

Explaining the Decrease in Adolescents' Math and Sports Ability and Interest:
An Example Using Hierarchical Linear Modeling

Stephanie Hyatt, Janis Jacobs, Jennifer Tanner
The Pennsylvania State University

Jacquelynne Eccles
The University of Michigan

ABSTRACT

Eccles and colleagues developed an achievement choice model to explain relationships that include task values, parents' beliefs about their children, children's characteristics, and children's self-perceptions of competence (Eccles et al., 1983). Previous research has found that children's ratings of their achievement abilities decline as children get older; however, most studies have considered only mean level change. Despite interest in how and why children's achievement beliefs change over time, few have actually assessed change or included variables that may be related to change. Hierarchical Linear Modeling (HLM; Bryk, Raudenbush, & Congdon, 1993) is especially well suited for considering how and why achievement beliefs change over time because it allows an examination of both change and covariates related to change over time in the same model.

The present study expands upon previous work based on the Eccles framework by using HLM to examine changes in 1st to 12th grade children's ratings of their abilities in, and their values of, mathematics and sports. The roles of mothers' perceptions of their child's abilities, the activities' importance, the child's gender, and the child's actual ability in those changes will be considered.

This research is funded by a grant from the NICHD to Jacquelynne Eccles, Allan Wigfield, Rena Harold and Phyllis Blumenfeld. We would like to thank the following people for their assistance over the years: Allan Wigfield, Rena Harold, Phyllis Blumenfeld, Kwang Suk Yoon, Amy Arbretton, Carol Freedman-Doan, Robert Roeser, Cle Mollasis, Kathy Houser, Helen Patrick, Jenn Abraham, Corinne Alfeld-Liro, Lisa Colarossi, Jenny Fredericks, John Kauffman, Allison Murphy, Vida Mina, and Barb Yates.

SAMPLE

N=761
(388 Females)
(373 Males)

250 from Cohort 1
278 from Cohort 2
233 from Cohort 3

Subjects are from the Childhood and Beyond (CAB) study, an ongoing longitudinal study investigating the development of children's achievement motivation. The sample is from four middle-class school districts in the upper Midwest, and the subjects are primarily White. Data collection began in 1988 and ended in 1996.

Students measured at 6 waves spanning grades 1 through 12:

| Grade: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|----------|---|---|---|---|---|---|---|---|---|----|----|----|
| Cohort 1 | X | X | X | | | | X | X | X | | | |
| Cohort 2 | | X | X | X | | | | X | X | X | | |
| Cohort 3 | | | | X | X | X | | | | X | X | X |

The subset of data analyzed in this study includes data from all subjects present at the first wave and their mothers.

MEASURES

Outcomes measured at six waves:

Self-perception of math ability (5 items, $\alpha = .76, .79, .84, .90, .92, .92$)

Math value (2 items, $\alpha = .35, .46, .58, .63, .67, .69$)

Self-perception of sports ability (5 items, $\alpha = .84, .84, .89, .93, .93, .94$)

Sports value (2 items, $\alpha = .58, .71, .78, .82, .86, .83$)

Covariates:

Child's gender

Child's actual sports ability

Child's IQ

Mom's ratings of:

perception of child's math ability (4 items, $\alpha = .93$)

importance of math for boys (2 items, $\alpha = .95$)

importance of math for girls (2 items, $\alpha = .95$)

perception of child's sports ability (4 items, $\alpha = .94$)

importance of sports for boys (2 items, $\alpha = .88$)

importance of sports for girls (2 items, $\alpha = .84$)

Hierarchical Linear Modeling (HLM)

HLM (Bryk, Raudenbush, & Congdon, 1993) is a methodology for fitting growth curve models to longitudinal data. This method allows us to:

- ▣ Assess reliability of instruments for studying change.
- ▣ Estimate correlation of initial status and growth rate.
- ▣ Study correlates of initial status and change.
- ▣ Incorporate time-invariant and time-varying covariates.
- ▣ Estimate individual growth.
- ▣ Estimate interindividual variation around mean growth.
- ▣ Explain variance in initial status and change.

