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Socioeconomic status amplifies the achievement gap throughout compulsory education independent of intelligence

Sophie von Stumm

Department of Psychology, Goldsmiths University of London, New Cross, SE14 6NW London, UK

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ABSTRACT

Children from lower socioeconomic status (SES) families tend to perform worse in school than children from more privileged backgrounds. However, it is unclear to what extent differences in intelligence account for the academic achievement gap between high and low SES children. A large, UK representative sample of 5804 children was assessed on intelligence and academic performance at the ages 7, 9, 10, 12, 14 and 16 years. Latent growth curve analysis showed that SES was positively associated with academic performance at age 7 (i.e. intercept; Est = 0.07; CI 95% 0.06 to 0.07; β = 0.32) and gains in academic performance or growth from age 7 to 16 (i.e. slope; Est = 0.02; CI 95% 0.01 to 0.02; β = 0.44). The associations were substantially attenuated but remained significant after adding IQ (intercept: Est = 0.03; CI 95% 0.04 to 0.07; β = 0.14; slope: Est = 0.01; CI 95% 0.01 to 0.01; β = 0.28), which accounted for 40% of the variance in academic performance and growth, respectively. Although IQ was the strongest predictor of academic performance from age 7 through 16, SES was associated with an independent benefit of half a grade level on average by the end of compulsory education.

Educational attainment affects a wide range of important life outcomes, including socioeconomic status, health, and quality of life (e.g. von Stumm, Deary, & Hagger-Johnson, 2013). The type and level of educational qualifications that people complete vary as a function of academic achievement: Children who perform badly in school obtain overall fewer educational qualifications than those who do well (Schoon, Jones, Cheng, & Maughan, 2012). Children's differences in academic achievement are associated with their cognitive ability, which are both related to their family's socioeconomic status (SES), with children from less privileged families struggling more on average to achieve good grades and perform well in cognitive tests than children of higher SES (Bradley & Corwyn, 2002; Hart & Risley, 1995; Heckman, 2006).

A recent analysis of a subsample from the Twins Early Development Study (TEDS) tested the relationship between family SES and children's intelligence at age 2, as well as with their IQ gains or cognitive growth from age 2 to 16 years (von Stumm & Plomin, 2015a). At the age of 2 years, children from the highest and lowest SES backgrounds were on average separated by 6 IQ points; by age 16, the IQ gap had almost tripled, exceeding one standard deviation in IQ (i.e. 15 points; von Stumm & Plomin, 2015a). The authors concluded that SES has a profound, lasting and increasing impact on cognitive development. Because intelligence and academic achievement are highly correlated (Deary, Strand, Smith, & Fernandes, 2007; Frey & Detterman, 2004), we predicted that the same pattern of association holds true when SES is related to academic performance. In particular, we explored for the first time the association between SES and academic performance in the early years of school (i.e. at age 7) and with change in academic performance over the course of compulsory schooling (i.e. from age 7 to 16 years). We hypothesized that SES will be positively associated with academic performance at age 7 years, and with gains in academic performance over time from age 7 to 16 years, akin to its link with cognitive growth. In other words, we expected that the advantage of children from higher SES backgrounds in school performance is evident early on and magnifies over time. Even more importantly, we then tested to what extent the positive association between SES with academic achievement could be explained by children's differences in contemporaneous intelligence. A substantial attenuation of the SES link with academic achievement will imply that SES-related differences in academic performance simply mirror children's SES-related differences in intelligence (cf. von Stumm & Plomin, 2015a). In this case, we might conclude that SES is associated with better academic outcomes purely because of its relationship with intelligence. By contrast, a strong association between SES and academic performance independent of intelligence will suggest that SES-related benefits for school grades operate through pathways other than advantages in cognitive ability.

In addition, we sought to extend the previous literature by testing for the first time if SES moderated the relationship between IQ and academic growth across the course of compulsory schooling. It has been argued that intelligence accelerates school performance in children from privileged family backgrounds, where their learning needs are often adequately addressed, compared to those from low SES homes, where

E-mail address: s.vonstumm@gold.ac.uk.

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study support is typically scarce (Schoon et al., 2012). That is, children from high SES families may do better in school, even when they have lower intelligence, because they receive the help that they need to do well. By comparison, children from low SES homes, who experience less academic support, are likely to perform worse than high SES children across levels of intelligence (Bradley & Corwyn, 2002).

1. Methods

1.1. Sample

The Twins Early Development Study (TEDS) recruited initially over 15,000 families of twins born in England and Wales between 1994 and 1996. Although TEDS has seen substantial attrition over the years, the sample has remained representative of the U.K. population (Kovas, Haworth, Dale, & Plomin, 2007). For the current study, we excluded all twins from the analysis who suffered from severe medical problems during pregnancy, currently or at birth (e.g. postnatal surgery; N = 1672); whose first language was not English (N = 520); and who had been assessed on academic achievement fewer than two times between the ages of 7 and 16 years (N = 14006). For the final analysis sample, we randomly selected one twin from each pair (N = 5804 with 3075 girls and 2729 boys). All analyses were replicated in the other twins (N = 5778 with 3057 girls and 2721 boys). Because estimates were almost identical across both samples, in line with previous analyses of TEDS (von Stumm & Plomin, 2015a, 2015b), the results from the other twins' sample are reported in the supplementary materials.

