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AUTHOR Huntsinger, Carol S.; And Others
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ABSTRACT

This study compared Chinese-American and Caucasian-American children and families in order to better understand which cultural and family characteristics, parent beliefs, and parent practices operate at the early childhood level to produce the more uniform high level of math achievement among Asian-American children. Forty second-generation Chinese-American and 40 Caucasian-American preschoolers and kindergartners from well-educated, 2-parent families were given math, name writing, visual discrimination, spatial relation, and vocabulary measures. Parents completed questionnaires, interviews, and a social behaviors checklist. The study found that Chinese-American children outperformed Caucasian-American children on measures of mathematics, spatial relations, visual discrimination, numeral formation, and name writing. Caucasian-American children had higher scores on receptive English vocabulary. Chinese-American parents indicated a stronger belief in the role of hard work and early skill development in academic achievement, gave more direct math instruction, structured their children's time to a greater degree, and reported more encouragement for math-related activities than did Caucasian-American parents. Ethnicity, parents' child-specific attitudes, and directive teaching techniques were the strongest predictors of child math performance, numeral formation, and motor coordination. Six tables showing study data are included. A description of Chinese-American and Caucasian-American parent characteristics is appended. Contains 29 references. (MDM)

# Ethnic Differences in Early Math Learning:

# A Comparison of Chinese-American and Caucasian-American Families

Carol S. Huntsinger

College of Lake County

Paul E. Jose

Loyola University of Chicago

Wei-Di Ching

College of Lake County



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Abstract

Forty second-generation Chinese-American and 40 Caucasian-American children (10 preschool girls, 10 preschool boys, 10 kindergarten girls, and 10 kindergarten boys in each group) were drawn from well-educated two-parent families in the suburban Chicago area. Chinese-American children outperformed Caucasian-American children on measures of mathematics, spatial relations, visual discrimination, numeral formation, and namewriting. Caucasian-American children had higher scores on receptive English vocabulary. Chinese-American parents indicated a stronger belief in the role of hard work and early skill development in academic achievement, gave more direct math instruction, structured their child's time to a greater degree, and reported more encouragement for math-related activities than did Caucasian-American parents. Chinese-American parents endorsed Chinese personality characteristics to a greater degree than Caucasian-American parents. Ethnicity, parents' child-specific attitudes, and directive teaching techniques were the strongest predictors of math performance, numeral formation, and motor coordination.

Ethnic Differences in Early Math Learning: A Comparison of Chinese-American and Caucasian-American Families

A primary concern of our nation's educational systems today is that of raising the mathematics levels of its students. A large number of cross-national studies demonstrate the pervasiveness of poor mathematics performance among American school children relative to that of Chinese, Japanese, and Korean children (e.g., Hess, Chang, & McDevett, 1987; Stevenson, Lee, Chen, Lummis, Stigler, Fan, & Ge, 1990; Stevenson, Lee, Chen, Stigler, Hsu, & Kitamura, 1990). Because these differences are evident as early as first grade (e.g., Geary, Bow-Thomas, Fan, & Siegler, 1993; Stevenson, Lee, Chen, Stigler, et al., 1990), one can hypothesize that cultural and family factors contribute significantly to the difference. In this country, Asian-American children outperform other American children in the mathematics domain, even though they have been educated in the same school systems (e.g., Caplan, Choy, & Whitmore, 1992). Again, cultural and family factors are implicated. There is very little research comparing parental and family influences on early mathematics learning within the United States. The present study was designed to compare Chinese-American and Caucasian-American children and families in the suburban Chicago area in order to better identify which cultural and family characteristics, parent beliefs, and parent practices operate at the early childhood level to produce the more uniformly high level of math achievement among Asian-American children.

Research into characteristics of the culture which may facilitate mathematics achievement has focused on linguistic differences. Geary et al. (1993) attributed the Chinese kindergarten and first grade advantage in addition performance to greater levels of arithmetic practice among the Chinese and to linguistically-mediated differences in memory span. Chinese young children have demonstrated a greater capacity in memory span for numbers in Chinese than American young children in English (e.g., Chen & Stevenson, 1988; Stigler, Lee, & Stevenson, 1986). The explanation is that digit names in Chinese require a shorter pronunciation time and therefore take up less space in working memory.

Other researchers (e.g., Fuson and Kwon, 1991; Miura, Kim, Chang, & Okamoto, 1988) point out that learning to count in languages based on ancient Chinese (Chinese, Japanese, and Korean) is easier than learning to count in English, because the Chinese spoken numerical names are organized so they agree with the traditional base 10 numeration system. Only the names of the first ten numbers need to be memorized. All numbers beyond ten are generated according to an orderly set of rules, e. g., eleven is read as ten-one, twelve is read as ten-two, etc.

Cross-national differences in parents' beliefs regarding the value of effort, the importance of education as a means for personal advancement, the importance of teacher influence, collective vs. individual goals, and internal vs. external motivation have been demonstrated and used to explain the Chinese superiority in math performance (e.g., Chen & Uttal, 1988; Hess et al., 1987). Hess et al. (1987) found that Chinese-American parents viewed the home as more influential in children's success than did Caucasian-American parents. Yang (1986) has described a difference in personality characteristics: The traditional Chinese personality is more cautious, patient, restrained, and self-contained. Obedience, conformity, humility, perseverence, conscientiousness and harmony are characteristics that are highly valued by Chinese families.