Four linear growth trajectories are modeled:

- Self-perception of math ability
- Math value
- Self-perception of sports ability
- Sports value

HLM provides the capability of handling longitudinal data which is not equally spaced across time.

Missing Data Software: NORM

NORM (Schafer, 1997) is a recently developed software product for imputing missing data. NORM uses *data augmentation*, a simulation-based approach, to perform *multiple imputation*.

TO PERFORM MULTIPLE IMPUTATION:

- ① Generate $m > 1$ imputed datasets
- ② Analyze each dataset using standard complete-data methods (HLM in this study)
- ③ Assess convergence (time-series plots, autocorrelations)
- ④ Combine results using Monte Carlo averaging (Rubin, 1987)

⇒ NORM is available at: <http://methcenter.psu.edu/>

RESULTS

GENERAL GROWTH TREND

Math and sports ability perceptions and value all decline between 1st and 12th grade.

GENDER DIFFERENCES (SEE GRAPHS)

Gender differences have already occurred by 1st grade in sports. Discrepancies between girls' and boys' perceptions are not increasing with age:

- Girls stay lower than boys for value of sports and math, and for perceptions of sports ability.
- Boys' math ability perceptions drop off faster than girls' throughout school, although they are still higher than girls by 12th grade.

Male: MATH ABILITY = $5.97^* - .11^* (\text{TIME})$

Female: MATH ABILITY = $5.55^* - .09^* (\text{TIME})$

Male: MATH VALUE = $6.33^* - .16 (\text{TIME})$

Female: MATH VALUE = $6.13^* - .17 (\text{TIME})$

Male: SPORTS ABILITY = $6.47^* - .13 (\text{TIME})$

Female: SPORTS ABILITY = $5.45^* - .10 (\text{TIME})$

Male: SPORTS VALUE = $6.25^* - .16 (\text{TIME})$

Female: SPORTS VALUE = $5.38^* - .13 (\text{TIME})$

MOTHERS' PERCEPTIONS OF ABILITIES

- Higher Mom perception of ability (both math and sports) related to higher rating of ability in 1st grade, and to slower drop in ability perceptions.

MATH ABILITY = $B_0 + B_1 (\text{TIME})$

$B_0 = 4.67^* - .39^* (\text{SEX}) + .23^* (\text{MOM ABILITY SCORE})$

$B_1 = -.23^* + .03^* (\text{SEX}) + .02^* (\text{MOM ABILITY SCORE})$

SPORTS ABILITY = $B_0 + B_1 (\text{TIME})$

$B_0 = 4.67^* - .39^* (\text{SEX}) + .23^* (\text{MOM ABILITY SCORE})$

$B_1 = -.23^* + .03^* (\text{SEX}) + .02^* (\text{MOM ABILITY SCORE})$

ACTUAL ABILITY

- IQ does not predict math ability perceptions at grade 1.
- Higher IQ related to slower drop in math ability perceptions.
(IQ not related to math value intercept or slope.)

MATH ABILITY = $B_0 + B_1 (\text{TIME})$

$B_0 = 6.02^* - .42^* (\text{SEX}) + .00 (\text{IQ})$

$B_1 = -.36^* + .04^* (\text{SEX}) + .002^* (\text{IQ})$

SPORTS ABILITY = B0 + B1 (TIME)

B0 = 6.33* - 1.00* (SEX) + .00 (PHYSICAL ABILITY)

B1 = -.20* + .03* (SEX) + .01* (PHYSICAL ABILITY)

SPORTS VALUE = B0 + B1 (TIME)

B0 = 6.21* - .88* (SEX) + .00 (PHYSICAL ABILITY)

B1 = -.23* + .03 (SEX) + .001* (PHYSICAL ABILITY)

IMPORTANCE OF ACTIVITY FOR BOYS AND GIRLS

- Higher importance of math for boys predicts slower drop in math ability perceptions.

