Gender differences in mathematical achievement development: A family psychobiosocial model

Mei-Shiu Chiu (meishiuchiu@gmail.com)
National Chengchi University https://orcid.org/0000-0002-2929-5151
Bo-Jen Chen
The University of Edinburgh

Research Article

Keywords: cognitive development, gender difference, mathematical achievement, psychobiosocial model, socioeconomic status

Posted Date: May 6th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-387693/v1

Abstract

This study proposes a family psychobiosocial model on gender differences in cognitive development. Specifically, the aim is to investigate how family biological, socioeconomic, and psychological factors predict child mathematics achievement (MAch) development. The data was obtained from the Millennium Cohort Study. Children's pattern construction scores collected at ages 5 and 7 years worked as MAch (n = 18,497). The predictors were family data collected when the children were 9 months. The results of path analyses for all students indicate that all three factors in the family psychobiosocial model play some roles in children's MAch development. Analyses for the female and male students separately reveal that girls' positive MAch development was significantly predicted by four psychobiosocial factors (fewer mother in-pregnancy alcohol intakes, more family income, higher mother education levels, and more mother cognitive stimulation); boys' MAch development is predicted by only one factor (higher mother education levels). The results support the psychobiosocial model as a whole. Family psychobiosocial factors, especially social factors, impact children's cognitive development more for females than for males.

Highlights

- Factors for mathematics achievement are SES, cognitive stimulation, and low in-pregnancy alcohol intake.
- Family psychobiosocial factors impact girls' mathematics achievement more than boys'.
- Social factors impact girls' mathematics achievements more than boys'.

Various biological and cultural issues set the boundaries for individual development, with family factors playing key roles (McCulloch & Joshi, 2001). Children's cognitive developments may be informed by parental biological, social, and psychological factors in their early family experiences.

Mathematical achievement (MAch) or ability is one of the major indicators or representations of children's cognitive abilities. Child development in MAch may be properly understood by investigating the direct or proximal bio-ecological processes that impact children's early lives. With a large spectrum of contributing factors, influences of family's lives and parental behaviors start since children's birth (Bronfenbrenner, 1986, 1994; Bronfenbrenner & Ceci, 1994).

The relative importance of the diverse biology, social, and psychological factors of families for child cognitive or MAch development has rarely been addressed in previous academic research. Longitudinal data are especially valuable in examining this issue. The purpose of this study, therefore, is to use longitudinal data to identify relatively significant family biological, social, and psychological factors relating to child cognitive, MAch development.

Theoretical Basis

Theoretical Statement 1. Family psychobiosocial factors impact children's MAch along time. The *psychobiosocial model* (PM) explains why there are gender differences in cognitive abilities (Halpern, Wai, & Saw, 2005). The PM emerges mainly in response to the two educational phenomena: (a) the persistent underrepresentation of females in science, technology, engineering, and mathematics (STEM) careers and (b) the most (though unstable) lowered female mathematics achievement. For academic interests, the PM compensates the weakness of past research only studying puzzle pieces of elements that influence cognitive achievements or abilities. The PM also urges to place the pieces together in order to see the whole dynamic picture of the elements and their interactions and changes over time.

The PM depicts an individual having initial inputs from biological factors (e.g. genes), followed by psychological factors in the environment, which in turn alter biological factors (Halpern et al., 2005, p. 52). Examples of biological factors include genetic predisposition, hormones secretions, and brain functions. Examples of psychological factors include stereotypes (e.g. males having higher MAch than females), traits (e.g. values, expectancy, and motivation), cognitive processes (e.g. visual-spatial representation), and problem-solving strategies (e.g. novel approaches). The social factors include experiences from learning in the social context or environment. By reviewing the related studies, the PM suggests that most psychobiosocial factors favor boys in MAch.

The PM focuses on children's personal factors in the biological, psychological, and social aspects, with little focus on family factors. For educational purposes, *a family psychobiosocial model (FPM)*, posited in this study, can capture a fuller picture of family factors for children's development. The term 'biopsychosocial' appears to be popularly used especially in medicine, psychiatry (Frazier, 2020), and gender issues (Leavitt et al., 2020), and a reasonable continuum from biology (more natural sciences), psychology, to sociology (more social sciences). This study starts its argument with the PM (Halpern et al., 2005), which aims at addressing the issue of gender differences in STEM achievements (including MAch), similar to the focus of this study. As such, this study uses the term 'psychobiosocial', which is also used in research on sport (Filho, 2020) and on gender differences in clinical psychology (McCarthy, Koman & Cohn, 2018). Both 'biopsychosocial' and 'psychobiosocial' mean the same for this study because the three factors are interwoven in each individual's lifespan though they may be with different degrees of relative significance in different phases.

To examine the FPM, three levels of questions should be raised: (1) Do family psychobiosocial factors impact children's mathematics ability? (2) Are there gender differences in the impact? (3) Because there are three major factors in the PM, the next question is: What is the relative importance of the psychobiosocial factors?

The answer to the first question should be positive because the FPM can be viewed as an extension from the PM. The PM assumes that gender differences in cognitive performance, especially mathematics achievement, can be explained by the three (psychobiosocial) factors.

Theoretical Statement 2. Family psychobiosocial factors impact children's MAch development more for females than for males. A persistent phenomenon in gender difference is that boys have higher variances in achievement than girls, known as the *greater male variability hypothesis* (GMVH) (Chen, Chen, Chang, Lee, & Chen, 2010; Hyde, 2014). The hypothesis have been evident in STEM and language fields in some studies, (Baye & Monseur, 2016; Gray et al., 2019) but only in mathematics and not in languages in others (Pargulski & Reynolds, 2017). Most empirical studies support the hypothesis and only a few studies do not (Chen, 2003; Hyde & Mertz, 2009). As evidenced by recent large-scale international studies, despite inter-cultural gender differences, a general phenomenon is that more boys than girls are top mathematics achievers (Organization for Economic Co-operation and Development, 2014, p. 72) or advanced mathematical problem solvers (Mullis, Martin, Foy, & Hooper, 2016). No cross-cultural studies to date have ever provided evidence to attribute social factors to the GMVH.

In summary, research on the GMVH implies that more diversity of boys' MAch than girls' is due to nature (i.e., sex or gender), not nurture. In terms of data analysis, the GMVH indicates that, compared to girls, boys have more variances in Mach. This means that boys' MAch is less likely to be accounted for by any certain factors other than gender. In this study, family biological and psychological factors cannot be completely separated from family social factors. It is because the three factors interact in the long-term socialized family environment and can be seen as a combined social factor, which is more nurture than nature. As such, the GMVH may successfully apply to the scenario of family psychobiosocial factors predicting MAch. In terms of statistical terms, Theoretical Statement 2 can be evidenced by higher variances or lower portions of the three family psychobiosocial factors combined in predicting MAch for boys than for girls.

