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Reversing fortunes or content change? Gender gaps in math-related skill throughout childhood ☆

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ABSTRACT

Many scholars and policy makers of education have focused significant attention on male advantages in math skills during adolescence, but have often overlooked female advantages in math skills that emerge before school begins. As a way to explain this conflicting pattern, some scholars cite exposure to schooling as a reason why girls experience what some have termed girls' "reversal of fortunes." By using first-of-its-kind data I examine math-related skills with proscriptive data from early to late childhood using two nationally-representative data sets. Moving beyond standardized assessments of math skills, this study reconciles these two competing trends using subset measures. Far from a reversal of fortunes, girls excel in math skills that are less complex (i.e. counting, shape recognition) across childhood. Girls' disadvantages in math emerge with content change—as item complexity increases over time (i.e. multiplication, division, and fractions). In contrast to standardized assessments of cognitive skills, gender gaps in item complexity may be more revealing for understanding the origins and development of gender stratification.

1. Introduction

Girls fall behind boys on standardized tests of math skills[1] sometime after school begins, what many argue is the origin of gender differences in math (Leahey and Guo, 2001; Entwisle et al., 1997). However, the opposite pattern is evident in early childhood, girls are found to excel in many math-related skills (for reviews, see Halpern, 2000; Geary, 1998; Worell and Goodheart, 2006). In an attempt to reconcile these competing patterns, one explanation posits that girls excel in these skills before school begins, but in the transition to school, are exposed to structural and cultural constraints that work against girls' initial advantage (Sadker and Sadker, 1994). But do girls' fortunes really reverse?

Many scholars of cognitive skills, especially sociologists, rely on standardized measures of math skill that are constructed from multiple subtests (Leahey and Guo, 2001; Geary, 1998), but if wide variations in *subtests* of math and math-related trajectories exist, then a singular focus on aggregated math scores obscures these underlying patterns. Subtests may reveal gender gaps that simultaneously converge, diverge and even show parity over time depending on the type of math skill assessed. With more detailed components of global math tests, an apparent reversal of fortunes may simply reflect a shift in math content. Disregarding these more subtle patterns could lead to misplaced conclusions regarding the relationship of girls' early advantages in math and subsequent adolescent and adult outcomes.

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[1] I use the term "math skill" to refer to both standardized scores of math skill as well as skills thought to be precursors to standardized math skill, referred here as either math-related skill or early math, where appropriate.

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To date, a test of the gender reversal hypothesis, requiring a comprehensive view of girls' transition from "home child" to "school child" and its effect on cognitive skill development, has yet to be undertaken (see Entwisle et al., 1997). This study uses comprehensive data across infancy and childhood to reconcile gender trends before and after school entry.

2. When do gender differences in math emerge?

Two separate literatures have debated the origins of gender differences in math and reading skill in isolation, with little cross-fertilization. As their specializations imply, *educational sociologists* have primarily focused on gender gaps after school begins. In contrast, *child developmentalists* have targeted early childhood (see Entwisle et al., 1997) although more recent work in this field has begun to include outcomes in adolescence (see Halpern, 2000). As a result, despite considerable attention and empirical rigor, the origins and explanations of gender differences in math skills remain unclear (Halpern, 2000; Gallagher and Kaufman, 2005; Geary, 1999; Feingold, 1996; Leahey and Guo, 2001; Buchmann et al., 2008).

2.1. Childhood and adolescence

There is broad consensus among educational sociologists that gender differences emerge sometime *after* formal schooling begins. On average, boys outperform girls on standardized tests of math, whereas girls outperform boys on tests of reading and verbal skill (Maccoby and Jacklin, 1974; Hedges and Nowell, 1995; Nowell and Hedges, 1998; Feingold, 1996; Voyer et al., 1995; Lynn and Irwing, 2004; Whitley et al., 1986; Friedman, 1989; Penner and Paret, 2008; Hyde et al., 1990; Hyde, 2005). Several studies in the sociological tradition are noteworthy given that their findings isolate the origins of these differences sometime in the middle to high school years.

Using the *National Longitudinal Survey of Youth* (NLSY) and the *National Educational Longitudinal Study* (NELS:88), Leahey and Guo (2001) posit that meaningful gender differences do not form until high school. Their work is novel in that they utilize growth curve modeling to account for previous gaps over time. By focusing on subsets of math skill in the NELS data, they find important variations in gender gaps in adolescence based on the type of math skill assessed. Although they note early female advantages from age 4 to about age 11, no explanation or further analysis is provided to understand this puzzling finding. And despite extensive documentation of gender gaps in math skill across development, they did not examine gender differences in reading skill.

In Entwisle et al.'s work (1994) examining social influences on educational outcomes, their study suggests that gender gaps in *average* math skills emerge sometime in late middle school or early high school. They argue, however, that the examination of averages mask *extreme* score distributions. They examine the top distribution of math scores by gender and find that boys' advantages emerge as early as middle school.[2] Also, by examining extreme scores, Penner and Paret (2008) report that boys outperform girls on standardized math tests even sooner, as early as kindergarten. With more extensive longitudinal data, Leahey and Guo (2001) find that from ages 4 to 7, higher-scoring girls do better than higher-scoring boys, but by ages 11–13, there is no statistical difference. It appears that girls may have initially higher scores that reverse around the time of school entry.[3]

Although gender differences in extreme scores are an important consideration in the literature, this study will focus on average score differences. For the most part, the average and extreme score gender difference literatures reveal similar trends. And for this study, the data show only minimal extreme score differences by gender in the early years.[4]

Overall, the most critical limitation of the sociological inquiries is the near exclusion of early childhood. This oversight is understandable. Finding evidence of near gender parity at school entry does not provide a clear indication that gender gaps in adolescence may have reversed from early childhood. But when the developmental period preceding kindergarten entry (early childhood) is considered, as Leahey and Guo (2001) show, female advantages are found. What appears as an anomaly among the sociological literature is a pattern found throughout the early childhood literature. If gender differences in math skills are thought to emerge in adolescence, what should educational sociologists make of gender differences in early childhood?

2.2. Early childhood

Child developmentalists find that many early-math advantages favor girls. At ages before school entry, girls outperform boys on memory tests of spatial locations (Kimura, 1999), simple arithmetic (Ginsberg and Russell, 1981), mathematical problem solving (Hyde et al., 1990), basic computation (Hyde et al., 1990), and standardized assessments of early math skill

[2] Using neighbor-level conditions, they find that in middle school, out-of-school activities moderate gender gaps, specifically neighborhood effects (gender differences in play). Work by Downey and Vogt-Yuan (2005) support this argument—in middle school, boys' and girls' time spent outside of school contributes to gender differences in math and reading skill. See the parent socialization section for more discussion.

[3] For reading, gender differences show a different pattern than math. Boys fall behind girls in reading in kindergarten (Tach and Farkas, 2006) and continue to struggle with reading in elementary school (Trzesniewski et al., 2006). In addition, boys are more likely than girls to have reading disabilities, such as stuttering and delayed speech throughout childhood (Halpern, 1997; Muter, 2003; Rutter et al., 2004).

[4] Variance ratios (ratios of male score variance to female score variance) across math-related assessments in this study range from less than 1% difference in early childhood, to a 5% difference in first grade, 12% difference in third grade, and 20% difference in fifth grade (see Hedges and Nowell 1995). Rather than a consistent higher male variance over time, the largest differences appear to emerge in late childhood. This is an interesting trend, but beyond the scope of this study to explore.