MATH ABILITY = B0 + B1 (TIME)

B0 = 5.94* - .42* (SEX) + .02 (IMPORTANT - BOYS)

B1 = -.21* + .03* (SEX) + .02* (IMPORTANT - BOYS)

- Higher importance of sports for boys predicts slower drop in sports value, not ability perceptions.

SPORTS ABILITY = B0 + B1 (TIME)

B0 = 5.94* - .97* (SEX) + .10* (IMPORTANT - BOYS)

B1 = -.18* + .03 (SEX) + .01 (IMPORTANT - BOYS)

SPORTS VALUE = B0 + B1 (TIME)

B0 = 5.87* - .85* (SEX) + .08 (IMPORTANT - BOYS)

B1 = -.29* + .03 (SEX) + .02* (IMPORTANT - BOYS)

- Importance of math for girls not related to math ability perceptions.
- Importance of sports for girls related to slower drop in sports ability perceptions and value.

SPORTS ABILITY = B0 + B1 (TIME)

B0 = 5.98* - .97* (SEX) + .10* (IMPORTANT - GIRLS)

B1 = -.22* + .03* (SEX) + .02* (IMPORTANT - GIRLS)

SPORTS VALUE = B0 + B1 (TIME)

B0 = 5.83* - .84* (SEX) + .09* (IMPORTANT - GIRLS)

B1 = -.31* + .04* (SEX) + .03* (IMPORTANT - GIRLS)

SUMMARY

- Math and sports ability perceptions and value decline across grades 1 through 12. This is true for boys and girls.
- Gender differences in ability perceptions and value are already established by 1st grade in math, and especially in sports. Discrepancies between girls' and boys' perceptions are not increasing with age; discrepancies remain or lessen slightly.

Rate of change in perceptions of math ability affected by:

- > Mothers' perceptions of their children's math ability
- > Mothers who think math is important for boys
- > Child's IQ

Rate of change in perceptions of sports ability affected by:

- > Mothers' perceptions of their children's sports ability

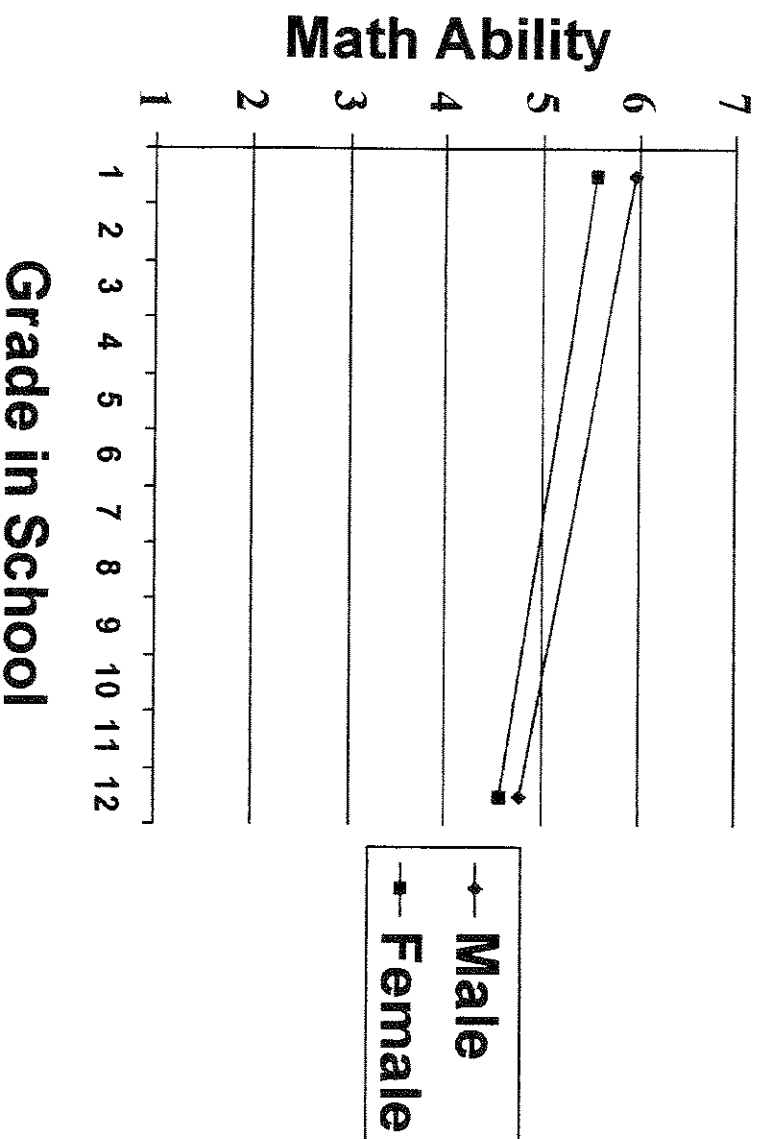
- Mothers who think sports are important for girls
 - Child's actual sports ability at Time 1
- Greatest impact on perceptions of ability and value occur PRIOR TO 1ST GRADE, highlighting the importance of that time period.