Theoretical Statement 3. Social factors account for more MAch for females than for males. The third question: What is the relative importance of the psychobiosocial factors? If addressed in statistical terms, that is: What are the proportions of the variances in mathematics achievement explained by the biological, socioeconomic, and psychological factors, respectively? This question is hard to answer because the three factors become interwoven along time of development. Speculations, however, may be inferred from related studies.

Research indicates that social support may reduce gender differences in MAch. Despite the small male advantages on MAch, recent meta-analysis and cross-cultural studies reveal that more gender-equal societies have fewer gender differences in MAch (Guiso, Monte, Sapienza, & Zingales, 2008), known as the *gender stratification hypothesis* (Else-Quest, Hyde, & Linn, 2010). The findings further support the *gender similarities hypothesis* (Hyde, 2005), which contends that gender differences in MAch are small and subject to social factors. In other words, social factors (e.g., gender-equal society and family socioeconomic status) account for gender differences in MAch. For educational practices, females need more positive social factors for MAch than males.

In summary, the *gender stratification* and *similarities hypotheses* give birth to Theoretical Statement 3: Relatively compared with family biological and psychological factors, family social factors serve as a more salient predictive factor for children MAch in their later lives. The claim arises from past research evidence that gender-equal society and societal support would reduce gender differences in MAch. In statistical terms, regression and related methods (e.g., path analysis) can examine this claim because the standardized solutions for each factor indicate its capability in predicting outcome variables (MAch in this study), controlling for the other predictive factors.

Roles of Family Psychobiosocial Factors in MAch

To examine the FPM, the best is to use a longitudinal dataset that includes valid, standardized, and repeatedly measured outcomes on child mathematical achievements and predictors on family biological, social, and psychological factors. The Millennium Cohort Study (MCS) provided high-quality and related measures to meet the need. For educational purposes, we (the authors with expertise in educational psychology and medicine) decided to focus on educationally meaningful, changeable family measures (e.g. maternal behaviors) that may fit the three theoretical statements of the FPM as suggested by the following literature reviewed.

Maternal Biological Factors. The family biological sub-factors used in this study focused on maternal ones, including maternal during-pregnancy and early-childhood alcohol intake and depression. Past literature suggests that the three sub-factors have a negative role in children's MAch.

During-pregnancy and early-childhood maternal alcohol intake. The timing of maternal alcohol intake is a factor in child development though with some uncertainty. Light drinking (more than one or two units of alcohol per week) during pregnancy does not relate to mathematical, spatial, and behavioral development for children at age 7 years (Kelly et al., 2013). A later study, however, finds that week-12 gestation and pre-pregnancy even with 2 units per week alcohol intake (an allowed intake suggested by the Department of Health guidance, England) both have detrimental effects, leading to preterm birth or low-birth-weight babies (Nykjaer et al., 2014). A meta-analysis study comparing the effects of different quantities of prenatal alcohol intake on child cognitive development finds that binge alcohol intake has consistent negative effects on child cognition and there is no known safe amount of alcohol intake during pregnancy (Flak et al., 2014).

The equivocal results about the effects of during-pregnancy maternal alcohol intake suggest a further investigation using a different model or methodology. There appears to be no study to date focusing on the effect of maternal alcohol intake during their children's early childhood. The MCS provides both during-pregnancy and early-childhood maternal alcohol intake data, which are reasonably effective predictors for children's cognitive abilities, including MAch, which is the outcome measure of this study. The juxtaposition of during-pregnancy and early-childhood maternal alcohol intake can facilitate our understanding of the relative importance of "biological" and "behavioral" alcohol intake in influencing children's MAch.

Maternal depression. Parental depression relates to increased physical discipline use, reduced parental warmth, lower child mathematics achievements, and undesirable approaches to learning (Bodovski & Youn, 2010). Mother prenatal depression may have a slightly negative effect on child IQ at age 8 years, but mother postnatal depression does not have an effect on child IQ (Evans et al., 2012). Maternal mental health when children at 0–30 months of age relate to the offspring's educational and occupational attainments at 30 years of age, although the relationship is mediated by the offspring's academic competence and mental health at 18 years of age (Slominski, Sameroff, Rosenblum, & Kasser, 2011). Despite the diverse study contexts, previous research stably evidences the negative effect of maternal depression on children's cognitive development.

Family Social Factors. Family social or socioeconomic status (SES) has long been a concern of educators. SES disadvantages are stable factors for students' low cognitive achievements and high behavioral problems from early childhood to early adolescence (Rees, 2018). Three indicators of family SES selected in this study are family income, maternal education, and household minority language use, which are essential family SES factors for children's cognitive, mathematics achievement development, as indicated by related studies as follows.

Family income. Research on economics generally finds that family income is a strong predictor of children's cognitive development. For example, Dickerson and Popli (2016) analyzed the MCS data and found that family poverty was a persistent, negative predictor of cognitive development for children of ages from 9 months to 7 years even after controlling for family background variables and parental investment (e.g. maternal education). Similar findings were found for U.S. and Canadian children of ages 2 to 5 years (Duncan, Morris, & Rodrigues, 2011).

Maternal education. Maternal education is viewed as a major indicator of cultural capital or family investment. Even after controlling family income, maternal education remains a positive predictor of cognitive, mathematics achievement development for early-year children in the U.K. (Dickerson & Popli, 2016). Parental education plays a more significant role in the initial and growth of mathematics achievement of adolescents than family income in Taiwan (Chiu, 2016). It is therefore interesting to place family income and maternal education in a model to assess their relative impacts on children's MAch.

Household minority language use. Immigration or ethnic minority tend to be disadvantaged cultural capital for children's cognitive development. The main reason may be non-mainstream household language use, which detriment children's opportunity to learn especially in the early years. A large-scale cross-cultural study indicates that immigrant students at age 15–16 tend to have lower mathematical and science problem-solving skills than non-immigrant students, which may be affected by multiple conditions related to immigration such as age, age of arrival, gender, language use, and family SES (Martin, Liem, Mok, & Xu, 2012). Secondary students in Taiwan speaking ethnic minority languages at home tend to have a low initial and negative growth in mathematics achievement (Chiu, 2016). However, research finds that the disadvantage of ethnic minorities may gradually diminish. For example, students with Bangladeshi heritage in the U.K. have higher progress from Key Stage 2 (ages 8–11) to KS4 (ages 14–16) than their counterparts (Sammons et al., 2014).

Maternal Psychological Factors. Parental psychological behaviors (e.g. playing shape games) impact their children's mathematical achievements (Chiu, 2018). There appear to be no studies to date focusing on parental psychological behaviors occurring during very early childhood (e.g. children at age 9 months), though when parental behaviors may not be able to focus on mathematics. This study focused on maternal psychological behaviors because mothers are the major caregivers in very early childhood for most societies. An exploratory factor analysis of the MCS data identified three potential maternal psychological behaviors (cognitive stimulation, positive affect, and secure attachment), which may impact children's cognitive developments, as suggested by the following literature.