There is strong evidence that parental perceptions about their child's ability and interest in academic areas are related to the child's attitudes and academic performance (e.g., Eccles, 1993; Eccles-Parsons, Adler, & Kaczala, 1982; Holloway & Hess, 1985; Jacobs, 1991). Parents appear to form their impressions of their child's interests and abilities on the basis of both objective feedback about their child and their own biases (e.g., Eccles, 1993). Parents communicate their own attitudes and their beliefs about their child through their practices.

Differences in parental practices have been demonstrated. Chinese-American parents as compared to Caucasian-American parents have been found to be more restrictive and controlling, but also more democratic (Chiu, 1987); more direct in their teaching styles (Huntsinger & Jose, 1994); and more likely to provide regular, formal instruction at home for their preschoolers (Steward & Steward, 1974). Few cross-cultural studies have explored the links between parental practice and child math-related outcomes. Dunn (1981), however, found that American parents who had used didactic math teaching techniques with their young children had children who achieved at higher levels.

We expected to find that Chinese-American children would obtain higher scores than Caucasian-American children on the math test, name writing, numeral writing, visual discrimination, and spatial relations tasks. We expected Caucasian-American children to outscore Chinese-American children in receptive English vocabulary because Caucasian-American children are native English speakers.

Chinese-American parents were predicted to be more direct when teaching their young children, to set aside a daily homework period for their children to practice skills, and to limit their children's TV viewing to a greater extent than Caucasian-American parents. Chinese-American parents were expected to endorse beliefs about education which reflected Confucian heritage (hard work and discipline), whereas Caucasian-American parents were expected to endorse beliefs reflecting the influence of democratic values and European and American philosophers: Rousseau (free choice), Piaget (discovery), and Dewey (self-directed activity). Chinese-American parents were also expected to endorse more strongly the encouragement of personality characteristics in their children which reflect the traditional Chinese emphasis on concentration, neatness, precision, politeness, and calmness.

Finally, we expected parents' own attitudes, their child-specific attitudes, teaching techniques, and allocation of their children's time to be predictive of children's performance on math-related tasks.

## Method

### Sample Description

Children were recruited via letters to the parents in preschools, kindergartens, and weekend Chinese schools in the north and west suburban Chicago area. Letters to the parents in the weekend Chinese schools were written in Chinese.

Children in the Chinese-American sample (10 preschool girls, 10 preschool boys, 10 kindergarten girls, and 10 kindergarten boys) had a mean age of 5.7 years and had attended preschool programs 22.2 months on average. Ten children had attended day care programs full time. Eleven were first-borns, 7 were middle children, 19 were last-born, and 3 were only children. There were 2.2 children per family. Mothers, on average, were 37.4 years old, had an educational attainment level of 16.7 years, and had lived in the United States for 11 years. Fathers were, on average, 39.8 years old, had an educational attainment level of 18.2 years, and had lived in the United States for 12.3 years. Twenty-eight families had incomes over $60,000. The mean Hollingshead four-factor social status score was 59.8. Countries of origin included Taiwan (31 families), mainland China (4 families), Hong Kong (4 families), and the Philippines (1 family). Thirty-nine families spoke a Chinese dialect in their homes. Sixteen were Buddhist, 16 were Christian, and 8 were non-religious. Eight of the families had grandmothers living in their homes; two had Chinese nannies living with them. (Refer to Table 1.)

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Insert Table 1 about here

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The mean age of the Caucasian-American sample (10 preschool girls, 10 preschool boys, 10 kindergarten girls, and 10 kindergarten boys) was 5.6 years. They had attended preschool programs for an average of 21.4 months. Six children had attended day care programs full time. Eighteen were first-born, 7 were middle children, 12 were last-born, and 3 were only children. There were 2.4 children per family. Mothers on average were 36.9 years old and had an educational attainment level of 17.2 years. The corresponding means for fathers were 39.6 years and 17.7 years. Thirty-four families had incomes over $60,000.

The mean Hollingshead four-factor social status score was 60.8. All parents except two fathers were born in the United States; one father was born in Canada and one in Austria. English was spoken in all homes. The majority of the families (36) were Christian. None of the families had grandparents living in the home.

No significant differences were found on parental variables of age, educational attainment level, Hollingshead status scores, or on child variables of age and length of preschool attendance. The Chinese-American parents did have careers with significantly greater math relevance, however. Chinese-American parents have pursued graduate work in the United States in scientific and technical fields for several reasons: (a) Among recent immigrants, lack of facility in English results in greater relative confidence in math; (b) Scientific fields represent a faster route toward upward mobility (Sue & Okazaki, 1990); (c) Scientific fields are highly valued as careers in developing countries such as Taiwan; and (d) Their bachelor's degree was in the math-science area. The math relevance variable was obtained by rating the careers of the mothers and fathers in this study on a 3-point Likert-type scale from low math relevance (1) to high math relevance (3). The first author and an independent rater, uninformed of the hypotheses of the study, separately rated the randomly presented careers and achieved high agreement (kappa = .78). The differences were mutually resolved.

