than Japanese and Taiwanese mothers to effort. American mothers also assigned significantly more points than Japanese and Taiwanese mothers to innate ability. Task difficulty and luck received relatively few points in all countries.

In another set of questions, mothers in the three countries were asked to rate, on a seven-point scale, their agreement with statements concerning influences on children's achievement. American mothers strongly disagreed with the statement, 'People tend to have the same amount of math ability'; their average ratings were 2.3 on the 7-point scale, with 1 representing complete disagreement. The mean ratings of Taiwanese and Japanese mothers were 3.7 and 4.2, respectively. American mothers also agreed more strongly with the statement, 'Your child was born with his/her mathematics ability' than did Japanese and Taiwanese mothers.

There were also several interesting correlates of mothers' beliefs about the relative importance of innate ability and effort. One concerns beliefs about the their child's innate ability in mathematics and their child's potential for future success. If parents believe that innate ability is largely responsible for a child's level of achievement, then ratings of ability and potential for success should be highly correlated. For example, if mothers rate their child as being very intelligent, then they should also believe that their child will do well in mathematics. The answers to the questions confirmed this hypothesis: the correlations between mothers ratings of their child's intelligence and potential for future success were significantly higher in the United States than in Japan or Taiwan. The American correlations were .65 for mothers of first graders and .70 for mothers of fifth-graders. In Japan and Taiwan, the correlations ranged from .36 to .51 (Stevenson et al., 1990).

A second, related correlate of the American focus on innate ability is a belief that it is possible to predict children's future success early in their lives. If American parents believe that innate ability determines future success, then it should be possible to make predictions about future success as a soon as a child is old enough to allow a valid assessment of his or her ability. Accordingly, American and Chinese mothers were asked to estimate when in a child's life it is possible to make accurate predictions about performance in high school mathematics. More than one-third of the American mothers, but only 10% of the Chinese mothers, believed that accurate predictions could be made by the end of elementary school.

Children's beliefs

For the most part, children's beliefs were consistent with those of their parents. In comparison to their Asian counterparts, American children believe that innate ability determines, to a large extent, their level of mathematics achievement.

As in the interviews of mothers, children were asked to rate their agreement with a set of statements regarding influences on mathematics achievement. American children were significantly less likely

than Asian children to agree with the statement, 'The best student in the class always works harder than the others students'. American children also agreed more strongly with the statement, 'The tests you take can show how much or how little natural ability you have'.

Possible consequences of the American belief in the importance of innate ability

In this section, I argue that focusing on innate ability may lead parents and children to expend relatively little effort on mathematics and to be satisfied with mediocre performance. Although it is impossible to demonstrate a direct causal relation between beliefs and children's level of achievement, the pattern of results is quite consistent with the claim that a focus on innate ability may lead Americans to devote less effort and attention to mathematics than their Asian counterparts.

Satisfaction with children's performance

One possible consequence of the American focus on innate ability concerns mothers' satisfaction with their children's academic performance. Despite the relatively poor performance of American children, their parents are quite satisfied with their level of performance. In contrast, Asian parents are substantially less satisfied with their children's performance. These results are based on portions of the interviews in which Japanese, Taiwanese and American parents were asked whether they were not satisfied, satisfied, or very satisfied with their child's performance in school mathematics. More than 40% of the American parents said they were very satisfied, but less than 10% of the Japanese and Taiwanese parents chose this answer. In contrast, less than 10% of the American parents said they were dissatisfied, but over 20% of the Japanese and Taiwanese were dissatisfied.

Further evidence for cross-national differences in levels of satisfaction concerns the relation within each country between a child's performance on the test of mathematics achievement and his or her mother's level of satisfaction. In the United States, mothers were likely to say they were satisfied even if their child's score was slightly *lower* than the American average; they only expressed dissatisfaction when their child's score was substantially lower than the American average. In contrast, Japanese and Taiwanese mothers expressed satisfaction only if their child's score was substantially above the mean for his or her country, and the mothers were *dissatisfied* with scores that were only slightly above average.

