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SCHOOLING EFFECTS ON COGNITION IN THE ANCASH REGION OF THE PERUVIAN ANDES

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ABSTRACT

Research shows significant schooling effects on general cognition, particularly executive functioning. This paper analyzes the relationship between schooling and cognition in the Ancash Region of the Peruvian Andes, showing statistically significant correlations between schooling and executive functioning. A regression analysis demonstrates positive and significant schooling effects for two of the four measures of executive functioning, controlling for age, gender, area of residence, language at birth and crystallized intelligence. Schooling effects are significant because they correlate with cognition and healthful habits. Thus, school interventions are a way to mediate positive health outcomes in developing nations.

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Chapter 1

Introduction

The purpose of this research is to determine schooling effects on cognition, specifically executive functioning, for people in the *Ancash* region in the Peruvian Andes. Studies of schooling effects have risen in frequency and significance as education becomes a global institution (Baker & LeTendre, 2005). Strong schooling effects provide basis for schooling interventions in developing countries, which seek to improve decision making and health outcomes for local populations.

A review of the literature suggests a strong correlation between schooling and performance on IQ tests (Ceci, 1991). IQ tests purportedly measure two types of intelligence: crystallized and fluid. Crystallized intelligence is a compilation of facts and skills derived from learning and experience, such as knowledge of measurements and the ability to tie a shoe. Fluid intelligence builds on crystallized intelligence. Associated with perceptual and conceptual abilities, inhibitory control, attention shifting, and working memory; fluid intelligence is the capacity to process and use new information and crystallized knowledge (Ceci, 1991; Blair, 2006).

The term executive functioning (EF) will be used in place of fluid intelligence for the majority of this paper, since over-use has rendered the latter ambiguous. Executive functioning (EF) can be defined as domain neutral processing that involves conscious maintenance of information in the working memory to reach a set end (Baddeley 1986; Kane & Engle 2002). EF includes working memory, inhibitory control, and attention shifting processes (Miyake, Corley, Young, DeFries, & Hewitt, 2006).

This paper will critically analyze the executive functioning component of IQ tests and its relationship to schooling. Embedded in Baker et al.'s (forthcoming) theory that schooling enhances executive functioning, which strengthens decision-making, and improves health outcomes; we will reveal the salience of the relationship between schooling and executive functioning.

Background on IQ Tests

Before executive functioning, however, we must examine the broader and more widespread way of demonstrating schooling effects: IQ. By reviewing the history of IQ, we can grasp its foothold in research and society; and by analyzing its components, we identify the niche for a new way of looking at schooling effects.

IQ has played a dominant role in education literature since the beginning of the twentieth century. In the early 1900s, the French government commissioned psychologist Alfred Binet to develop a tool to identify children who required specialized attention in the public schools. Binet and his partner, Theodore Simon, developed a scale to measure innate ability in relation to others in a cohort, based on purportedly non-schooled items. Questions address attention, memory, and problem-solving in an attempt to capture, what Cattell (1971) later termed, fluid and crystallized intelligence. Binet warned that intelligence is not simple or fixed and the Binet-Simon IQ test should not be over-utilized by decision makers. To whatever end, American policymakers did not heed Binet's warning.

In 1911, Stanford psychologist Lewis Termin published an adapted version of the IQ test, which he standardized for the American populace and named the Stanford-Binet intelligence test. The Stanford-Binet test distinguished itself by generating individual scores, intelligence quotients (IQs), by dividing mental age by chronological age and multiplying by 100. Originally, the test was hard to administer on a large scale due to requisite facilitator training; however, Lewis Terman and Arthur Otis developed a pencil and paper version in 1916, which allowed one person to administer the test to a group. Such cost- and time-efficiency allowed for widespread IQ testing in the United States during and after World War I.

From 1914 to 1929, IQ tests experienced a boom period in the United States, due to a confluence of factors: successful testing during WWI, large-scale immigration from Eastern Europe, and compulsory primary education. IQ testing was used in World War I to identify officers and those unsuited for military service. Approximately, 200,000 recruits were tested per month, with a total of 1,750,000 being evaluated by the end of the war (Fancher, 1985, p. 269). Such widespread use shot-gunned the IQ test into the public consciousness and paved the way for its use in other fields. Immigration and compulsory education policies created a glut of new students in the U.S. According to the census, from 1900 to 1920, nearly 38 million immigrants arrived in the country (Gibson, Campbell, Jung, Kay, & the U.S. Bureau of Census). Meanwhile, the percentage of 5-17 year olds enrolled in school increased from 68.9 percent in 1889-90 to 84.4 percent in 1939-40 (http://www.nces.ed.gov/). Education provided a way to organize, integrate, and Americanize the newcomers (Fass, 1980). Yet, population influxes overwhelmed the school system, prompting administrators to use IQ and achievement tests to sort students into tracks for efficient and effective schooling (Fass, 1980). The scientific basis for IQ testing also helped legitimize the fields of education and psychology (Hines, 1923, p. 82; Samelson, 1977).