Materials

The Test of Early Mathematics Ability-2. The TEMA-2, a standardized test developed by Ginsburg and Baroody (1990), was used to assess both informal (35 items) and formal (30 items) mathematical thinking in young children. Informal mathematics, which is acquired outside the context of formal schooling, is assessed by three kinds of items: concepts of relative magnitude, counting, and calculation. Formal written mathematics, which is learned through explicit instruction using rules, principles, and procedures, is assessed by four kinds of items: knowledge of convention, number facts, calculation (addition and subtraction), and base-ten concepts. It is normed for children from three to eight years, 11 months.

Name Writing. The child was asked to write her/his name, using pencil, on a sheet of 8 1/2 x 11 paper. The maturity of the handwriting was used as one measure of the child's developing fine-motor coordination.

Visual Discrimination. The perceptual speed test (1st grade) from the Michigan Cognitive Battery (Stevenson et al., 1990) was used to assess the accuracy of children's ability to visually match one of four alternative pictures to a target picture. The test was not timed. The examiner pointed to each target picture and said, "Here is a picture of a ______. Point to the picture in this row that is exactly like the one in the box." The examiner then circled the child's answer. Older children were allowed to circle the answers themselves if they wished. The test consists of three practice items and 18 scored items.

Spatial Relations. A wooden puzzle with inlays of three circles, three squares, and three hexagons, each divided into two pieces was given to assess the child's ability to perceive rotations in space. The puzzle frame is natural wood and the two halves of each geometric shape are different primary colors and are colored on both sides. Color is not a cue in fitting the two halves of the shape together. The inside cut of each of the three like shapes is different, i.e., one circle has a straight cut separating the two halves; one circle has a zigzag cut; and one circle has a curving cut. The solution time required and the strategies the child uses to solve the puzzle were recorded. The completed puzzle was shown to the child for 10 seconds. Then the researcher disassembled it, put all the pieces to the child's right in random order, and placed the puzzle frame in front of the child with the circles at the top.

The Peabody Picture Vocabulary Test. The PPVT-R Form M was administered to assess children's receptive vocabulary. In this scale, children are shown four pictures and are asked to identify the picture that signifies a target word (e.g., nest, stretching).

Parent Questionnaire. Mothers and fathers independently completed questionnaires surveying parents' education, employment, age, religion, household composition, country of origin, attitudes toward academic subjects and extracurricular activities, beliefs regarding education and child-rearing, child's preschool experience, expectations for their child, and personality characteristics that they view as important to encourage in their child. These questionnaires were translated into Chinese by the third author and were available for parents who preferred them. Responses to all questions below were made on 5-point Likert scales. Questions used in this paper include: 1) How much did you like the following school subjects? [art, computer courses, foreign languages, physical education, literature, mathematics, music, science, social studies, writing] (1 = strong dislike, 5 = strong like); 2) Indicate how difficult or easy it was for you to achieve good grades in each of the following subjects ? [Same subject areas as #1] (1 = very difficult, 5 = very easy); 3) How would you rate your competence in each of the following areas? [Same subject areas as #1] (1 = low competence, 5 =

high competence); 4) How important do you think it is for your child to develop competence in each area listed below? [music, science, language arts, social studies, foreign language, computers, mathematics, art, sports] (1 = unimportant, 5 = very important); 5) How much does your child like to do each of the following? [make-believe play; puzzles; climbing, running, jumping; listening to stories; playing with blocks; singing, listening to music; painting, coloring, drawing; counting, math activities; sports (swimming, soccer); science activities] (1 = not at all, 5 = very strong like); 6) How easy or difficult do you think it will be for your child to get good grades in each of the following subjects? [art, computers, foreign language, physical education, literature, mathematics, music, science, social sciences, writing] (1 = very difficult, 5 = very easy); 7) How much will you encourage your child to participate in each of the following activities in elementary or junior high school? [orchestra, band, chorus, soccer, football, tennis, religious classes, math or science team, library reading program, Girl or Boy Scouts] (1 = strongly discourage, 5 = strongly encourage); 8) How important do you think it is to encourage the following personality traits in your child? [self-confidence, persistence, curiosity, obedience, sociability, politeness, creativity, calmness, assertiveness, neatness, concentration, independence, precision, respect] (1 = not important, 5 = very important); 9) How strongly do the following statements characterize your beliefs about schooling? (See Table 4 for specific statements.) Answers were given on a 5-point scale,with 1 representing "not at all" and 5 representing "very strongly." This 17-statement scale, with both Chinese and American belief subscales, was derived from the existing literature (e.g., Chen & Uttal, 1988; Hess, Chang, & McDevett, 1987) by the authors.

Interviews. Mothers and fathers were interviewed together in their homes regarding child-rearing practices, their role in facilitating reading and math development in their child, discipline techniques, and time allocation in their child's typical weekday. About one fourth of the Chinese-American parents chose to be interviewed in Mandarin Chinese by the third author. Questions used in this paper include: 1) How do you attempt to facilitate your child's development in reading? How do you facilitate your child's development in math? 2) Would you describe your child's typical weekday schedule? 3) What do you think is the best balance between play and work on academics in a preschool program?