The answers to one additional question regarding levels of satisfaction were particularly telling. American and Chinese mothers were asked the following set of questions: Suppose your son or daughter took a test in mathematics, and the average score was 70. What score do you think your child would receive? With what score would you be satisfied? Both American and Chinese mothers expected that their children would receive scores somewhat above the average; American and Chinese mothers on average expected their children to receive scores of 82 and 85, respectively. However, American mothers on average said they would be satisfied with a score (76) that was lower than what they expected their child to receive. In contrast, Chinese mothers would only be satisfied with a score (94) that was substantially higher than what they expected their child to receive.

Why are American parents so satisfied with performance that is actually mediocre at best? One likely possibility is that American parents are unaware of the data that demonstrates how poorly their children are performing when assessed by international standards. However, it should be noted that despite the large increase in the past decade in reports of the poor performance of American children in mathematics, mothers' level of satisfaction has consistently remained high in each successive study. Either mothers are still not hearing about the international studies or they are not taking this information into account when considering their satisfaction with their child's performance. Moreover, there is evidence of active resistance to changing one's level of satisfaction as a result of learning about the poor performance of American children. For example, the columnist Jeff Greenfield (1992) reacted with disdain to reports of poor mathematics achievement; he wrote:

> Well, here we go again. Once more, for the 3,207th time an Officially Important Survey has revealed that our children are a bunch of morons. This time, the Officially Important Survey reveals, they have been proven a bunch of mathematical morons. And you know what? I don't think I care all that much. (p. D13).

Another possible explanation for the unrealistically high levels of satisfaction of American mothers concerns their focus on innate ability. American parents may simply accept low levels of performance because they do not believe that there is much that can be done

to improve performance. It may be preferable to be satisfied with relatively poor performance than to think that one's child lacks natural ability (see Uttal, 1995). Setting high standards for satisfaction also may not be consistent with the American focus on self-esteem. If poor performance is taken as evidence of low ability, then even temporary setbacks can be very serious threats to children's self esteem.

Estimates of children's ability

Another variable that may be related to the American belief in the importance of innate ability is mothers' estimates of their own child's ability. In all of the studies reported here, mothers have been asked to rate their child's ability in mathematics and other school subjects. The belief that one's own child is above average seems to be a cultural universal – mothers in all countries have consistently rated their child higher than the hypothetical 'average' child. However, this tendency is much greater in the United States than in China, Japan, or Taiwan; American mothers rate their children as having significantly more natural ability than do parents in the other countries.

In addition, American children also believe that they are more talented than children in Asia. Students were asked, 'If you were to rank all the students in your class from the brightest to the most stupid, where would you put yourself?' American children gave themselves significantly higher ratings than did Japanese or Taiwanese children.

Other possible consequences of the American focus on innate ability

The American focus on innate ability could have several important consequences regarding children's motivation in mathematics. Taken to the extreme, a focus on innate ability may make effort seem unnecessary or useless. By this view, effort is unnecessary for an innately smart child and a waste of time for a child of lesser intelligence (see Uttal, 1995). Evidence that is consistent with this claim comes from comparisons of the amount of time that children in Asia and the United States devote to homework. The average American fifth-grader spent about 4 hours per week doing homework (on all school subjects). In contrast, fifth-graders in Japan and Taiwan devoted 6 and 11 hours per week to homework, respectively. In addition, American mothers expressed mixed opinions about the value of homework, whereas Japanese and Taiwanese believed that homework was very important for success in mathematics.

Another issue that arises from the American focus on innate ability concerns the role of errors that children make when attempting to solve math problems in class. Errors, particularly those made in public, can often serve a critical function in mathematics education. The teacher learns, before a formal examination, which concepts are difficult for children. Individual students are given a chance to correct minor problems before they become deeply entrenched misunderstandings. Moreover, the entire class benefits by following other children's work and identifying errors.

