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Sex differences in academic strengths contribute to gender segregation in education and occupation: A longitudinal examination of 167,776 individuals

S. Dekhtyar[a,d,*], D. Weber[b,e], J. Helgertz[c,f], A. Herlitz[a,**]

[a] Department of Clinical Neuroscience, Division of Psychology, Karolinska Institutet, Sweden
[b] World Population Program, Wittgenstein Centre for Demography and Global Human Capital, International Institute for Applied Systems Analysis, Austria
[c] Centre for Economic Demography, Department of Economic History, Lund University, Sweden
[d] Aging Research Center, Department of Neurobiology, Care Sciences and Society, Karolinska Institutet, Sweden
[e] Health Economics and Policy Division, Vienna University of Economics and Business, Austria
[f] Minnesota Population Center, University of Minnesota, Minneapolis, MN, USA

ABSTRACT

We investigate whether sex differences in academic strengths have an impact on society by affecting the career choices made by women and men. By longitudinally following 167,776 individuals from Sweden, we found that (1) more 16-year old girls than boys had a relative strength in verbal/language school subjects than in technical/numerical ones, whereas more boys than girls had a relative strength in technical/numerical school subjects than in verbal/language ones; (2) when these girls and boys attained higher education and entered employment, they largely pursued careers cognitively matching their initial academic strengths; (3) while individuals generally made career choices in line with their academic strengths, men and women matched on these strengths nevertheless made rather distinct career choices, in particular women with technical/numerical strengths who largely avoided careers demanding these skills; (4) sex distribution in education and occupation was related to the extent these career paths were perceived as either numerically or verbally demanding. Taken together, although gender segregation is to some extent associated with individuals making choices matching their academic strengths, the vast discrepancies in career outcomes between men and women can be only in part attributed to sex differences in academic performance.

1. Introduction

Differences in cognitive performance between men and women have been reported with respect to some, but not all tasks. For example, women often outperform men on reading comprehension (Guiso, Monte, Sapienza, & Zingales, 2008; Hedges & Nowell, 1995) and episodic memory (Herlitz & Rehnman, 2008; Weber, Skirbekk, Freund, & Herlitz, 2014). Men, on the other hand, tend to perform at a higher level on visuospatial tasks (Voyer, Voyer, & Bryden, 1995) and on some numerical tasks (Guiso et al., 2008; Lindberg, Hyde, Petersen, & Linn, 2010; Weber et al., 2014). In contrast, there are typically no differences between men and women on tasks assessing vocabulary (Hyde & Linn, 1988). While these cognitive sex differences are often modest in magnitude (Hyde, 2016), they have been consistently reported throughout the lifespan and across geographical regions (Else-Quest, Hyde, & Linn, 2010; Lippa, Collaer, & Peters, 2010; Stoet & Geary, 2013; Stoet & Geary, 2015; Weber et al., 2014).

Furthermore, academic achievement, as in grade point average (GPA), has been linked with cognitive performance (Coyle & Pillow, 2008; Gygi, Hagmann-von Arx, Schweizer, & Grob, 2017; Rosander & Bäckström, 2014; Roth et al., 2015). Similarly, verbal and quantitative abilities have been related to performance on curriculum based tests in English and mathematics (Calvin, Fernandes, Smith, Visscher, & Deary, 2010), whereas curriculum based tests in language and mathematics are related to school grades in these very same subjects (Lundahl, 2017). When it comes to sex differences, academic performance is typically higher among women, in spite of cognitive sex differences favoring either men or women (Voyer & Voyer, 2014). The female advantage in grade point average (GPA) extends to most school subjects, but tends to be largest in language subjects and smallest in math, thereby mirroring sex differences in cognitive strengths.

Educations and occupations are typically horizontally gender-

* Correspondence to: S. Dekhtyar, Aging Research Center, Department of Neurobiology, Care Sciences, and Society, Karolinska Institutet, Gävlegatan 16, S-11330, Stockholm, Sweden.
** Correspondence to: A. Herlitz, Department of Clinical Neuroscience, Division of Psychology, Karolinska Institutet, Nobels väg 9, S-17177, Stockholm, Sweden.
E-mail addresses: serhiy.dekhtyar@ki.se (S. Dekhtyar), agneta.herlitz@ki.se (A. Herlitz).

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Table 1
Characteristics of the study population.

Characteristic	Men N (%)	Women N (%)
Birth cohort		
1977	29,712 (35%)	28,498 (34%)
1978	27,243 (32%)	27,281 (33%)
1979	27,309 (33%)	27,733 (33%)
Parental immigrant background		
Both parents Swedish-born	74,087 (88%)	73,231 (89%)
At least one foreign-born parent	10,177 (12%)	10,281 (11%)
Educational level (highest attained)		
Gymnasium/high-school	43,137 (51%)	29,424 (35%)
Professional	4242 (5%)	4272 (5%)
University	35,633 (42%)	48,690 (59%)
Postgraduate	1252 (2%)	1126 (1%)
Education (325 unique fields)		
General education	8659 (10%)	6758 (8%)
Pedagogics and teacher education	3500 (4%)	11,690 (14%)
Humanities and art	5015 (6%)	7803 (9%)
Soc. sciences, law, business, admin.	13,537 (16%)	18,910 (23%)
Natural sciences, math, comp. science	4251 (5%)	2917 (4%)
Technology and manufacturing	35,273 (43%)	6438 (8%)
Agricult., forestry, veterinary med.	2136 (2%)	2004 (2%)
Health- and social care	5254 (6%)	21,824 (26%)
Services	6639 (8%)	5168 (6%)
Occupation at age 32 (355 unique titles)		
Legislators, sen. officials, managers	3462 (4%)	2151 (3%)
Professional occupations	19,473 (23%)	22,236 (26%)
Technicians and associate professionals	18,706 (22%)	21,790 (25%)
Clerks and customer service personnel	5065 (6%)	9397 (11%)
Service workers and sales personnel	9644 (11%)	21,520 (26%)
Skilled agricultural and fishery workers	987 (1%)	492 (1%)
Crafts and related trades workers	12,456 (15%)	784 (1%)
Machine operators, incl. transport	11,147 (13%)	2142 (3%)
Occupations not requiring training	3121 (4%)	2967 (4%)
Armed forces	206 (1%)	33 (0%)