In the early 1900s, Binet cautioned people of the limits of IQ scores in measuring, what he deemed to be, the non-fixed entity of intelligence. Nevertheless, in the past century, American society has embraced IQ as a ranking and sorting tool and, more or less, equated IQ and innate intellectual ability (Herrnstein & Murray, 1994). The preeminence of IQ in formal and informal national literature makes it a valid place to begin to assess the relationship between schooling and cognition; though, first, we must determine the extent to which intelligence is heritable, or open to change.

Schooling and IQ Correlation: Old Framework

Scholars have long grappled with the nature versus nurture argument regarding intelligence. Jensen (1998) highlights the heritability of brain quality and resulting IQ, providing ample support for the genetic argument. At the same time, a number of twin studies support and quantify the environmental effects on IQ (e.g. Tellegen, Lykken, Bouchard, Wilcox, Segal, & Rich, 1988). The twin studies find that identical twins (monozygotic) raised in different homes share more characteristics as adults, including IQ, than fraternal twins, non-twin siblings, and adopted children raised by the same people in the same setting. These studies suggest that 50 to 75% of variation in IQ scores can be attributed to genetic differences, leaving 25 to 50% to be explained by the environment, as recent studies have attempted to do (e.g. Ceci & Williams, 1997; Ramey & Campbell, 1984).

Many of the studies on environmental effects on IQ have identified schooling as a primary influence; yet differ in conclusions about correlation versus causation, and the strength and duration of the schooling effect. Steven Ceci (1991) compiled a literature review of the relationship between schooling and IQ, which will provide the backbone for this section. It is important to note that Ceci's is not a true meta-analysis, but a compilation of natural studies. Natural studies are those that observe, rather than manipulate, variables in an environment. They are important in education research for ethical reasons, since students cannot be excluded from school for the purpose of a study. Ceci worked to avoid the selection effects associated with natural studies, by using historical research which captured schooling effects in areas without universal schooling. Lack of universal schooling reduces selection effects, since attendance is often less related to innate ability than to non-cognitive factors like access, money, or gender preference (Peters, Baker, Dieckmann, Leon, & Collins forthcoming).

In terms of the connection between schooling and IQ, Ceci highlights the following: the correlation between IQ and years in school; and the influences on IQ of summer vacation, intermittent school attendance, delayed entrance to school, and early termination of schooling:

1. *Correlation between IQ and Years of Schooling:* Ceci's review reveals that the number of years of schooling and IQ have high positive correlations, often exceeding .8 (Bouchard, 1984; Ceci & Liker, 1986). Even after controlling for socioeconomic status (SES) and other social variables, the correlation remains between .60 and .80 (Kemp, 1955; Wiseman, 1966). Lastly, the relationship maintains significance after controlling for the fact that children with high IQs often begin school earlier and remain in school longer than their peers (Howe, 1972).

2. *Summer Vacation and IQ:* Widely acknowledged by educators, studies also show that scores on IQ and achievement tests that improve over the course of the school year decrease over the summer (Heyns, 1978), particularly for low income children who are less exposed to structured, enriching activities than higher income peers (Jencks, Smith,

Acland, Bane, Cohen, Gintis, Heyns, & Mitchelson, 1972; Hayes & Grether, 1982; Heyns, 1978).

3. *Intermittent School Attendance and IQ:* As suggested by Hugh Gordon in 1923 (reported in Freeman, 1934), continued school attendance is related to IQ. Gordon studied low IQ children in London, some who regularly attended schools and others who attended infrequently due to disability or family lifestyle (i.e. gypsies, canal boat pilots, etc.). Gordon argued that children with low IQs that attended school were mentally retarded, but that children with low IQs in the other cohort lagged for lack of schooling. IQ scores for both groups were positively correlated with amount of school attended, r=.37, suggesting a "cumulative deficit" based on underexposure to "factual knowledge, values, modes of responding, and classifying, as well as attentional and metacognitive factors."

   A study by Sherman & Key (1932) of children raised with limited to no access to schooling or mainstream society outside of Washington D.C. supported Gordon's conclusion. IQ scores were inversely related to children's access to schooling, with 10- to 30-point advantages for those with most schooling. Interestingly, Sherman and Key also observed lower IQs in older children than younger children, with scores declining over time. Tyler (1965) and Wheeler (1942) came to similar conclusions about children born in a mountainous area of Eastern Tennessee.