Maternal cognitive stimulation or regulation. Maternal cognitive stimulation may positively impact children's later mathematics achievement development. It is because numeracy activities are a kind of cognitive stimulation and research had indicated that parental numeracy activities (either formal or informal ones) have a positive impact on children's mathematical achievements (Dunst, Hamby, Wilkie, & Dunst, 2017; Skwarchuk et al.'s (2014)). A meta-analysis indicates that the most effective parental involvement programs normally include some cognitive stimulation activities for their children (e.g., shared reading; Jeynes, 2012).

Maternal positive affect or emotion**.** As suggested by the positive-affect-to-success (PAS) hypothesis, the personal positive affect will generate successful outcomes (e.g. mathematical achievement; Lyubomirsky, King, & Diener, 2005). Inferred from the personal PAS hypothesis to form a parental PAS (PPAS) hypothesis: positive parental affect may positively impact children's MAch development, which is supported by parenting studies. For example, parental support and democratic control positively relate to adolescent academic performance and negatively relate to the onset of smoking (Morin, Rodriguez, Fallu, Maïano, & Janosz, 2012). Parental control behavior over child academic performance plays a negative role in 3rd and 4th graders' school achievements in German and mathematics in Germany (Su, Doerr, Spinath, Johnson, & Shi, 2015).

The underlying mechanism of the PPAS may be that parental adverse control behavior has a negative effect on child performance goals (aiming for high achievement), which may also be additionally mediated by child negative emotions such as anxiety while parental involvement behavior plays a direct positive role in child mastery goals (aiming to learn and improve) (Duchesne & Ratelle, 2010). Further, parental emotional sensitivity can protect children from adverse experiences, especially for disadvantaged students (Oxford & Lee, 2011). Insensitive parenting may play a role in student social withdrawal in primary school (Booth-LaForce & Oxford, 2008). Dysfunctional parenting and negative family climate relate to child depression at age 7 (Castelao & Kröner-Herwig, 2014). All these studies suggest a positive effect of parental positive affective or emotional states on children's cognitive and behavioral development.

Maternal secure attachment. Secure attachment addresses the desirable quality of close relationships. There appears to be no study to date focusing on mothers' secure attachment reports. However, studies on performers' secure attachment suggest that maternal secure attachments will positively relate to children's MAch. For example, child secure attachment measured with the traditional attachment task (i.e. standard strange situation) at ages 24 and 36 months (though not at 15 months) relates to child academic achievement and IQ test results in the 3rd and 4th grades (West, Mathews, & Kerns, 2013). Child secure attachment responses to mother-child stories relate to some child coping behaviors reported by mothers for children at age 10–11 (Brumariu, Kerns, & Seibert, 2012). The mechanism as suggested by adult research may be that (employees') self-report secure attachment (with their supervisors) leads to positive performance through trust (Simmons, Gooty, Nelson, & Little, 2009).

The Present Study

The *psychobiosocial model (PM)* and *family PM (FPM)* suggests family biological, socioeconomic, and psychological factors predict children's cognitive development, especially in MAch. In addition, the prediction patterns are different between genders. We selected variables from the MCS with support from related literature to examine the three theoretical statements of the FPM (cf. Theoretical Basis).

In terms of statistical examinations, the research framework can be presented in Figure 1. This study aims to examine the following three hypotheses for the three theoretical statements, respectively.

Hypothesis 1. Family biological, socioeconomic, and psychological factors at early childhood predict children's MAch development at later childhood. (Hypothesis 1 is for Theoretical Statement 1 excluding gender.)

Hypothesis 2. The prediction pattern described in Hypothesis 1 as a whole fits data for girls better than for boys. (Theoretical Statement 2; Figure 1)

Hypothesis 3. In the prediction pattern described in Hypothesis 1, socioeconomic factors predict mathematics achievement better for females than for males. (Theoretical Statement 3; Figure 1)

Hypotheses 2-3 examine whether gender plays a moderating role in the prediction pattern described in Hypothesis 1.

Method

Data Source and Sample

The present study used cohort data from the MCS compiled by the U.K. Data Service. The MCS is a longitudinal study collecting children's family and personal data starting from their birth in 2000 or 2001. The first sweep of data (MCS1) was collected when children at age 9 months (family n = 18,552) in 2001, with additional families (n = 692) joining the second sweep data collection in 2004 (i.e. MCS2). The families and their children were continuously surveyed or followed up when the cohort members (children) were at ages 3 (MCS2), 5 (MCS3), 7 (MCS4), 11 (MCS5), 14 (MCS6), and 17 (MCS7) years old until 2018, when this paper was written. A common identifier ('MCSID') was used to merge five MCS datasets;

(1) The longitudinal family dataset for sampling weights;

(2) The parent interview dataset (for biological and psychological measures) collected at MC1;

(3) The family derived dataset (for social measures) collected at MCS1;

(4) The child cognitive assessment dataset (as Outcome1) collected at MCS3;

(5) The child cognitive assessment dataset (as Outcome2) collected at MCS4.

The two datasets of children's cognitive assessment (4 and 5) were used because "BAS Pattern construction" was the only MCS cognitive measure that could represent the construct of children's MAch and were collected using the same assessment tool, which could justify longitudinal development. The five datasets were merged by the following steps.

(1) Select only the families joining MCS1 in the longitudinal family dataset (n = 18,552). The parent interview dataset and family-derived dataset collected MCS1 have the same sample size (n = 18,552). The new families joining at MCS2 were not included because they did not have MCS1 parent interview data.

(2) Select only the data of the first child in one family from the two assessment datasets at MCS3 (n = 15,246) and MCS4 (n = 13,857), which let each child from a different family. The Step (1) family dataset was used as the base to merge all the other four datasets. In other words, the sample size remained as 18,552 cases (observations, children, or families) until this step.

(3) Select only the cases that their natural mothers were interviewed. This procedure would reduce the bias produced by variations in respondents though with a slightly reduced sample size (n = 18,497, including 8,999 girls and 9,498 boys) for the later analysis.

Measures

Two dependent variables were used to represent child MAch. The variables were children's spatial ability assessment results over two sweeps at ages 5 and 7 years (i.e. MCS3 and MCS4). Nine independent variables were selected to represent the constructs of family biological, socioeconomic, and psychological factors, each factor containing three variables, which were collected at MCS1 (i.e. children age 9 months). The supplementary file Section A presents all the measures' names, labels, values, data preparation procedures, and located dataset names with their line numbers in the dataset.

Child mathematical achievement. The MCS used several standardized tests to examine children's cognitive abilities or achievement from MCS2 to MCS5. The only MAch-related tests administered more than once were the British Ability Scales (BAS) pattern construction (BAS-PC) at MCS3 (i.e. MAch5 in this study) and MCS4 (MAch7). We, therefore, used these two variables to represent MAch development. The BAS-PC test asked children to "put flat squares or solid cubes with black and yellow patterns on each side" to construct a geometrical design; the BAS-PC scores contained children's accuracy and speed in completing the tasks and represented children's achievement on spatial awareness (including dexterity and coordination) and traits of perseverance and determination (Hansen, 2014, p. 64).

