Intelligence 48 (2015) 137–151

Contents lists available at ScienceDirect

Intelligence

Sex differences in academic achievement are not related to political, economic, or social equality

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ARTICLE INFO

Article history:
Received 2 December 2013
Received in revised form 22 August 2014
Accepted 11 November 2014
Available online 17 December 2014

Keywords:
Sex differences
Scholastic performance
Reading
Mathematics
Science

ABSTRACT

The national differences in gender equality in economic and political participation have garnered considerable attention as an explanation of boys' better achievement in mathematics in most countries, but the debate is far from resolved. Using data from four international assessments of the academic achievement of 1.5 million 15 year olds (Programme for International Student Assessment, PISA), we demonstrate that the relation between sex differences in PISA achievement and national measures of gender equality is not consistent across assessments, and several of the positive findings are confounded by outliers. Further, for overall achievement across reading, mathematics, and science literacy girls outperformed boys in 70% of participating countries, including many with considerable gaps in economic and political equality, and they fell behind in only 4% of countries. The results raise doubts about the relation between national equality policies and mathematics achievement, and raise broader questions regarding women's underrepresentation in political, economic, and academic leadership despite stronger academic skills and regarding the long-term economic prospects and social stability of nations with many men who are not competitive in the modern economy.

1 . Introduction

The discussion of sex differences in educational attitudes and achievement dates back hundreds of years. For example, the British philosopher John Locke (1693) mentioned the relative ease with which girls are able to learn a second language in his treatise *Some thoughts concerning education*. The systematic study of sex differences in educational achievement started in the first half of the 20th century (Woolley, 1914). Overall, for the past 100 years girls have been found to perform better than boys in academic areas that involve language skills, including reading and spelling (Burt & Moore, 1912; Halpern, 2012), and boys in some mathematical areas, especially in adolescence and adulthood (Geary, 1996; Stockard & Bell, 1916). The stability and magnitude of these differences are vigorously debated, although a recent meta-analysis of sex differences in school grades from 1914–2011 concluded that the gap remained stable (Voyer & Voyer, 2014). This debate directly relates to a core question in the field of differential psychology and cognitive abilities, namely the degree to which sex differences in cognitive abilities are related to environmental factors. Some researchers have argued that these sex differences have been largely stable over the decades (Ellis et al., 2008), while others have argued they are disappearing (Feingold, 1988), or have essentially disappeared (Hyde, 2005; Hyde & Linn, 1988; Hyde & Mertz, 2009).

The purported disappearance of these sex differences, especially in mathematics, has been attributed to historical changes in social roles and movement toward gender parity in economic and political influence. This process is predicted by the gender similarities and gender stratification hypotheses, and some researchers have concluded that there is a linear relation between the size of the sex difference in mathematics

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http://dx.doi.org/10.1016/j.intell.2014.11.006
0160-2896/

performance and the extent to which men and women have equal social, economic and political opportunities (Else-Quest, Hyde, & Linn, 2010; Guiso, Monte, Sapienza, & Zingales, 2008; Hyde & Mertz, 2009; Reilly, 2012). We use four PISA assessments and national gender equality indices developed by the United Nations and the World Economic Forum to provide rigorous tests of these hypotheses, and find that they are not consistently supported.

The concept of gender stratification has its origin in sociology (Collins, Chafetz, Blumberg, Coltrane, & Turner, 1993), referring to the differentiation between men and women based on income and power. Hyde's gender similarities hypothesis about gender differences in psychological variables posits that males and females "are more alike than different" (Hyde, 2005; Hyde, Lindberg, Linn, Ellis, & Williams, 2008). On the basis of a meta-analysis of some constructs, she concludes that there are only few psychological variables on which men and women differ, such as some motor and sexual behaviors (Hyde, 2005). One of Hyde's main points is that the focus on sex differences results in an underestimation of girls' potential in mathematics.