Social Behaviors Checklist. The parents jointly rated their child on a checklist of 25 social behaviors considered important by early childhood and kindergarten teachers on a scale of 1 (never) to 5 (usually). The child's teacher also independently completed the social behaviors checklist.

Procedure

Children were assessed individually in their home or day care center using the Test of Early Mathematics Ability (TEMA-2), name writing, an untimed visual discrimination task (the perceptual speed test from the Michigan Cognitive Battery), a wooden geometric puzzle (spatial relations measure), and the Peabody Picture Vocabulary Test (PPVT). The tasks were administered in the above order for all 80 children because we felt the math test was the most cognitively demanding and should be given first while the children were fresh. This order provided variety for the children and held their interest. Fathers and mothers independently completed questionnaires assessing cultural and educational backgrounds and beliefs. Parents were interviewed together in their homes about childrearing practices, educational support for their children, and time allocation in their child's typical day. Teachers and parents independently rated the child's social behaviors on a 25-item checklist compiled from behaviors typically considered important by early childhood teachers.

Variable Explanations

Math Teaching Methods. A list of all the unique answers provided by parents to the math facilitation interview question was compiled. The list was ordered randomly and presented for purposes of rating to a female college early childhood education instructor, who was unaware of the nature of the study. The methods mentioned by the parents were rated on a 3-point Likert scale on the basis of formality or directness, with 1 representing indirect, spontaneous, informal, play-oriented methods ("We bring out math in everyday experiences, like grocery shopping") and 3 representing direct, formal, regular, work-oriented methods ("We have enrolled her in the Kumon math program. She does five pages of homework every day"). The education instructor and the first author achieved high interrater reliability (Cohen's kappa = .84). A mean directness-indirectness index was derived for each family by coding each method they had named with 1, 2, or 3 and finding the arithmetic average of the sum.

Maturity of Numeral Formation. Two experienced early childhood educators rated (on a 5-point Likert scale) the maturity of the numerals the children had written during the course of taking the TEMA-2. The least mature numerals were rated 1 and the most mature numerals were rated 5. Interrater reliability between the two blind raters was high ($r$ = .88). The ratings of the two raters were averaged together. Criteria used by the two raters were as follows:

proper formation of numerals, uniformity of spacing, alignment in a plane, size of numerals, and line quality.

Maturity of Name Handwriting. Two other experienced early childhood teachers rated the children's written names in a similar fashion. Interrater reliability was high ($r = .88$). Criteria used by the two raters were as follows: proper formation of letters, uniformity of spacing, alignment in a plane, size of letters, and line quality.

Motor Coordination. The numeral formation and name writing ratings were highly correlated ($r = .64$) and thus combined into an index of fine motor coordination by averaging the two ratings.

## Results

### Children's Outcomes

All of the results reported in this section were obtained through 2 x 2 x 2 MANOVA (Ethnicity x Sex of child x Age) procedures. A MANOVA performed on the math, numeral formation, drawing, visual discrimination, spatial relations, and vocabulary measures revealed significant main effects for ethnicity, $F(5, 67) = 19.83$, $p < .0001$, and age, $F(5, 67) = 13.68$, $p < .0001$. Math relevance of parents' careers was used as a covariate to control for the fact that the careers of Chinese-American parents had significantly greater math-relevance than careers of Caucasian-American parents. Chinese-American children scored significantly higher than Caucasian-American children on the math, numeral formation, and name writing measures. (See Table 2.) Caucasian-American children scored significantly higher on the PPVT, which was administered in English. Kindergarten children scored significantly higher than preschool children on all measures. Because math is the primary focus of this paper, the remaining analyses will report only math-related findings.

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Insert Table 2 about here

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Parent Measures

Math Attitudes. Because parental liking of math, self-rated competence, and ease of getting good grades in math were highly intercorrelated ($r$s = .65 - .69), we combined them into one variable: parents' math attitudes. Two other variables, the parents' report of child's degree of enjoyment of counting/math activities and the prediction of how easy math will be for their child, were highly correlated ($r$ = .88) and therefore were combined into one variable called parents' child-specific math attitudes. The other variables, parental encouragement of math activities and importance of math competence for their child, were used singly. A MANOVA on parents' math attitudes, child-specific math attitudes, encouragement for participation in math activities, and importance of math competence revealed main effects for age, $F$ (4, 68) = 4.02, $p < .01$, and ethnicity, $F$ (4, 68) = 4.11, $p < .01$. Two univariate differences emerged. Parents of kindergarteners (M = 4.17) reported that their children liked counting/math activities more and would find math easier than did parents of preschoolers (M = 3.67), $F$ (1, 71) = 15.64, $p < .0001$. Chinese-American parents (M = 4.50) said they would more strongly encourage their child's participation in math/science club in elementary or junior high school than did Caucasian-American parents (M = 4.08), $F$ (1, 71) = 13.32, $p < .0001$. (Refer to the appendix for other activity preference differences.) No significant differences were found for the parent math attitudes. Chinese-American and Caucasian-American parents were similar on liking of math, self-rated math competence, and ease of getting good grades in math.