We chose to use the ability scores of BAS-PC, not raw scores or T-scores because this study focused on MAch development. The ability scores could represent the construct of longitudinal MAch development from early to later stages (i.e. from MCS3 to MCS4). The raw scores did not adjust for different item administration conditions and thus with little meaning; the T-scores were adjusted for children's age and would not contain the differences in variances at different ages, which therefore were not suitable for comparison between ages (Hansen, 2014, pp. 66-68).

Family biological factors. Three biological factors were obtained from the MCS1 parental interview dataset. All the variables were mother self-report data, including (bio1) mother alcohol intake during pregnancy, (bio2) mother alcohol intake at MCS1, and (bio3) mother depression at MCS1. The bio3 was the mean score of mother reports on nine items such as "tired most of time" and "often miserable or depressed" on a 2-point scale because exploratory factor analysis (EFA) results showing that the nine items could be viewed as one factor.

Family socioeconomic factors. Three social or socioeconomic-status (SES) factors were obtained from the MCS1 derived family dataset. The three factors were weekly net family income, maternal highest education level, and home foreign language use.

Family psychological factors. Psychological factors were obtained by using EFA on the 11 items regarding mother–baby interaction. The EFA resulted in three factors:

(a) mother cognitive stimulation, including four items: the importance of talking, cuddling, stimulation for development, and regular sleeping and eating, all on a 5-point Likert scale (1 = strongly agree to 5 = strongly disagree),

(b) mother positive affect, including four items: (1) feelings of annoyance or irritation (1 = almost all the time to 6= never), (2) feeling when caring (1 = incompetent and lack confidence to 4 = very competent and confident), (3) patience (1 = very impatient to 4 = extremely patient), and (4) feeling like giving up due to baby (1 = resent a lot to 4 = don't resent at all), and

(c) mother secure attachment, including two items: thinking about the baby when apart (1 = all time to 6 = never) and feeling when leaving baby (1 = sad; 5 = relieved).

The items were recorded to let higher scores represent higher degrees in the meaning of the factor names. For factors with items using different Likert scales (i.e. (b) and (c)), their items were scaled into standardized scores before the items of the factor were calculated to form mean scores.

Data Analysis

Data analysis was performed using R version 3.5.1 (R Core Team, http://www.R-project.org/) and RStudio version 1.1.456 (https://www.rstudio.com/). The EFA was performed using the nFactors package to determine the number of factors to extract and using the psych and GPArotation packages to run the EFA with the oblimin rotation and principal factor method.

Sampling weight and correlation. The sample weights for all countries of the UK across waves ("WEIGHT2") provided in the longitudinal family dataset were used in order to compensate the sampling design of unequal selection probabilities (Hansen, 2014). Although the MCS user guide suggested using weights taking account of attrition and non-response (e.g. avowt2 for MCS1 and dovwt2 for MCS4), this study used multiple waves of data altogether, and thus overall weight ("WEIGHT2") was used in combination with other sample design variables, including stratification ("PTTYPE2"), clustering ("SPTN00"), and finite population correction factor ("NH2") variables (Jones & Ketende, 2010, pp. 7-8). The major R syntax for setting the complex-sample plan and generating the correlation matrix is presented in the Supplementary File Section B.

Given the large sample size of this study, significant correlations were easily obtained even with small absolute correlation values. As such, this study used the criteria of the absolute correlation values: $r < 0.350$ as low, $0.360 \leq r \geq 0.670$ as moderate, and $r > 0.680$ as high relationships, to assess the degrees of relationships between the measures (Taylor, 1990).

Path analysis. The hypothesis was examined by path analysis, the regression analysis part of structural equation modeling (SEM). The model set that the six factors predict MAch at ages 5 and 7 years (MAch5 and MAch7), respectively. In addition, MAch7 regressed on MAch5, which assumed that previous mathematics abilities would at least partially address MAch7. The sample weights also activated. The R syntax is presented in the Supplementary File Section C.

The SEM model fit to empirical data was determined by the following four indices. The root mean square error of approximation (RMSEA), a typically used criterion for SEM, should be below 0.50 or 0.80. Recently, both RMSEA and standardized root mean square residual (SRMR) were used for comparing competing models with smaller RMSEA and SRMR representing better model fit (Chiu, 2020; Hair, Black, Babin, & Anderson, 2010). The comparative fit index (CFI) and the Tucker–Lewis index (TLI) should be above 0.900. Larger CFI and TLI represented better model fit. Although a non-significant chi-square (χ^2) was a criterion for model fit, χ^2 value may easily become significant if there is a large sample size, as this study. As such, this study would not use χ^2 value as a criterion for judging model fit (Bollen & Long, 1993) but used RMSEA, SRMR, CFI, and TLI.

Results

The correlations between the factors are presented in Table 1. The largest absolute value of the correlations was a moderate one (0.417) between family income (ses1) and mother education (ses2). All the other correlations were small (i.e. below 0.360; Taylor, 1990). The results implied that the sub-factors were different constructs and the results of the sub-factors could be compared. In addition, the regression analysis result would have few multicollinearity problems in regression analyses because all the correlations between the predictors were smaller than 0.900 (Hair, Black, Babin, Anderson, & Tatham, 2006). This section focuses on the results of examining the two hypotheses.

Hypothesis 1: Model fit for All students

Hypothesis 1 was examined by using single-group path analysis; that is, all the students were viewed as a whole in the path analysis. The model fitted the empirical data properly as indicated by the fit indices of Model 1 in Table 2.

Two social factors (ses1 and ses2) positively predicted both MAch5 and MAch7 significantly. Only one biological factor (bio1) negatively predicted MAch5 (Model 1 results in Table 3). The six factors accounted for only 6.5% of the total variance of MAch5. MAch5 moderately predicted MAch7 (0.567). The six factors and MAch5 accounted for 37.6% of MAch7. The results implied that later MAch was largely determined by previous MAch.

In summary, Hypothesis 1 is supported in terms of model fit (Model 1 in Table 2). However, only two social factors stably predicted both MAch5 and MAch7. One biological factor and one psychological factor predicted MAch5 only, not MAch7. The result generally concurred with the *family psychobiosocial model (FPM)*'s Theoretical Statement 1.

Hypothesis 2: Gender differences in the FPM's fit to data

Firstly, Hypothesis 2 was examined by using multigroup SEM to compare model parameter estimates between boys and girls. Model 2 set equal regression coefficients, which could be supported because the fit indices were all desirable (Table 2). Model 3, which set equal regressions, intercepts, and residuals across genders, however, was not so desirable due to a below 0.900 TLI value (= 0.894). The results implied that boys and girls may have different intercept and residual estimates.

Secondly, single group SEM was used to examine Hypothesis 2 for boys and girls separately. Model 4 was for girls and with desirable fit indices. However, Model 5 for boys was not desirable with RMSEA (= 0.089) larger than 0.080 and TLI (=0.822) smaller than 0.900. This result partially concurred with FPM's Theoretical Statement 2.