2. Measures

2.1. School achievement

At the twins' ages 7 through 14, teachers rated their achievement in English, including the categories 'speaking', 'reading', and 'writing', and Maths, including 'use & applying', 'numbers', and 'shapes, spaces and measures', relative to 'the national expected standard' of children of the same age on a 5-point scale that ranged from 0 = 'working to towards level 1' and 1 = 'level 1', indicating achievement below the national expected standard, to 2 = 'level 2' that represented achievement at the expected standard, to 3 = 'level 3' and 4 = 'level 4+' that marked achievement above the national expected standard. From the twins' age of 9 years onward, teachers also rated their achievement in Science, including the categories 'scientific enquiry', 'life processes', and 'physical processes', using the same 5-point scale. At the twins' age of 12, teachers rated their achievement in the same subjects as described above on a 9-point rating scale that corresponds corresponding to National Curriculum Levels (https://www.gov.uk/national-curriculum/overview). For one subcategory of English, 50% of the sample had missing data; this category was therefore excluded from the analyses. Maths and Science each included additional categories of 'handling data' and 'science materials', respectively, resulting in overall 10 sub-categories with teacher ratings for academic achievement at age 12. At the twins' age of 14, teachers rated their 'overall achievement' in English, Maths and Science on the same 9-point scale used at age 12. At the twins' age of 16, their GCSE grades, which are based on national school examinations, were extracted from official records for English, including 'language' and 'literature', Maths, and Science that ranged from the top A* (i.e. "A-star") to A, B, C, D, E, F and G.

2.2. Socioeconomic status (SES)

Parental education and occupation (mother's and father's highest educational qualification and job status) were recorded at the first contact with the families, when twins were 2 years old, and again when they were 7 years old. Family income was assessed when the twins were 9 years old. A composite of parental education and occupation at twins' age of 2 years correlated at 0.77 with a composite of parental education and occupation at twins' age 7, which in turn correlated at 0.57 with family income at twins' age 9, suggesting that SES was stable over time in TEDS (Hanscombe et al., 2012).

2.3. Intelligence (IQ)

The twins' IQ assessments at 7, 9, 10, 12, and 14 used parent-administered and web- and phone-based tests, which have been described in detail elsewhere (Hanscombe et al., 2012) and are only briefly reviewed here. *Measures at age 7*: Children were tested on verbal and nonverbal abilities by telephone (Petrill, Rempell, Oliver, & Plomin, 2002). Prior to the telephone call, parents were sent a booklet of test items along with testing instructions for two verbal tests (Similarities subtest and Vocabulary subtest from the Wechsler Intelligence Scale for Children (WISC-III-UK; Wechsler, 1992), and two nonverbal tests (Picture Completion subtest from the WISC-III-UK and Conceptual Grouping from the McCarthy Scales of Children's Abilities; McCarthy, 1972). *Measures at age 9*: Participants were mailed a test booklet with two verbal and two nonverbal tests to be administered under the supervision of the parent, who had received a corresponding instruction booklet. The verbal tests comprised vocabulary and general knowledge tests adapted from the multiple-choice version of the WISC-III-UK (Wechsler, 1992). The nonverbal tests included a Puzzle test adapted from the Figure Classification subtest of the Cognitive Abilities Test 3 (CAT3; Smith, Fernandes, & Strand, 2001) and a Shapes test also adapted from the CAT3 Figure Analogies subtest (Davis, Arden, & Plomin, 2008). *Measures at age 10*: Testing was web-based, and children completed two verbal and two non-verbal tests using their home computers. Tests were drawn from the WISC-III-PI, including Multiple Choice Information (General Knowledge), Vocabulary Multiple Choice, and Picture Completion (Wechsler, 1992), and from Raven's Standard Progressive Matrices (Raven, Court, & Raven, 1996). *Measures at age 12*: Testing was web-based and conducted using home computers with age-matched versions of the two verbal and two non-verbal tests previously used at age 10. *Measures at age 14*: Twins completed two web-based tests at their home computers: WISC-III-PI Vocabulary Multiple Choice for 14-year olds (Wechsler, 1992) and Raven's Progressive Matrices (Raven et al., 1996). *Measures at age 16*: Twins completed web-based adaptations of Raven's Standard and Advanced Progressive and the Mill-Hill Vocabulary Scale using their home computers (Raven, Court, & Raven, 1998; Raven et al., 1996).

3. Statistical analysis

Teacher ratings of academic performance at the ages 7, 9, and 10 were recorded on a scale from 0 to 4. To enable comparing academic achievement across time, ratings and grades at ages 12, 14 and 16 were rescaled to also range from 0 to 4. Recoded and original scores correlated above 0.98 in all cases. Unit-weighted composite scores adjusted for the number of subject categories were computed for each age (i.e. 7 through 16 years).

At each assessment age (i.e. 7, 9, 10, 12, 14 and 16 years), the first principal component was extracted from the intelligence tests that were administered at the time. Regression factor scores were retained (mean = 0, SD = 1), representing age-matched *g*-scores herein referred to as IQ, and specified as reflective indicators of a latent IQ factor from age 7 through 16. Rather than modeling the IQ scores as time-variant covariates in the latent growth factor models (details below), modeling a latent IQ factor is more appropriate, because IQ scores are causally related over time.[1]

For an SES index, standardized composites of parental education and occupation at the ages 2 and 7 years were summed together with the

[1] I thank an anonymous reviewer for this modeling suggestion.

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