4. *Delayed Entrance and IQ:* During World War II, many children in the Netherlands could not enter school for several years due to Nazi presence, and their IQ scores suffered by

approximately 7 points (Degroot, 1951). Similarly, children of Indian ancestry living in South African villages lost 5 IQ points for every year their schooling was delayed by teacher shortages (Ramphal, 1962). Schmidt (1967) found a similar relationship in another South African village, which remained significant after controlling for SES and parental motivation. The correlation between length of schooling and IQ was .49 for a nonverbal measure of intelligence and .68 for a verbal measure of intelligence.

5. *Early Termination and IQ:* Harnquist (1968) studied the effect of dropping out of school on children with similar IQ, SES, and school grades at age 13. Harnquist determined that each year of missed secondary schooling corresponded with a 1.8 loss in IQ score, for a maximum 8-point disadvantage. Husen (1951) reached similar findings with a sample of 613 Swedish men. The studies have been criticized because inherent differences may have existed between those who left and those who remained in school, with the idea that those with higher IQ remain in school longer (Madaus, Airasian, & Kellaghan, 1980).

Based on the studies in Ceci's review, one can say with reasonable certainty that schooling affects IQ. It is important to note that some of this relationship can be accounted for by the fact that IQ tests measure fluid intelligence (executive functioning) *and* crystallized intelligence (factual knowledge), the latter of which produces some schooling effects. This and other explanations for the correlation between schooling and IQ will be explored, as we move toward the ultimate goal of uncovering the relationship between schooling and executive functioning.

Holes in the Schooling-IQ Framework

Establishing causality in the relationship between schooling and IQ proves much more difficult than establishing correlation. Theories exist for the primacy of each of the variables. Reality may not be one theory, but an amalgamation of several. The theories that will be explored in this section are as follows: schooling provides the values and skills tested on IQ tests; schooling impacts IQ but gains do not exist as Flynn (1984, 1987) suggests; and IQ is determined by factors other than school.

Teaching to the Test

There are several arguments for how schooling teaches the skills required for IQ tests. It is important to note that "teaching to the test," despite its connotation, is not inherently bad. In determining schooling effects on cognition, it is necessary to compare inputs and the reward for such inputs in the final measure. If the schooling input is factual knowledge, and regurgitation on the test warrants a higher score, then IQ tests measure surface schooling effects. If the input is a new way of thinking and application yields reward, then IQ tests measure schooling's deeper cognitive effects. The latter measurement is ideal since it demonstrates the ability to process, rather than reproduce information. The likelihood is that IQ captures processing and memorization, which begs the question of whether there is a less adulterated measure of executive functioning, or at least one to supplement the IQ test. But now to determine what IQ tests measure:

Ceci (1991) suggests that some questions on IQ tests directly probe material taught in school. For example, the following questions from the WISC-R require factual knowledge, rather than higher order thinking skills: "In what continent is Egypt?"; "Who wrote Hamlet?";

"What is the boiling point of water?"; and "How many miles is New York from L.A.?" These questions demonstrate an overlap between intelligence and achievement tests, the latter of which does not purport to measure higher order cognition.

On the same note, DeVries (1974) used factor analysis to measure the performance overlap on the Stanford-Binet Intelligence test, Piagetian tasks, and school achievement tests. According to DeVries, "IQ tests are not derived from any theory of intelligence but are based, instead, on certain assumptions about intelligence… IQ is thus defined in terms of individual differences with regard to a wide variety of items which have no theoretical significance in themselves." On the other hand, Piagetian tasks are grounded in Jean Piaget's theories of cognition (Piaget, 1964). The Piagetan tasks involve the concepts of conservation, constancy, sorting, and transitivity, to name a few. Success on the tasks depends on an individual's stage of cognitive development, which Piaget has delineated as follows: sensorimotor, pre-operational, concrete operational, and formal operational. DeVries found no overlap between performance on Piagetan tasks and the school achievement test, and moderate overlaps between the Stanford-Binet IQ test and Piagetan tasks (r= .33) and the Stanford-Binet test and achievement test (r= .34). These findings suggest that each test assesses a relatively different cognitive skill set, with the Piagetan tasks being the least focused on facts and rote memorization.

Coming from a different direction, Flavell (1981) suggests that schools promote the attitudes and values that help students succeed on IQ tests. Students learn to respond to adult questioning, monitor time, verbalize ideas, and sit still. After comparing the dichotomous scores of schooled and non-schooled Indian children on five subtests of an intelligence test, Bhatia (1955) concurs that schooling promotes the concentration and the ability to sit still: two factors influencing test performance. Of course, IQ tests provide a more efficient means for evaluating a large number of students, but care must be taken when comparing scores of those who have not been socialized with formal schooling.