The FPM's Theoretical Statement 2 was saliently supported by R^2 values. Girls' MAch5 (10.8%; Model 4 in Table 3) were more explained by the six factors than boys' (5.9%; Model 5). Further, girls' MAch7 (40.4%) were more explained by both the six factors and MAch5 than boys' (37.6%). As indicated in the literature review, the FPM's Theoretical Statement 2 can be inferred by the *greater male variability hypothesis* (Hyde, 2014).

Hypothesis 3: Gender Differences in Path Parameter Estimates

The examination of Hypothesis 3 also used single group SEM for boys and girls separately. The path analysis results focused on comparing the path parameter estimates between Model 4 and Model 5 (Table 3). The significance patterns of regression coefficients for girls almost mirrored those for the sample of all students (Model 1): two social factors stably predicted both MAch5 and MAch7. One biological and psychological factor predicted MAch5 only, not MAch7.

For boys, there was only one significant regression coefficient; that is, ses2 (mother education) positively predicted MAch5. The result generally supported the FPM's Theoretical Statement 3.

Discussion

The discussion section focuses on addressing the three theoretical statements of the FPM using the results obtained from examining Hypotheses 1-2.

Theoretical Statement 1

The results from a single-group SEM for the sample of all students generally support the FPM's Theoretical Statement 1. The most salient predictors are ses1 (family income) and ses2 (mother education), predicting both MAch5 and MAch7. Bio1 (mother in-pregnancy alcohol intake) and psy1 (mother cognitive stimulation) only predict MAch5.

Positive factor: SES. SES plays the most role in children's mathematical ability development among the nine psychobiosocial indicators. However, only the SES indicators of family income and mother education play a significant role, not home foreign language.

Family income has persistent, positive effects on child MAch development. The result is consistent with Duncan et al.'s (2011) results for pre-school children. The role of family income, however, reduces after age 7, a result consistent with the finding that family income could not substantially predict children's subjective well-being at 11 years old (Rees, 2018).

The finding of a non-significant role of home foreign language use at home is consistent with Sammons et al.'s (2014) finding. The result suggests that mixed-language, cultural backgrounds may not be a disadvantage for children's long-term academic and psychosocial development. Some longitudinal studies, however, indicate a negative role of immigration or ethnic minority status (Chiu, 2016; Martin et al., 2012).

Weak, positive factor: Mother cognitive stimulation. Mother cognitive stimulation during mother-baby interaction plays only a weak role on MAch at the age of five years. The results are consistent with research findings that programs focusing on parent–child cognitive interaction generate positive child learning outcomes (Jeynes, 2012).

Both mother positive affect and secure attachment fail to play a role. The results are not consistent with some related findings. Past findings indicate that sensitive, supportive parenting with a positive baby–parent emotional interaction relates to positive child cognitive and behavioral abilities (Castelao & Kröner-Herwig, 2014; Morin et al., 2012; Oxford & Lee, 2011). The inconsistent finding of this study compared with relevant past research may be due to the use of mother self-reported positive affect for children at 9 months of age as a measure. In this study, self-reporting of too much confidence, patience, and acceptance in caring for children may reveal that mothers actually lack sufficient involvement in children's learning (Duchesne & Ratelle, 2010) due to over-confidence and some biological and family reasons. Future research needs to consider the meanings or validity of the diverse positive affect measures.

The relationships between child abilities and secure attachment are unstable for different attachment measures (Brumariu et al., 2012). Another reason may be past research focused on earlier years (West et al., 2013) and this study focuses on later development in late primary school.

Weak, negative factor: In-pregnancy (prenatal) alcohol intake. The present findings emphasizing the negative longitudinal role of prenatal alcohol intake (bio1) is consistent with most related findings obtained using maternal alcohol intake "during pregnancy" as the factor (Flak et al., 2014). Nykjaer et al.'s (2014) study focuses on both pre-pregnancy and in-pregnancy alcohol intake but only on their roles in infant development. This finding adds to the literature that in-pregnancy alcohol intake has persistent roles in child development even at age 5, but not age 7 years.

The new findings, however, need to be examined further by future research and by considering related psychosocial factors. The results also have implications for policy makers to educate the public to reduce alcohol intake during pregnancy by emphasizing the prolonged negative role of in-pregnancy alcohol intake in children's mathematics achievement.

Mother depression (bio3) fails to play a role. Mother self-reported depression negatively relates to later child cognitive or psychosocial development. The result is consistent with the findings of most studies (Bodovski & Youn, 2010; Slominski et al., 2011; Evans et al., 2012),

Theoretical Statement 2

Theoretical Statement 2 insists that family psychobiosocial factors impact children's mathematics achievement development more for females than for males. This study supports Theoretical Statement 2 in terms of higher proportions of the outcome explained by the model (R squared, or lower variances) and more significant path coefficients for girls than boys (Table 3).

Theoretical Statement 2 is an extension of the *greater male variability hypothesis* (GMVH) (Chen, Chen, Chang, Lee, & Chen, 2010; Hyde, 2014). The GMVH is especially evidenced in STEM fields (Baye & Monseur, 2016; Gray et al., 2019Pargulski & Reynolds, 2017).

This study may be the first to attribute social factors to the greater male variability hypothesis. The family psychobiosocial model (FPM) actually combines three factors but place greater emphasis on social factors, as evidenced by more significant path coefficients for girls than boys.

Theoretical Statement 3

Theoretical Statement 3 states that social factors account for more mathematics achievement for females than for males. This study supports Theoretical Statement 3. It is because girls have both family income (ses1) and mother education (ses2) impacting mathematics achievements when they are 5 and 7 years old. However, boys only have mother education (ses2) impacting when they are 5 years old.

Theoretical Statement 3 is based on the *gender stratification hypothesis* (Else-Quest, Hyde, & Linn, 2010) and *gender similarities hypothesis* (Hyde, 2005). This study extends to the focus of the two hypotheses on social factors in determining gender differences in mathematics achievement.

Conclusion

Contributions to knowledge. This study posits a family psychobiosocial model (FPM) with three specific theoretical statements. The results of the analysis on a longitudinal dataset from a specific culture generally support the model with related three theoretical statements. This study finds three effective family factors for children's MAch development: high SES, high mother cognitive stimulation, and low in-pregnancy alcohol intake, in descending order. The FPM as a whole is more salient for girls than for boys. The predictive capacity of family social factors for MAch is relatively stronger than that of family biological and psychological factors, which is more in the girls' population. All these appear to be new in knowledge, yet with reference to past related research and hypotheses.

Contribution To Education Policy

Two findings of this study may attract attention from policymakers: (1) three effective family factors for children's MAch development: high SES, high mother cognitive stimulation, and low in-pregnancy alcohol intake; (2) the influence of social factors in MAch development especially for girls. Educational, health, and social policymakers may advertise this knowledge to the public and implement related programs and measures such as educating parenting skills of cognitive stimulation, supporting low SES children' early learning, and enriching girls' capacity and interest in STEM by social support (e.g. females role models in teaching materials and social media).