Personality characteristics. A MANOVA performed on the parents' ratings of the importance of fostering particular personality characteristics in their child showed a significant main effect for ethnicity, $F(14, 57) = 5.43$, $p < .0001$. (See Table 3.) Chinese-American parents' ratings (on a 5-point scale, with 1 representing "not important" and 5 representing "very important") of the importance of politeness, calmness, neatness, concentration, and precision were higher than ratings from Caucasian-American parents. On the other hand, the rating of independence by Caucasian-American parents was marginally significantly higher than Chinese-American parents.

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Insert Table 3 about here

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Two subscales were formed: A set of typical Chinese-American characteristics (Cronbach's alpha = .82) included persistence, obedience, politeness, calmness, neatness, concentration, precision, and respect; and a set of typical Caucasian-American characteristics (Cronbach's alpha = .70) included self-confidence, curiosity, sociability, creativity, assertiveness, and independence. A MANOVA performed on the Chinese-American and Caucasian-American personality subscale sum totals revealed an ethnicity main effect, $F(2, 70) = 10.98$, $p < .0001$. Chinese-American parents (Sum = 68.62) rated Chinese personality characteristics as significantly more important than did Caucasian-American parents (Sum = 63.58), $F$ (1, 71) = 13.86, $p < .0001$. No ethnicity differences emerged for the American subscale.

Educational Beliefs. A MANOVA performed on responses to the 17 educational beliefs statements was significant for ethnicity, $F$ (17, 54) = 6.90, $p < .0001$. (Refer to Table 4 for univariate results.) Also, two subscales were constructed, one reflecting Chinese traditional beliefs (Cronbach's alpha = .72) and the other reflecting traditional American beliefs (Cronbach's alpha = .68). A MANOVA performed on the two scales was highly significant for ethnicity, $F$ (2, 69) = 9.68, $p < .0001$. Surprisingly, Chinese-American parents' ratings were higher on both Chinese (Sum = 64.84), and American (Sum = 59.58) subscales than ratings of their Caucasian-American counterparts (Sums = 59.95, 54.08). It may reflect a general tendency for Chinese-American parents to respond more positively to any items regarding education.

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Insert Table 4 about here

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Parent Practices. A MANOVA performed on data from the time diaries and math facilitation techniques revealed main effects for age, $F$ (5, 65) = 6.22, $p < .0001$, and ethnicity, $F$ (5, 65) = 16.85, $p < .0001$. (Refer to Table 5.) Kindergarten children were awake more hours per day and spent more time doing homework than did preschoolers. Chinese-American parents reported employing more direct, formal techniques for teaching math to their children than Caucasian-American parents. Chinese-American children spent more time in concentrated homework or practice, less time watching television or videos, and more time in scheduled activities than did Caucasian-American children.

The majority of Caucasian-American parents (82%) approved of rough-and-tumble play, whereas only 27% of Chinese-American parents did. Caucasian-American parents (M = 70.7%) desired a higher percentage of play as compared to academic work in a preschool program than Chinese-American parents (M = 60.7%), $t$ (37) = 3.04, $p < .01$.

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Insert Table 5 about here

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Teacher Social Behavior Ratings

Did the children in the two ethnic groups look different from one another in social behaviors? MANOVAs performed on teacher ratings of 25 social behaviors typically considered important by early childhood teachers revealed no significant main effects and only one significant univariate ethnicity difference. Teachers rated Caucasian-American children (M = 4.38) as more likely than Chinese-American children (M = 3.96) to seek out other children to play with, $F$ (1, 66) = 3.26, $p < .05$. (A rating of 3 represents "sometimes"; 4 represents "often"; 5 represent "usually.") The 25 social behaviors were analyzed using two separate MANOVAS, one with 13 behaviors and one with 12 behaviors. The one significant univariate ethnicity result could have been due to chance.

Regression Results

To assess the relationships of parental measures to children's math-related outcomes, we performed a series of forced-entry hierarchical multiple regressions, entering math relevance of parents' careers first to statistically control for the significant ethnicity difference on that variable. Ethnicity, parents' math attitudes, Chinese personality scale, American personality scale, parents' child-specific beliefs, directiveness of parents' teaching, and percentage of play preferred in a preschool program were entered in that order as independent variables on the dependent child outcome variables of math (TEMA-2) score, numeral formation, visual discrimination, motor coordination, and puzzle time.

Significant predictors were found for all outcomes, except puzzle time. (See Table 6.) Specifically, ethnicity, child-specific math attitudes, directiveness of parental math teaching, and percentage of play preferred in preschool predicted the math (TEMA-2) score. Chinese-American children had higher math scores. Parents who thought math was easier for their child and who reported their children had a greater liking of counting and math games had children with higher math scores. Parents who used more direct math teaching methods had children with higher math scores. Parents who preferred a higher percentage of work on academics in the preschool curriculum had children with higher math scores.