REFERENCES

- Bryk, A., Raudenbush, S. W., & Congdon, R. (1993). *HLM Version 3*. Chicago, IL: Scientific Software International.
- Eccles, J. S., Alder, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J., & Midgley, C. (1983). Expectancies, values and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives* (pp. 75-146). San Francisco: W. H. Freeman.
- Rubin, D.B. (1987). *Multiple imputation for nonresponse in surveys*. New York: J. Wiley & Sons.
- Schafer, J.L. (1997). *Analysis of incomplete multivariate data*. New York: Chapman & Hall.

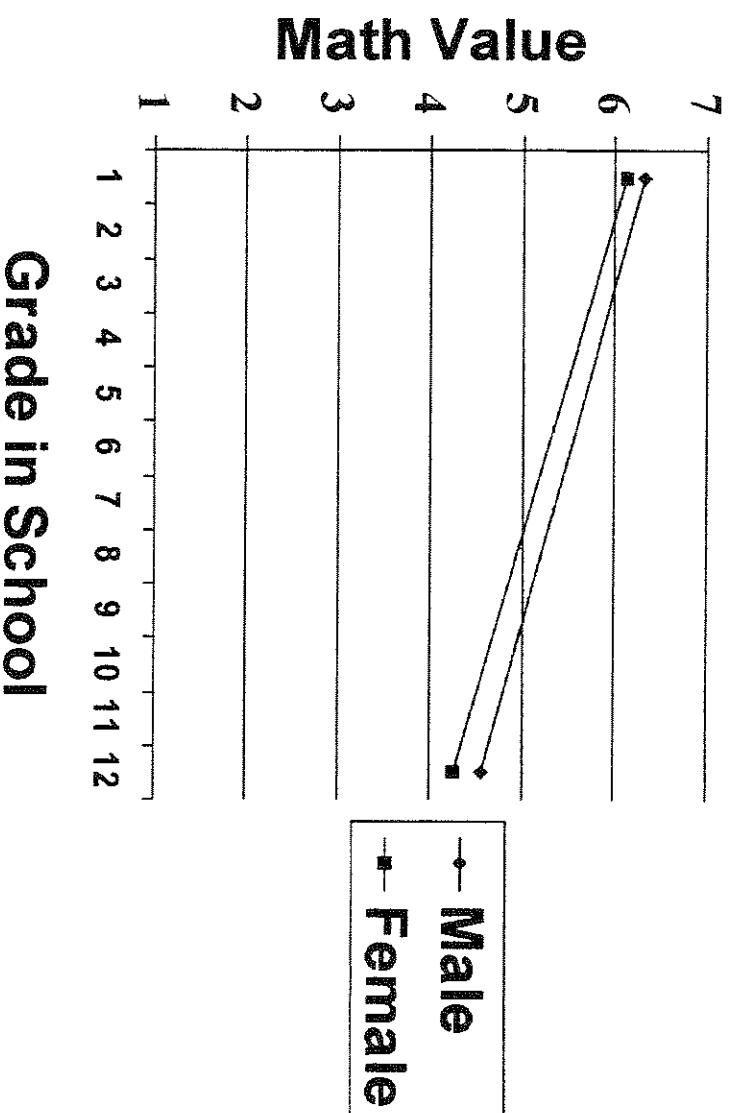
Self-Perception of Math Ability

Sex differences: Intercept and slope



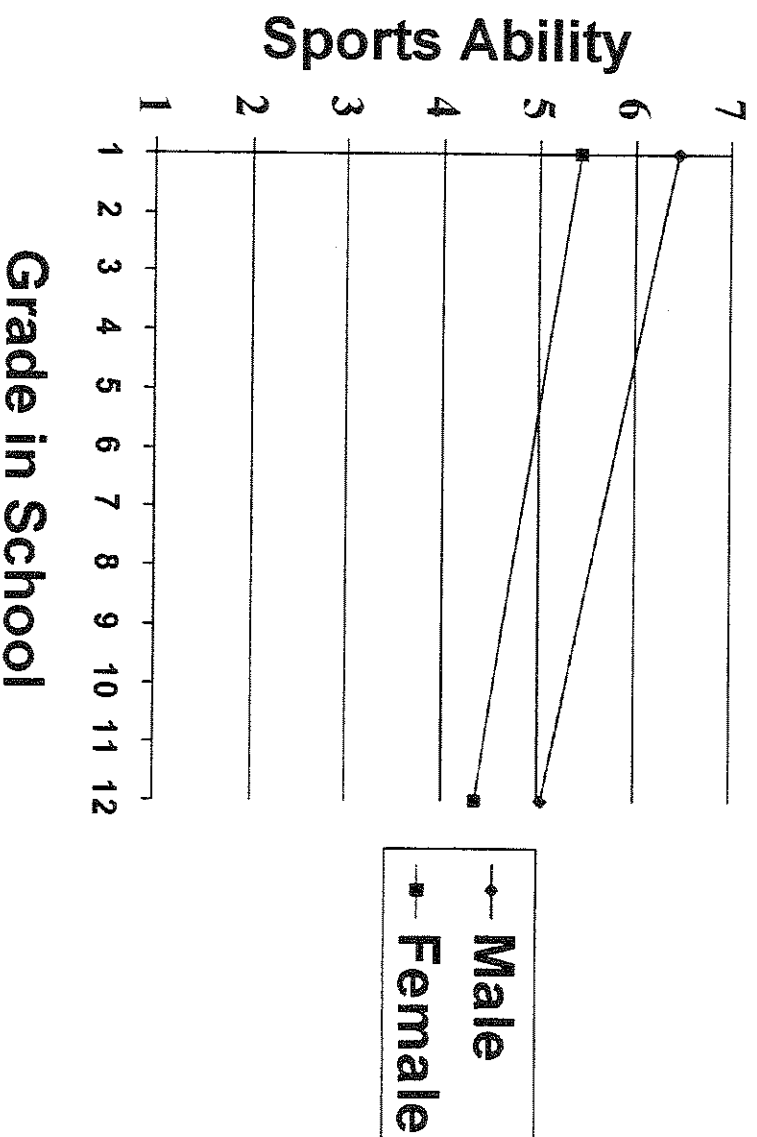
Self-Perception of Math Value

Sex differences: Intercept only



Self-Perception of Sports Ability

Sex differences: Intercept only



Self-Perception of Sports Value

Sex differences: Intercept only