Limitations And Suggestions For Future Research

This study focuses on the direct effects of early family psychobiosocial factors on later child MAch. Future research needs to consider the interactive mechanisms among the factors and their gender differences. Next, fathers' contribution to the family is less considered than mothers in this study. For example, this study uses maternal educational levels only. The emphasis on maternal factors also ignores a complex scenario that higher mother educational levels link to more chances of mothers having jobs, fathers involving in parenting, and higher family income. This ignorance may increase bias in this ongoing gender-equal matter. Future research can focus on the roles of both mothers and fathers using a cultural and ecological approach. Further, this study does not address schooling factors in children's MAch. School teaching plays role in children's MAch, which is beyond the scope of the posited FPM in this study. It is worth incorporating schooling factors into the PM in the future. Finally, future research needs to examine the model using datasets from different samples and cultures to validate the findings obtained in this study.

Declarations

Acknowledgements:

This work was supported by the Ministry of Science and Technology, Taiwan (MOST 109-2511-H-004 -001). The funder only provides financial support and does not substantially influence the entire research process, from study design to submission. The authors are fully responsible for the content of the paper.

Declaration of Conflicting Interests

There are no potential conflicts of interests with respect to the authorship and/or publication of this article.

References

Baye, A., & Monseur, C. (2016). Gender differences in variability and extreme scores in an international context. *Large-Scale Assessments in Education, 4*(1), 1-16. https://doi.org/10.1186/s40536-015-0015-x

Bodovski, K., & Youn, M. J. (2010). Love, discipline and elementary school achievement: The role of family emotional climate. *Social Science Research, 39,* 585-595. https://doi.org/10.1016/j.ssresearch.2010.03.008

Bollen, K. A. & Long, J. S. (1993). *Testing structural equation models*. Newbury Park, CA: Sage.

Booth-LaForce, C., & Oxford, M.L. (2008). Trajectories of social withdrawal from Grades 1 to 6: Prediction from early parenting, attachment, and temperament. *Developmental Psychology, 44*, 1298-1313. https://doi.org/10.1037/a0012954

Bronfenbrenner, U. (1986). Ecology of the family as a context for human development: Research perspectives. *Developmental Psychology*, *22*, 723–742. https://doi.org/10.1037/0012-1649.22.6.723

Bronfenbrenner, U. (1994). Ecological models of human development. *International Encyclopedia of Education*, *3*(2), 37-43.

Bronfenbrenner, U., & Ceci, S. J. (1994). Nature-nurture reconceptualized in developmental perspective: A bioecological model. *Psychological Review*, *101*, 568–586. https://doi.org/10.1037/0033-295X.101.4.568

Brumariu, L. E., Kerns, K. A., & Seibert, A. (2012). Mother–child attachment, emotion regulation, and anxiety symptoms in middle childhood. *Personal Relationships, 19*, 569-585. https://doi.org/10.1111/j.1475-6811.2011.01379.x

Castelao, C. F., & Kröner-Herwig, B. (2013). Different trajectories of depressive symptoms in children and adolescents: predictors and differences in girls and boys. *Journal of Youth and Adolescence, 42*, 1169-1182. https://doi.org/10.1007/s10964-012-9858-4

Chen, H., Chen, M. F., Chang, T. S., Lee, Y. S., & Chen, H. P. (2010). Gender reality on multi-domains of school-age children in Taiwan: A developmental approach. *Personality and Individual Differences, 48*, 475-480. https://doi.org/10.1016/j.paid.2009.11.027

Chen, P. P. (2003). Exploring the accuracy and predictability of the self-efficacy beliefs of seventh-grade mathematics students. *Learning and Individual Differences, 14*, 77-90. https://doi.org/10.1016/j.lindif.2003.08.003

Chiu, M.-S. (2016). Using demographics to predict mathematics achievement development and academic ability and job income expectations. *Open Journal of Social Sciences, 4,* 103-107. https://doi.org/10.4236/jss.2016.47017

Chiu, M.-S. (2018). Effects of early numeracy activities on mathematics achievement and affect: Parental value and child gender conditions and socioeconomic status mediation. *EURASIA Journal of Mathematics, Science and Technology Education, 14*(12), em1634. https://doi.org/10.29333/ejmste/97191

Chiu, M.-S. (2020). Exploring models for increasing the effects of school information and communication technology use on learning outcomes through outside-school use and socioeconomic status mediation: The Ecological Techno-Process. *Educational Technology Research and Development, 68*, 413–436.

Dickerson, A., & Popli, G. K. (2016). Persistent poverty and children's cognitive development: Evidence from the UK Millennium Cohort Study. *Journal of the Royal Statistical Society: Series A (Statistics in Society), 179*(2), 535–558. https://doi.org/10.1111/rssa.12128.

Duchesne, S., & Ratelle, C. (2010). Parental behaviors and adolescents' achievement goals at the beginning of middle school: Emotional problems as potential mediators. *Journal of Educational Psychology, 102,* 497-507. https://doi.org/10.1037/a0019320

Duncan, G. J., Morris, P. A., & Rodrigues, C. (2011). Does money really matter? Estimating impacts of family income on young children's achievement with data from random-assignment experiments. *Developmental Psychology, 47,* 1263-1279. https://doi.org/10.1037/a0023875

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*, 103-127. https://doi.org/10.1037/a0018053

Evans, J., Melotti, R., Heron, J., Ramchandani, P., Wiles, N., Murray, L., & Stein, A. (2012). The timing of maternal depressive symptoms and child cognitive development: A longitudinal study. J*ournal of Child Psychology and Psychiatry, 53,* 632-640. https://doi.org/10.1111/j.1469-7610.2011.02513.x

Filho, E. (2020). Shared Zones of Optimal Functioning: A Framework to Capture Peak Performance, Momentum, Psycho–Bio–Social Synchrony, and Leader–Follower Dynamics in Teams. *Journal of Clinical Sport Psychology*, *14*, 330-358.

Flak, A. L., Su, S., Bertrand, J., Denny, C. H., Kesmodel, U. S., & Cogswell, M. E. (2014). The association of mild, moderate, and binge prenatal alcohol exposure and child neuropsychological outcomes: a meta-analysis. *Alcoholism: Clinical and Experimental Research, 38*, 214-226. https://doi.org/10.1111/acer.12214

Frazier, L. D. (2020). The past, present, and future of the biopsychosocial model: A review of The Biopsychosocial Model of Health and Disease: New philosophical and scientific developments by Derek Bolton and Grant Gillett. *New Ideas in Psychology*, *57*, 100755.

Gray, H., Lyth, A., McKenna, C., Stothard, S., Tymms, P., & Copping, L. T. (2019). Sex differences in variability across nations in Reading, Mathematics and Science: a meta-analytic extension of Baye & Monseur (2016). *Large-Scale Assessments in Education, 7*(2), 1-29. https://doi.org/10.1186/s40536-019-0070-9

Guiso, L., Monte, F., Sapienza, P., & Zingales, L. (2008). Culture, gender, and mathematics. *Science, 320*, 1164-1165. https://doi.org/10.1126/science.1154094

Hair, J. F., Jr., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis: A global perspective* (7th ed.). Upper Saddle River, NJ: Pearson Education.