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Insert Table 6 about here

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Numeral formation was predicted by ethnicity, child-specific math attitudes, directiveness of teaching, and percentage of play preferred in preschool. Chinese-American children wrote numerals in a more mature fashion. Children, whose parents reported that math would be easier for their children and that their children had a greater liking for counting games/math activities, were rated as having more mature numeral formation. Parents who used more direct math teaching methods and who preferred more academic work in the preschool curriculum had children who wrote numerals in a more mature way.

Visual discrimination was predicted by only one factor: child-specific math attitudes. Parents who reported more positive child-specific math attitudes had children who scored higher on the measure of visual discrimination.

Motor coordination, an average of the numeral formation and name writing ratings, was predicted by four variables: ethnicity, Chinese personality characteristics, child-specific math attitudes, and directiveness of teaching. The Chinese-American children's motor coordination was superior to that of Caucasian-American children. The more important the parents rated Chinese personality characteristics, the lower the child's fine-motor skill tended to be. More positive child-specific math attitudes and more direct parental math teaching methods predicted higher motor coordination ratings.

The covariate, math relevance of parents' careers, accounted for the following amounts of variance upon entry into the regression equation: 2% on the TEMA-2 score, 3% on the visual discrimination task, 7% on the spatial relations puzzle and motor coordination task, and 8% on the numeral formation rating. Math relevance was not a significant predictor in any of these regression equations.

## Discussion

The data showed that this population of Chinese-American children scored higher than Caucasian-American children in all areas with the exception of English vocabulary. The math gap is evident prior to first grade entrance just as

Stevenson et al. (1990) had found in a recent cross-national comparison. We believe that the question of why this disparity is found is partially answered by examining parental beliefs and practices. In essence, Chinese-American parents provide a solid background in mathematics at the early childhood level. Chinese-American parents report a stronger belief in the role of hard work and early skill development in academic achievement, give more direct math instruction, structure their child's time to a greater degree, and intend to provide more encouragement for involvement in math-related activities at later ages.

Ethnicity emerged as the strongest predictor of numeral formation (27% of the variance) and motor coordination (25% of the variance). It contributed 8% of the variance for the raw math (TEMA-2) score. Parents' child-specific attitudes also contributed to the prediction of all four outcome measures, contributing 21% of the unique variance to the raw math (TEMA-2) score, 12% to motor coordination, 10% each to numeral formation and visual discrimination. The variable, directiveness of math teaching predicted raw math (TEMA-2) scores, numeral formation, and motor coordination, accounting for 6% of the unique variance in each. Percentage of work on academics preferred by parents in preschool programs predicted raw math (TEMA-2) score (4% of the variance) and numeral formation (3% of the variance.)

Neither the math attitudes of the parents nor the math relevance of parents' careers predicted math outcomes in these young children. The parents' perceptions about their child's future math facility and the degree to which their child enjoyed math-related activities appear to be much more influential in predicting children's math-related performance than were parents' own selfconcepts about math. This suggests that sensitive parents had taken note of the interests and abilities the child had already shown in regard to math. Because these children were enrolled in pre-first grade programs, their parents had not yet had much formal feedback from teachers regarding the children's math performance.

Directive teaching techniques appear to have been more effective than indirect techniques in teaching mathematics to these young children, corroborating Dunn's (1981) conclusion that didactic parental teaching of math was correlated with higher math achievement in their children. In the current study directive teaching contributed over and above ethnicity; Caucasian-American (as well as Chinese-American) parents who reported using more formal math teaching methods had children who performed better in math. However, these results challenge the dominant early childhood philosophy in the United States which recommends a non-directive discovery approach to young children's mathematics. For example, Brewer (1992) has said, "It is best if the child discovers the [counting] strategy, rather than having it imposed by the teacher or parent" (p. 303) .

Chinese-American children were much more skilled at numeral formation than Caucasian-American children. Parents or older siblings had shown them how to form the numbers correctly and had encouraged them to practice writing them at home. Their overall fine motor coordination was superior to that of their Caucasian-American counterparts. Intercorrelations among all the child outcomes showed motor coordination ratings and raw math scores ($r$ = .71) to be the most highly correlated outcomes.

Thus an intriguing question arises in reference to the relationship between the earlier emergence of fine-motor skills in the Chinese-American children and their superiority in math. The emergence of fine-motor abilities may facilitate some aspects of cognitive development (Bushnell & Boudreau, 1993). It is consistent with Piagetian theory that the ability to represent quantity through written numerals would enhance a child's ability to think about numerical concepts. Also, when numeral-writing becomes automatic, a child can concentrate her/his energies on higher level cognitive skills. This fine motor superiority on the part of the Chinese-American children may not be simply a matter of practice. The earlier emergence of fine motor coordination could point to a biological contribution. Motor development in early childhood is determined to a significant degree by maturation (Salkind, 1994). If handwriting is physically easier for young Chinese-American children, they will feel successful and will be able to practice for longer periods of time without becoming frustrated. Another related biological contribution could involve temperament. Chinese-American newborns have been found to be calmer than Caucasian-American newborns (Freedman & Freedman, 1969). Chinese infants in Beijing have been recently found to be less active, irritable, and vocal than Caucasian infants in the United States and Ireland (Kagan, Arcus, Snidman, Feng, Hendler, & Greene, 1994). This predisposition to calmness or imperturbability in infancy could contribute to greater patience for formal instruction demonstrated by Chinese-American children during early childhood.