The gist of the stratification hypothesis is that sex differences in economic and educational opportunities result in sex differences in mathematics performance (Else-Quest et al., 2010; Guiso et al., 2008). In short, this theoretical model proposes a causal link between gender equality and educational outcomes. The gender similarities and gender stratification hypotheses form a coherent theoretical model, which essentially states that nearly all psychological sex differences are the result of social and political factors. It thus follows that implementing policies that create equality of opportunity will ultimately eliminate the stratification of society by gender, and so eliminate any sex differences in achievement. It should be noted, though, that this theoretical model has been criticized for overlooking many psychological constructs that are quite large (e.g., occupational interests, Su, Rounds, & Armstrong, 2009), for creating the impression that psychological sex differences are categorical, that is, an all or none issue (Lippa, 2006), and for being based on inadequate methodology (Del Giudice, Booth, & Irwing, 2012). Nevertheless, the gender similarities hypothesis has received and continues to receive much attention in both academia and popular science and it is therefore important to subject the associated predictions to rigorous empirical tests. We specifically address the claim that indicators of social, political, and economic equality are related to the sex difference in mathematics achievement, and draw the attention of the field to a wider problem, that of boys' overall underachievement throughout most of the world.

The PISA is well suited for such an assessment, as it not only measures achievement in mathematics, reading, and scientific literacy in 15-year olds around the world, but also a considerable number of demographic and socioeconomic variables. The first PISA assessment was conducted in 2000, and repeated every three years since then, with an increasing number of countries, participating schools, and students across assessments; in the 2009 assessment, 515,958 students in 18,641 schools in 74 countries and economic regions participated (see Methods and Supplementary online material [SOM] for details).

Performance on the PISA is also linked to national differences in economic output, although it is unclear to what degree the national differences on the PISA (across the mathematics, reading, and science literacy scales) reflect general intelligence, variation in educational systems, or most likely some combination (Hunt & Wittmann, 2008; Lynn & Mikk, 2009; Rindermann, 2008). In any event, PISA scores matter; for example, it has been argued that an increase of 25 PISA points (in mathematics and science) in the next twenty years would raise the GDP by 115 trillion US dollars across OECD countries (OECD, 2006, p.27). In short, no other international instrument matches the PISA in terms of assessed breadth of educational achievement and related factors or in terms of assessed human capital and the economic well-being of countries and individuals. The one drawback is the narrow time frame of the PISA, which limits its sensitivity to long-term secular changes in achievement and factors that influence any such changes.

The results from previous comparisons of boys' and girls' performance in PISA assessments, and especially how differences in performance might be related to differences in gender equality measures (below) are confusing to say the least. Some studies, published in highly visible journals, conclude that there is a link between sex differences on the PISA and national gender equality policies (Else-Quest et al., 2010; Guiso et al., 2008; Hyde & Mertz, 2009; Reilly, 2012), whereas others do not find such a link (Fryer & Levitt, 2010; Kane & Mertz, 2012; Stoet & Geary, 2013).

Our approach to resolving the contradictory conclusions is to analyze all of the PISA assessments between 2000 and 2010. If the gender similarities and gender stratification hypotheses are correct, countries with higher levels of gender equality have smaller sex differences in educational achievement in mathematics as well as reading and science literacy. Previous tests of the hypotheses have focused primarily on mathematics and thus we do as well. Further, we argue that the focus is often on girls and mathematics, while boys' performance gets less attention, despite boys falling behind in reading around the world (Stoet & Geary, 2013).

We will show that when overall scholastic achievement is calculated from the core competencies in mathematics, reading, and scientific literacy, boys fell behind in the majority of countries. This is not only relevant for the gender stratification hypothesis, because it raises the question of why – despite educational opportunities and success – women are under-represented in leadership positions in politics, business, and academia. We will present support for two factors that might explain this. First of all, we show that the sex difference in educational achievement depends on the overall level of achievement, with boys at the highest levels doing equally well or better than girls at the highest levels. The second factor is relative academic strength. Students' relative academic strengths and weaknesses are critical to understanding sex differences in later schooling and occupational outcomes (Humphreys, Lubinski, & Yao, 1993). Students who are relatively better at language related competencies than mathematics are more likely to choose humanities majors in college, whereas students who are relatively better at mathematics than language related competencies are more likely to choose physical science, technology, engineering, and mathematics majors (Park, Lubinski, & Benbow, 2007). These differences in turn contribute to later occupational choices and success within these occupations (Park et al., 2007). In other words, when it comes to choices made by individual students, mean sex differences in mathematics or reading may not be as important as whether they are, as individuals, better at mathematics than