Hair, J. F., Jr., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate data analysis* (6th ed.). Upper Saddle River, NJ: Prentice-Hall.

Halpern, D. F., Wai, J., & Saw, A. (2005). A psychobiosocial model: Why females are sometimes greater than and sometimes less than males in math achievement. In J. Kaufman & A. Gallagher (Eds.), *Gender differences in mathematics: An integrative psychological approach* (pp. 48–72). Cambridge: Cambridge University Press.

Hansen, K. (Ed.). (2014). *Millennium Cohort Study: A guide to the datasets* (8th ed.) London, UK: Centre for Longitudinal Studies.

Hyde, J. S. (2005). The gender similarities hypothesis. *American Psychologist, 60*, 581-592. https://doi.org/10.1037/0003-066X.60.6.581

Hyde, J. S. (2014). Gender similarities and differences. *Annual Review of Psychology, 65*, 373-398. https://doi.org/10.1146/annurev-psych-010213-115057

Hyde, J. S., & Mertz, J. E. (2009). Gender, culture, and mathematics performance. *Proceedings of the National Academy of Sciences, 106*, 8801-8807. https://doi.org/10.1073/pnas.0901265106

Jeynes, W. (2012). A meta-analysis of the efficacy of different types of parental involvement programs for urban students. *Urban Education, 47,* 706-742. https://doi.org/10.1177/0042085912445643

Jones, E. M., & Ketende, S. C. (2010). *Millennium Cohort Study: User guide to analyzing MCS data using SPSS*. London, UK: Centre for Longitudinal Studies.

Kelly, Y., Iacovou, M., Quigley, M. A., Gray, R., Wolke, D., Kelly, J., & Sacker, A. (2013). Light drinking versus abstinence in pregnancy–behavioral and cognitive outcomes in 7-year-old children: A longitudinal cohort study. *BJOG: An International Journal of Obstetrics & Gynaecology, 12*0, 1340-1347. https://doi.org/10.1111/1471-0528.12246

Leavitt, C. E., Siedel, A. J., Yorgason, J. B., Millett, M. A., & Olsen, J. (2020). Little things mean a lot: Using the biopsychosocial model for daily reports of sexual intimacy. *Journal of Social and Personal Relationships*, 0265407520977665.

Lyubomirsky, S., King, L., & Diener, E. (2005). The benefits of frequent positive affect: Does happiness lead to success?. *Psychological Bulletin*, *131*, 803-855. https://doi.org/10.1037/0033-2909.131.6.803

Marsh, H. W., Kuyper, H., Seaton, M., Parker, P. D., Morin, A. J., Möller, J., & Abduljabbar, A. S. (2014). Dimensional comparison theory: An extension of the internal/external frame of reference effect on academic self-concept formation. *Contemporary Educational Psychology, 39*, 326–341. https://doi.org/10.1016/j.cedpsych.2014.08.003

Martin, A. J., Liem, G. A., Mok, M., & Xu, J. (2012). Problem solving and immigrant student mathematics and science achievement: Multination findings from the Program for International Student Assessment (PISA). *Journal of Educational Psychology, 104,* 1054-1073. https://doi.org/10.1037/a0029152

McCarthy, B., Koman, C. A., & Cohn, D. (2018). A psychobiosocial model for assessment, treatment, and relapse prevention for female sexual interest/arousal disorder. *Sexual and Relationship Therapy*, *33*, 353-363.

McCulloch, A., & Joshi, H. E. (2001). Neighborhood and family influences on the cognitive ability of children in the British National Child Development Study. *Social Science & Medicine, 53,* 579-591. https://doi.org/10.1016/S0277-9536(00)00362-2

Morin, A. J., Rodriguez, D., Fallu, J. S., Maïano, C., & Janosz, M. (2012). Academic achievement and smoking initiation in adolescence: A general growth mixture analysis. *Addiction, 107,* 819-828. https://doi.org/10.1111/j.1360-0443.2011.03725.x

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016). *TIMSS advanced 2015 international results in advanced mathematics and physics.* Retrieved from Boston College, TIMSS & PIRLS International Study Center website: http://timssandpirls.bc.edu/timss2015/international-results/advanced/

Nykjaer, C., Alwan, N. A., Greenwood, D. C., Simpson, N. A., Hay, A. W., White, K. L., & Cade, J. E. (2014). Maternal alcohol intake prior to and during pregnancy and risk of adverse birth outcomes: Evidence from a British cohort. *Journal of Epidemiology and Community Health,* Published Online First: March 10, 2014.

Organization for Economic Co-operation and Development. (2014). *PISA 2012 results: What students know and can do – student performance in mathematics, reading and science* (Volume I, Revised edition, February 2014). Paris, France: Author. Retrieved from http://dx.doi.org/10.1787/9789264201118-en

Oxford, M. L., & Lee, J. O. (2011). The effect of family processes on school achievement as moderated by socioeconomic context. *Journal of School Psychology, 49,* 597-612. https://doi.org/10.1016/j.jsp.2011.06.001

Pargulski, J. R., & Reynolds, M. R. (2017). Sex differences in achievement: Distributions matter. *Personality and Individual Differences, 104*, 272-278. https://doi.org/10.1016/j.paid.2016.08.016

Rees, G. (2018). The association of childhood factors with children's subjective well-being and emotional and behavioral difficulties at 11 years old. *Child Indicators Research*, *11*, 1107-1129. https://doi.org/10.1007/s12187-017-9479-2

Simmons, B. L., Gooty, J., Nelson, D. L., & Little, L. M. (2009). Secure attachment: Implications for hope, trust, burnout, and performance. *Journal of Organizational Behavior*, *30*, 233-247. https://doi.org/10.1002/job.585

Slominski, L., Sameroff, A., Rosenblum, K., & Kasser, T. (2011). Longitudinal predictors of adult socioeconomic attainment: The roles of socioeconomic status, academic competence, and mental health. *Development and Psychopathology, 23,* 315-324. https://doi.org/10.1017/S0954579410000829

Su, Y., Doerr, H. S., Johnson, W., Shi, J., & Spinath, F. M. (2015). The role of parental control in predicting school achievement independent of intelligence. *Learning and Individual Differences, 37,* 203-209. https://doi.org/10.1016/j.lindif.2014.11.023

Taylor, R. (1990). Interpretation of the correlation coefficient: A basic review. Journal of Diagnostic *Medical Sonography, 6*, 35-39. https://doi.org/10.1177/875647939000600106

West, K. K., Mathews, B. L., & Kerns, K. A. (2013). Mother–child attachment and cognitive performance in middle childhood: An examination of mediating mechanisms. *Early Childhood Research Quarterly, 28,* 259-270. https://doi.org/10.1016/j.ecresq.2012.07.005

Tables

Table 1

Correlations Between the Predictors and Outcomes for the Total Student Sample

		bio1	bio2	bio3	ses1	ses2	ses3	psy1	psy2	psy3	MAch5
Predictors (data collected at child age 9 months)											
bio1	Mother in-pregnancy alcohol intake										
bio2	Mother current alcohol intake	.356									
bio3	Mother depression	.083	.061								
ses1	Family income	-.186	-.180	-.135							
ses2	Mother education	-.155	-.143	-.075	.417						
ses3	Home foreign language	-.043	-.105	.036	-.104	.067					
psy1	Mother cognitive stimulation	-.039	-.008	-.039	.125	.148	-.075				
psy2	Mother positive affect	.000	-.036	-.344	.038	-.038	-.051	.097			
psy3	Mother secure attachment	-.077	.001	-.033	.189	.157	-.075	-.072	-.125		
Outcome: MAch measured as pattern construction											
MAch5	MAch at child age 5 years	-.095	-.063	-.053	.169	.148	-.063	.041	.023	.074	
MAch7	MAch at child age 7 years	-.114	-.052	-.064	.203	.159	-.086	.044	.025	.091	.561

Note. The correlation coefficients underlined are not significant at the $p < .050$ level. MA = mathematics achievement.