It is possible that the Chinese-American advantage in mathematics performance demonstrated at this level will not be maintained once all children are exposed to more formal mathematics teaching in the elementary school. A longitudinal study to determine whether this ethnicity differential will continue through the primary grades should be conducted. Also, children were rated as socially similar in this study, but future research could explore possible negative effects on children of introducing more mathematics at an earlier age.

This research has important implications for early childhood education practice. Because many American parents and early childhood teachers believe that formal teaching of academics to young children is inappropriate (e.g., Bredekamp, 1990) and that children should not be hurried in their schooling (Elkind, 1981), and because American elementary school teachers "profess little fondness for and modest skill" in math (Stevenson, Lee, Chen, Lummis, et al., 1990), it appears that Caucasian-American young children are exposed to much less math than they are capable of learning. Carpenter, Ansell, Franke, Fennema, and Weisbeck (1993) have recently suggested that more challenging math problems should be introduced to kindergarten and first-grade children. Chinese-American parents systematically "preteach" math to their children at home, thus ensuring that their children have a solid foundation in math. Research-based interventions directed to changing math attitudes and math teaching techniques of the adults who work with young children could be a starting point for improving the math performance of children in the United States.

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Appendix

Chinese-American parents were more likely to say they would encourage their children to participate in math and science teams, orchestra, and tennis in elementary and junior high school, whereas, Caucasian-American parents were more likely to encourage participation in religious classes and organized soccer. No ethnicity differences were found for band, chorus, football, library reading programs, or Girl and Boy Scouts. Sixty-five percent of the Chinese-American children and 10% of the Caucasian-American children were taking private music lessons; 20% of the Chinese-American children and 65% of the Caucasian-American children were enrolled in organized sports.

Chinese-American parents reported that their children had a stronger like of playing with blocks; whereas, Caucasian-American parents reported a stronger like of make-believe play for their children. No ethnicity differences were found for puzzles; climbing, running, jumping; listening to stories; singing, listening to music; painting, coloring, drawing; sports; counting, math activities; or science activities.

Table 1

Sample Demographics

| | Chinese-American | | Caucasian-American | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Age of child | 5.67 | .34 | 5.60 | .32 |
| Number of children in family | 2.21 | .55 | 2.41 | .71 |
| Mother's age | 37.38 | 2.88 | 36.88 | 4.40 |
| Father's age | 39.77 | 3.09 | 39.62 | 4.84 |
| Mother's educational attainment | 16.73 | 1.94 | 17.18 | 1.32 |
| Father's educational attainment | 18.23 | 2.21 | 17.68 | 1.81 |
| Math relevance of parents' careers† | 2.23 | .52 | 1.74 | .51 |
| Hollingshead status scores | 59.33 | 6.81 | 60.78 | 4.63 |
| Months in preschool program | 22.15 | 13.67 | 23.75 | 13.05 |

†Difference is significant, $F(1, 72) = 17.66$, $p < .0001$.

Table 2

Ethnicity Differences in Children's Measures◊

| Measure | Chinese-American | | Caucasian-American | | |
|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | F |
| TEMA-II Math raw score | 35.33 | 9.93 | 27.35 | 11.27 | 6.51* |
| Geometric puzzle solution time (min.) | 4.09 | 3.64 | 6.47 | 5.24 | N.S. |
| Visual discrimination raw score | 16.43 | 1.74 | 15.20 | 2.70 | N.S. |
| Maturity of number formation‡ | 3.63 | 0.84 | 2.00 | 0.76 | 31.80*** |
| PPVT raw score† | 61.39 | 17.18 | 81.55 | 13.46 | 36.78*** |
| Maturity of handwritten name‡ | 3.55 | 0.53 | 2.66 | 0.77 | 12.24*** |

Notes. ◊Math relevance of parents' careers was entered as a covariate.
†PPVT was administered in English. Most of the Chinese-American children speak Chinese in their homes.
‡Ratings of two blind raters averaged together.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3

Ethnicity Differences in Parents' Ratings of Importance of Personality Characteristics

| Personality Characteristic | Chinese-American Mean | Caucasian-American Mean | F |
|---|---|---|---|
| Chinese Scale | | | |
| Persistence | 4.63 | 4.55 | N.S. |
| Obedience | 3.94 | 3.83 | N.S. |
| Politeness | 4.51 | 4.27 | 4.96* |
| Calmness | 4.11 | 3.45 | 16.64*** |
| Neatness | 4.02 | 3.43 | 33.54*** |
| Concentration | 4.64 | 4.39 | 8.27** |
| Precision | 3.92 | 3.56 | 4.78* |
| Respect | 4.49 | 4.51 | N.S. |
| American Scale | | | |
| Self-confidence | 4.81 | 4.91 | N.S. |
| Curiosity | 4.50 | 4.59 | N.S. |
| Sociability | 4.22 | 4.29 | N.S. |
| Creativity | 4.59 | 4.51 | N.S. |
| Assertiveness | 4.14 | 3.95 | N.S. |
| Independence | 4.32 | 4.52 | 3.55† |