In the United States, the focus on innate ability may rob teachers and students of the benefits of observing and correcting errors in class. If errors are taken as a measure of innate ability, then students may be unwilling to risk making an error in public. Stevenson and Stigler (1992) have summed up well the cross-national differences regarding the role of errors in instruction:

> We have been struck by the different reactions of Asian and American teachers to children's errors. For Americans, errors tend to be interpreted as an indication of failure in learning the lesson. For Chinese and Japanese, they are an index of what still needs to be learned...these divergent interpretations result in very different reactions – embarrassment on the part of the American children, relatively calm acceptance by Asian children. (p. 192)

In sum, the consistent American belief in the role of genetics may be partly to blame for the failure of children to perform well in mathematics. Perhaps more than any other school subject, mathematics requires effort, diligence, and persistence even in the face of temporary setbacks. A focus on innate ability may discourage children from doing precisely what they must do to succeed in mathematics.

Origins of belief systems

What accounts for the differences in Asian and American mothers' beliefs about influences on mathematics achievement? It seems clear that the Asian focus on effort is derived from Confucian philosophy, which stressed the possibility of moral perfection through effort and study. Confucian beliefs gradually dispersed into more general cultural values regarding influences on achievement and development. 'Human beings were considered to be malleable, and like clay, subject to

molding by the events of everyday life. Differences among individuals in innate abilities were recognized, for no one can claim that all people are born with the same endowments. But more important was the degree to which a person was willing to maximize these abilities through hard work'. (Stevenson & Stigler, 1992, p. 97). Both Chinese and Japanese children are exposed to numerous stories about folk heroes who succeeded through effort despite overwhelming odds.

Americans folklore and cultural history is also filled with images of the value of hard work, such as the Horatio Alger stories. However, these values no longer seem to predominate. Why have American shifted toward believing so strongly in the role of innate ability? Although many factors are involved, it seems likely that the increased attention to genetics and genetic influences on behavior, disease, and human nature has contributed to the belief that genetics matters most. New research on genetic influences is reported quite frequently in the popular press. Geneticists and other scientists realize that genetic influences are complex, and that almost all human traits or abilities develop in the context of interactions between the genotype and the environment in which organisms are reared. Unfortunately, however, it does not appear that the average American citizen shares this understanding. Instead, many Americans believe that genetic influences directly *cause* or control the expression of abilities, personality traits, etc.

Conclusions

This paper has shown that Americans hold an unjustified belief that achievement in mathematics performance is determined largely by innate ability. Although innate ability almost certainly constrains and influences one's level of achievement, the work presented here has demonstrated that American children at all levels of intellectual ability are performing much worse than their counterparts in China, Japan, and Taiwan. Moreover, the research has demonstrated clear and consistent differences in the beliefs of American and Asian parents regarding influences on children's achievement. Americans believe that genetics matters most, whereas Asian believe more in the role of effort. The American emphasis on the role of innate ability may contribute to the poor mathematics performance of American children.

The research presented here has important implications for efforts to improve the performance of American children. Much of the effort is devoted to improving teaching or the school environment. However, the present results suggest that these efforts are not likely to be effective if the reforms do not also consider the cultural context and belief systems that influence children's motivation to perform well in mathematics. Effective teaching can help, but ultimately we must improve children's desire to take advantage of the teachers' efforts.

In sum, as research on biological influences on intelligence and achievement continues to increase, we need also consider how the findings are reported to parents and to the public in general. As scientists move beyond the dated nature-nurture debate, we must be careful also to help the general public to understand the interactions that characterize human development and achievement. Hopefully, increased emphasis on biological influences on intelligence and achievement will not impede the ongoing attempts to improve the mathematics achievement of American children.

Acknowledgements

Portions of this work were supported by Grant MH54504-01 from the National Institute of Mental Health. I thank Mike Bailey, Fred Bookstein, C.C. Chen, Andrew Fuligni, Jerry Hirsch, Shin-Ying Lee, and Harold Stevenson for their helpful discussions.