Table 2

Fit Index Results of the Path Analyses

Path Models / Fit index	$\chi^2(df)$	$p\ (\chi^2)$	RMSEA	SRMR	CFI	TLI
1. All students: Single group SEM	770.909(19)	0.000	0.000	0.000	1.000	1.000
2. All students: Multigroup SEM by setting equal regressions across genders	29.996(19)	0.052	0.035	0.025	0.987	0.973
3. All students: Multigroup SEM by setting equal regressions, intercepts, and residuals across genders	75.539(23)	0.000	0.035	0.025	0.936	0.894
4. Female student: Single group SEM	390.529(19)	0.000	0.000	0.000	1.000	1.000
5. Male students: Single group SEM	470.024(19)	0.010	0.089	0.011	0.987	0.822

Note. "0.000" means < 0.0005

Table 3

Path Analysis Results

predictor / outcome	Path coefficients (or Betas)										intercept	variance	R^2
	bio1	bio2	bio3	ses1	ses2	ses3	psy1	psy2	psy3	MAch5			
All students (Path Model 1 in Table 2)													
MAch5	**-.092**	.024	.034	**.123**	**.123**	-.072	**.095**	-.018	-.029		3.330	.935	.065
MAch7	-.032	-.005	.014	**.087**	**.074**	.016	-.035	-.051	-.016	**.567**	4.706	.624	.376
Female students (Path Model 4 in Table 2)													
MAch5	**-.119**	.027	-.060	**.189**	**.122**	-.049	**.108**	-.035	-.070		4.385	.892	.108
MAch7	.031	-.054	-.013	**.113**	**.078**	.030	-.045	-.035	.013	**.572**	4.475	.596	.404
Male students (Path Model 5 in Table 2)													
MAch5	-.070	.034	.104	.078	**.126**	-.104	.099	-.011	.015		2.508	.941	.059
MAch7	-.081	.044	.060	.061	.063	.000	-.015	-.052	-.040	**.569**	4.511	.624	.376

Note. The betas are standardized solutions. The **bold betas** are significant at $p < .05$ and the underlined betas are not significant at $p < .05$. Bio1–bio3, ses1–ses3, and psy1–psy3, MAch5, and MAch7: Table 1 shows the full names of the measures.

Figures

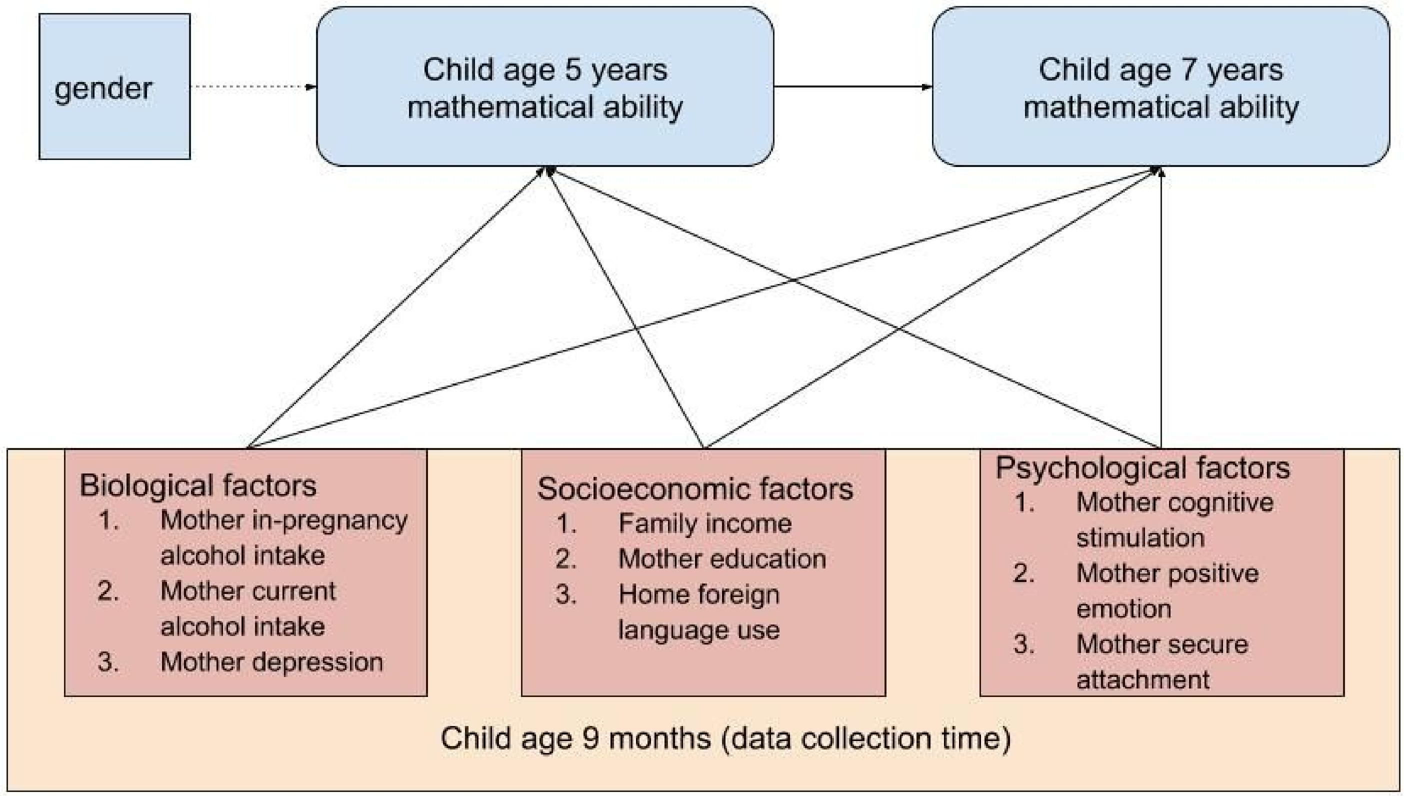

Figure 1

A research framework based on the family psychobiosocial model.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaryfile.docx