Notes. A 5-point scale, with 1 representing "not important" and 5 representing "very important," was used to rate each personality characteristic.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 4

Ethnicity Differences in Responses to Education Beliefs Scale

| Item | Chinese-American Mean | Caucasian-American Mean | F |
|---|---|---|---|
| Chinese Beliefs Scale | | | |
| A child's academic performance is a reflection of the effort invested by her/his family. | 4.13 | 3.96 | N.S. |
| The child's teacher is an important determinant of the child's academic achievement. | 3.96 | 3.81 | N.S. |
| The improvement of oneself through education is the first step toward improvement of society. | 4.39 | 4.53 | N.S. |
| A child who keeps trying will eventually succeed. | 4.30 | 3.99 | 5.46* |
| Parental influence is an important determinant of a child's academic achievement. | 4.38 | 4.43 | N.S. |
| A large part of a child's academic performance is respect for adults who desire for him/her to do well. | 3.56 | 3.36 | N.S. |
| All children, unless they are mentally retarded, can perform reasonably well on all academic subjects. | 3.82 | 1.41 | 30.81**** |
| Learning skills in school is a serious business, deserving long stretches of time where the child works to acquire a skill. | 3.88 | 3.00 | 22.98**** |
| American Beliefs | | | |
| It is important that teachers make school fun so that children will learn faster and better. | 4.37 | 3.58 | 30.38**** |
| What abilities a child is born with makes more of a difference in school performance than how hard he/she tries to learn. | 2.63 | 1.98 | 17.60*** |
| Whether a child enjoys a subject makes a difference in how well she/he performs in that subject at school. | 4.23 | 4.08 | N.S. |
| If a child doesn't like a particular subject, it is of no use to have them keep working on it. | 2.19 | 1.58 | 15.91**** |
| During the preschool years, it is more important to develop a child's self-esteem than to develop competence in specific academic areas. | 4.15 | 4.51 | 4.40* |

Table 4--Continued

| Item | Chinese-American Mean | Caucasian-American Mean | F |
|---|---|---|---|
| Some children are born with an ability to do well in a particular subject, whereas others will not do well, no matter how hard they try. | 2.90 | 2.64 | N.S. |
| Showing a young child how to do a task tends to destroy her/his creativity. | 2.34 | 1.53 | 10.17** |
| A child's academic success is due mainly to his/her innate ability (what he/she is born with). | 3.12 | 3.23 | N.S. |
| Early childhood is the time to foster creativity; skills are more appropriately developed in elementary school. | 3.66 | 3.36 | N.S. |

Notes. A 5-point scale, with 1 representing not at all and 5 representing very strongly, was used to respond to the beliefs about education..
*$p < .05$. **$p < .01$. ***$p < .001$. ****$p < .0001$.

Table 5. Ethnicity Differences in Parents' Practices

| Measure | Chinese-American | | Caucasian-American | | |
|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | F |
| Child's daily scheduled time (hrs.) | 7.89 | 1.70 | 6.30 | 1.56 | 12.03*** |
| Child's daily time on homework/practice (min.) | 55.56 | 43.41 | 5.92 | 13.16 | 47.75**** |
| Child's daily time watching TV (hrs.) | 1.35 | 0.86 | 1.87 | 1.01 | 5.55* |
| Directness of parents' math facilitation† | 2.19 | 0.72 | 1.67 | 0.48 | 17.75**** |

Notes. †Rated on a 3-point scale with 1 representing indirect, informal methods and 3 representing direct, formal methods.
*$p < .05$. ***$p < .001$. ****$p < .0001$.

Table 6

Prediction of Child Math Outcomes from Ethnicity, Parent Attitudes, and Parent Practices‡

| Child Outcome Measures | Predictors | $R^2$ Change | $R^2$ | Beta |
|---|---|---|---|---|
| Raw Math Score-TEMA-2 | Ethnicity | .08** | .11 | -.25 |
| | Parents' child-specific attitudes | .21*** | .33 | .41 |
| | Directive math teaching | .06* | .40 | .25 |
| | Percentage of play in preschool | .04* | .43 | -.21 |
| Maturity of Numeral Formation | Ethnicity | .27*** | .35 | -.49 |
| | Parents' child-specific attitudes | .10** | .47 | .24 |
| | Directive math teaching | .06** | .54 | .27 |
| | Percentage of play in preschool | .03* | .57 | -.20 |
| Visual Discrimination Score | Parents' child-specific attitudes | .10** | .26 | .31 |
| Motor Coordination | Ethnicity | .25**** | .32 | -.49 |
| | Chinese personality characteristics | .02 | .37 | -.25 |
| | Parents' child-specific attitudes | .12**** | .49 | .28 |
| | Directive math teaching | .06** | .55 | .27 |

Notes. Listed are those variables meeting a stepwise inclusion criterion of $p < .05$. Betas are from the final regression equation; $R^2$ change and $R^2$s are from the step at which the particular variable entered the equation.
‡ Math relevance of parents' careers was entered first as a covariate.
*$p < .05$. **$p < .01$. ***$p < .001$. ****$p < .0001$.