Note

[1] These comparisons are based on Japanese samples. Less information is available for Chinese samples, although Lynn and others have argued that the pattern of intellectual abilities is similar in individuals of Chinese and Japanese descent.

References

Benbow, C.P., 1988. Sex differences in mathematical reasoning ability in intellectually talented preadolescents: Their nature, effects, and possible causes. Behavioral and Brain Sciences 11: 169–183.

Chen, C.C. & D.H. Uttal, 1988. Cultural values, parents' beliefs, and children's achievement in the United States and China. Human Development 31: 351–358.

Chen, C.C. & H.W. Stevenson, 1989. Homework: A cross-cultural examination. Child Development 60: 551–561.

Garden, R.A., 1987. The second IEA mathematics study. Comparative educational review 31: 47–68.

Geary, D., 1994. Children's mathematical development: Research and practical application. American Psychological Association, Washington.

Greenfield, J., 1991. Officially Important Survey is moronic, not America's schoolchildren. Ann Arbor News, June 9, D13.
Gould, S.J., 1981. The mismeasure of man. Norton, New York.
Herrnstein, R.J. & C. Murray, 1994. The bell curve. The Free Press, New York.
Hirsch, J., 1975. The bankruptcy of 'science' without scholarship. Educational Theory 25: 3–28.
Lynn, R., 1982. IQ in Japan and the United States shows a growing disparity. Nature 297: 222–223.
Lynn, R., 1987. The intelligence of the mongoloids: A psychometric, evolutionary and neurological theory. Personality and individual differences 8: 813–844.
Lynn, R., 1988. Educational achievement in Japan. M.E. Sharp, Inc., Armonk, NY.
McKnight, C.C., F.J. Crosswhite, J.A. Dossey, E. Kifer, J.O. Swafford, K.J. Travers & T.J. Cooney, 1987. The underachieving curriculum: Assessing U.S. school mathematics from an international perspective. Stipes, Champaign, IL.
National Commission on Excellence in Education, 1983. A nation at risk: The imperative for educational reform. Government Printing Office, Washington.
Rushton, J.P., 1994. The equalitarian dogma revisited. Intelligence 19: 263–280.
Rushton, J.P., 1995. Race, evolution, and behavior: a life-history. Transaction Publishers, New Brunswick, NJ.
Steen, L.A., 1987. Mathematics education: A predictor of scientific competitiveness. Science 237: 251.
Stevenson, H.W., C. Chen & S.Y. Lee, 1993. Mathematics achievement of Chinese, Japanese, and American children: Ten years later Science 259: 53–58.
Stevenson, H.W. & J.W. Stigler, 1992. The learning gap: Why our schools are failing and what we can learn from Japanese and Chinese education. Summit Books, New York.
Stevenson, H.W., S.Y. Lee, C. Chen, M. Lummis, J. Stigler, L. Fan & F. Ge, 1990. Mathematics achievement of children in China and the United States. Child Development 61: 1053–1066.
Stevenson, H.W., S.Y. Lee, C. Chen, J.W. Stigler, C.C. Hsu & S. Kitamura, 1990. Contexts of achievement: A study of American, Chinese, and Japanese children. Monographs of the Society for Research in Child Development, Serial No. 221, Vol. 55.
Stevenson, H.W., S.Y. Lee & J.W. Stigler, 1986. Mathematics achievement of Chinese, Japanese, and American children. Science 231: 693–699.
Uttal, D.H., 1995. Beliefs, motivation, and achievement in mathematics: A cross-national perspective, pp. 25–38 in Motivation in mathematics, editex by M. Carr. NJ Press, Hampton, Cresskill.
Uttal, D.H., M. Lummis & H.W. Stevenson, 1988. Low and high mathematics achievement in Japanese, Chinese, and American elementary-school children. Developmental Psychology 24: 335–342.
Vernon, P.E., 1961. The structure of human abilities (2nd edn) Methuen, London.
Vernon, P.E., 1982. The abilities and achievements of Orientals in North America. Academic Press, New York.