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The cognitive impact of the education revolution: A possible cause of the Flynn Effect on population IQ

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ABSTRACT

The phenomenon of rising IQ scores in high-income nations over the 20th century, known as the Flynn Effect, indicates historical increase in mental abilities related to planning, organization, working memory, integration of experience, spatial reasoning, unique problem-solving, and skills for goal-directed behaviors. Given prior research on the impact of formal education on IQ, a three-tiered hypothesis positing that schooling, and its expansion and intensification over the education revolution, is one likely cause of the Flynn Effect is tested in three studies. First, a neuroimaging experiment with children finds that neuromaturation is shaped by common activities in school, such as numeracy, and share a common neural substrate with fluid IQ abilities. Second, a field study with adults from insolated agrarian communities finds that variable exposure to schooling is associated with related variation in the mental abilities. Third, a historical–institutional analysis of the cognitive requirements of American mathematics curriculum finds a growing cognitive demand for birth cohorts from later in the 20th century. These findings suggest a consilience of evidence about the impact of mass education on the Flynn Effect and are discussed in light of the *g*-factor paradigm, cognition, and the Bell Curve debate.

The development and spread of mass schooling over the past 150 years, known as the education revolution, represents a major social trend with nearly full enrollments attained in primary and secondary schools first in wealthier nations and since the middle of the twentieth century in most nations (e.g., Baker, 2014). The United States led the way in developing formal education intended for all children and youth by expanding gross enrollment rates from about 50% early in the 20th century to almost 90% by 1960, with mean education attainment levels increasing from 6.5 to 12 years over the same period (U.S. Department of Education, 1993). In addition to expanding exposure to formal education, the education revolution has given rise to a culture of academic achievement from early childhood education up through university graduate programs (e.g., Martinez, 2000; Nisbett, 2009). In distinct contrast to traditional societies, cognitive skills such as literacy, numeracy, and mastery of other academic subjects are assumed necessary for a successful adult life for all individuals. Furthermore, success in school and social status attainment are increasingly linked together across successive generations, thus

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the motivation to attend and achieve in school reinforce one another (e.g., Bills, 2004; Torche, 2011).

Over the course of the education revolution, evidence exists that schooling has become more "cognitized," in that higher order thinking and reasoning capabilities such as unique problem solving, flexible thinking, abstraction, informed interpretative skills, relational reasoning, generating new ideas and critique are increasingly assumed essential for successful academic achievement (e.g., Genovese, 2002; Martinez, 2000). And prior neurological and cross-cultural research point to the possibility that the learning of basic literacy, numeracy, and other academic subjects, even under rudimentary conditions for a limited time, leads to neural and cognitive enhancements (Baker, Salinas, & Eslinger, 2012). But the impact of the education revolution on changes in the cognitive capacity across generations is not clear. Schooling is often presumed to impart facts, information, and specific skills more than it is thought to influence general cognitive ability. The Flynn Effect — rising IQ scores in developed nations over the 20th century — offers a case for investigation of the impact of the education revolution's positive impact on the cognitive capacity of populations.

A three-tiered hypothesis is developed positing that schooling, with its expansion and intensification over the education revolution, is one likely cause of the Flynn Effect. The parts of the hypothesis are tested in three studies: 1) a neuroimaging experiment, 2) a field study of exposure to schooling and cognitive skill enhancement, and 3) a historical–institutional analysis of the cognitive demands of schooling. The implications of the results for the study of intelligence, its consequences, and the Bell Curve argument are discussed.

1. Rising population cognitive performance and exposure to education

Mean IQ test scores of cohorts of American adults increased by approximately 25 points over the last 90 years, a period during which successive cohorts of children and youth were exposed to more formal education as shown in Fig. 1. For Japan, South Korea, and nations of Western Europe, where there is a history of large-scale IQ testing, similar Flynn Effects and increases in educational attainment have been reported (Flynn, 1984, 1987; Lynn, 2009a; Lynn & Meisenberg, 2010; te Nijenhuis, Cho, Murphy, & Lee, 2012; UNESCO, 2002). The gains in crystallized intelligence reflected by the Wechsler Adult Intelligence Scale (WAIS) are surpassed by even steeper historical gains in fluid intelligence, assessed for example with Raven's Progressive Matrices Test. Fluid intelligence includes the effective use of cognitive executive functions that provide mental resources for planning, organization, working memory, integration of experience, spatial reasoning, unique problem-solving, and skills for goal-directed behavior related to reasoning ability as applied in novel contexts. These "cognitive executive functions" (hereafter CEFs) are widely hypothesized to be the foundation for domain-general intelligence (*g*) that IQ tests attempt to measure and are considered shared cognitive resources applicable across multiple specific content areas and situations (e.g., Nisbett et al., 2012). The focus here, fluid intelligence gains relying heavily on CEFs are approximately double those of crystallized cognitive ability gains, and are generally considered to have occurred too rapidly to be attributable to genetic selection (Flynn, 2009). Lastly, the Flynn Effect has been judged to be substantial and is corroborated by studies from early in the 20th century (e.g. Lynn, 2013; Runquist, 1936).

Since Spearman (1923) the reigning theoretical paradigm posits that intelligence is an underlying trait *g*, assumed to be an expression of mental ability, significantly inherited, and highly stable across successive cohorts. And although modern IQ tests experiencing the Flynn Effect were originally developed to predict educability of individuals, the *g*-factor paradigm assumes that such tests are accurate indicators of an individual's underlying domain-general intelligence. Supporting this paradigm are well-known studies of monozygotic twins raised separately that report IQ measures of intelligence reliably factoring into one latent general factor like *g*, which is associated with real world competence and is substantially inherited at levels between 0.50 and 0.75 (e.g., Gottfredson, 1997; Jensen, 1998).

In contrast, 3–7 point average gain each decade across same-aged test-takers on IQ tests (that have a mean of 100 points and

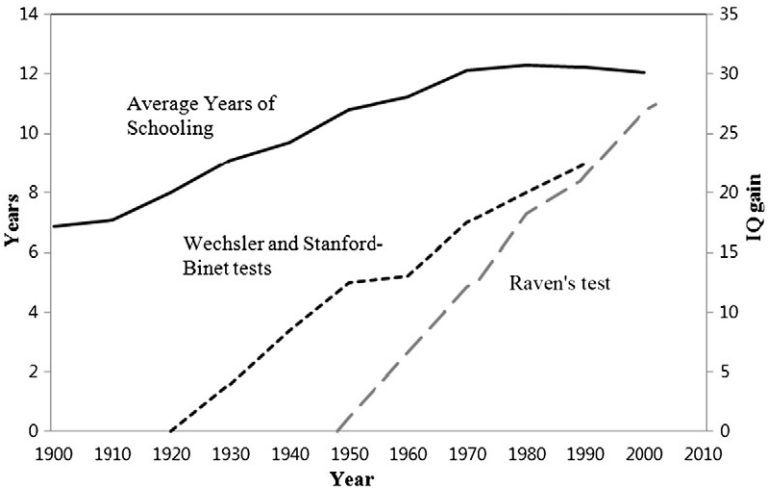

Fig. 1. Growth in educational attainment and adult IQ test score gains in the United States during the 20th century.
Sources: Average years of schooling competed by age 20: IPUMS; Wechsler and Stanford–Binet test (whites: Horgan, 1995); Raven's test IQ: Flynn (2009).