segregated, implying that the distribution of men and women is uneven across a variety of career paths (Barone, 2011; Ceci, Ginther, Kahn, & Williams, 2014; Statistics Sweden, 2012). For example, women are underrepresented in engineering, whereas they are overrepresented in humanities and social sciences (Charles & Bradley, 2009; Correll, 2001). The gender segregation is further transmitted to occupations, with a higher share of women in care industries than in technical sectors. Differences between men and women in career outcomes are likely affected by several factors, including expectations and societal traditions (Correll, 2001; Eagly & Steffen, 1984), but could also be hypothesized to be related to sex differences in cognitive or academic strengths (Miller & Halpern, 2014).

Only a handful of previous studies have investigated the association between sex differences in cognitive or academic performance and sex differences in career outcomes. Studies examining the choice of upper-secondary and university degree programs have found that boys and girls exhibit comparative advantages in distinctly different domains of school subjects and academic test scores, and that the probabilities of sorting into subsequent degree programs are affected by the pattern of these relative strengths (Jonsson, 1999; Paglin & Rufolo, 1990). These results, however, pertain to educational choices only, and in the case of Paglin & Rufolo (1990), lack longitudinal dimension. More recent findings have shown that within-individual differences on standardized math and verbal tests (i.e., ability tilt) not only varied between men and women, but also that a math tilt was much more prevalent than a verbal tilt among those with STEM-oriented college majors and occupations (Coyle, Purcell, Snyder, & Richmond, 2014; Coyle, Snyder, & Richmond, 2015). Despite these results, research on the relationship between sex differences in academic strengths and the cognitive demands of all types of career transitions in large representative study populations is needed in order to understand the relationship between academic strengths and gender segregation in career choices.

We address this gap by longitudinally following 167,776 Swedish men and women from age 16 until they are 32, and investigate (I) whether academic strengths (defined here as the relative performance differences between technical/numerical and verbal/language academic school subjects reported in the last year of compulsory school at age 16) are distributed unevenly between men and women; (II) if individual academic strengths affect both subsequent educational and occupational choices among men and women; and (III) whether the distribution of men and women in educational and occupational outcomes mirrors the distribution of men and women in academic strengths. Finally, to partially expose the extent to which our results are country specific, we also examine these outcomes in a subsample of children with another cultural or national background (i.e. second-generation immigrants), thereby strengthening the external validity of our findings. This study extends previous literature by enabling us to assess the effects of academic strengths in virtually all 16 year-olds in Sweden. We not only classify our study population's educational and occupational choices in accordance with the cognitive demands of each unique career path, but also provide a link between horizontal gender segregation across educations and occupations and the extent of cognitive demands exerted by these various career paths.

2. Method

2.1. Study population

The data come from the Swedish Interdisciplinary Panel (administered by the Centre for Economic Demography at Lund University), which is based on several population registers, linked together by a unique personal identity number assigned to each Swedish resident (Ludvigsson, Otterblad-Olausson, Pettersson, & Ekbom, 2009). The quality of the data in the registers is generally high, both with respect to coverage and timeliness (Ludvigsson et al., 2016). The study was approved by the Regional Ethics Review Board in Stockholm.

The baseline population is composed of all men and women born in Sweden during 1977–1979 extracted from the Total Population Register (see Table 1 for characteristics of the study population). The eligible population consists of Swedish-born men and women who were alive and resident in Sweden at the age of 16 in 1993–1995 and attended the 9th grade of compulsory school (N = 253,586). We subsequently excluded individuals who did not proceed beyond compulsory schooling (N = 22,956), or whose field of education was classified as unknown in the register (N = 3990). Unemployed individuals, and individuals whose occupation could not be classified according to the occupational scheme were also removed from the study population (N = 21,230). Additionally, we dropped persons who did not obtain individual school grades in technics, but instead received a composite grade in a subject called sciences, which covered topics in biology, chemistry, technics, and physics (N = 22,260). Finally, we removed individuals with missing information on important confounders, such as parental education, parental country of birth, and parental age at birth, as well as duplicate observations (total N = 15,374). In the end, the population analyzed in the study consists of 167,776 individuals (84,264 men and 83,512 women).

2.2. School grades

To measure academic performance, we used teacher-assigned school grades from the 9th grade (age 16), reported to the National School Register (Statistics Sweden, 2004). All children in Sweden are obliged to attend nine years of school, typically until June of the calendar year in which they turn 16 years. Upon completion of