Norm- Referencing

Cahan & Cohen (1989) support the idea of a schooling-IQ correlation, but reject the notion of massive IQ gains through time. Using a sample of fourth, fifth, and sixth graders attending Jerusalem's Hebrew-Language, state-controlled elementary schools in 1987, Cahan & Cohen conducted 12 general ability tests and observed age effects between grades. They concluded that schooling affects IQ scores about twice as much as age. This is significant because the elements of intelligence measurement (mental age, intelligence quotient, and the modern concept of deviation-IQ) are age-normed, and there are large age variations across grades. Baltes & Reinert (1969) and McDonald (1998) come to similar conclusions.

On the other hand, in relaying a trend toward rising IQ scores in the United States and abroad, Flynn (1984) reveals that earlier Stanfod-Binet and Wechsler IQ tests "suffer from obsolescence in the sense that their norms are easier to meet than later tests." Regardless of whether demonstrated IQ gains are legitimate or result from poor standardization, dozens of studies need to be re-calibrated as a result.

Non-Schooling Variables

Vocabulary is arguably one of the best predictors of overall IQ score (Jensen, 1980, p. 146); and while students learn vocabulary in school, Sternberg & Powell (1983, p. 878-93) suggest that they more fluidly acquire it in everyday contexts. Thus, students with more enriching home environments develop stronger vocabularies (Lareau, 2003, p. 129), which makes IQ scores more of an indication of socio-economic status than ability to absorb information (Turkheimer, Haley, Waldron, D'Onofrio, & Gottesman, 2003).

Thorndike (1977) approaches the environment theory in a different way: saying that, as an aggregate, pre-schoolers in the U.S. are growing up in more stimulating home environments than previous generations. Parents have two and three years more education, and children are exposed to a wider array of stimulating toys, books, and television programs (i.e. Sesame Street). Tuddenham (1948) suggests that nutrition and improved public health could influence IQ; however he provides no evidence and presents the supposition before a more robust endorsement of the schooling-IQ correlation.

Schooling- Cognitive Ability: New Framework

In the effort to hone in on the relationship between schooling and executive functioning, we identify schooling effects on cognitive abilities regardless of the measure, based on a review by Ceci (1991). It is important to note that some of the studies in this section were conducted in places where schooling is not compulsory; thus, same-aged children have varying levels of schooling. Researchers have used a priori and post hoc approaches to control for confounding variables, though caution should still be used in making inferences (Ceci, 1991).

Perceptual ability, including understanding and application of perspective information, ability to distinguish between figure and ground, and ability to deconstruct visual-spatial patterns, has shown schooling effects (Berry, 1976; Dawson, 1967; Greenfield & Childs, 1972; Kilbride & Leibowitz, 1975). Hudson (1960) studied a group of 85 Bantu factory workers in Africa, administering a picture projection test to determine pictorial depth perception. Hudson found that subjects who had attended school perceived depth more consistently than those who had not. Schooled subjects could also identify three-dimensionality in outline drawings with higher frequency.

Blair, Gamson, Thorne, & Baker (2005) argue that perceptual ability has been enhanced by mass enrollment in school, irrespective of prior intelligence, and the increasing complexity of math curricula in the early elementary grades. From the 1890s to the 1990s, mathematics instruction evolved from an emphasis on algorithms and rote memorization to one on visual-spatial relations (i.e. pattern recognition, pattern completion) and other cognitive tasks. Blair et al. contends that mathematics requires the most fluid processing of the elementary curricula and that instruction has become increasingly correlated with the cognitive development and the skills required for IQ tests.

Conceptual ability can be assessed with tasks like rule learning, free association, analogical reasoning, and multiple classification. According to Ceci (1991) and other scholars, "compared with their nonschooled peers, schooled children are more likely to (a) sort stimuli by form and class rather than by color, (b) group items that belong to the same taxonomic class rather than to the same thematic class, (c) demonstrate greater flexibility in shifting between domains during problem solving, and (d) spontaneously engage in more verbal descriptions of their classifications (Ceci & Liker, 1986; Evans & Segal, 1969; Gay & Cole, 1967; Greenfield, Reich, & Oliver, 1966; Hall, 1972; Stevenson, Parker, Wilkinson, Bonnevaux, & Gonzalez, 1978)." Sharp, Cole, & Lave (1979) tested free association, free recall, and paired-associate learning on a group of Indio (Maya) and Mestizo subjects from 10 to 56 years of age in rural Yucatan, Mexico. Those with secondary schooling or more were most successful on these tasks.

Memory is enhanced by Western-style schooling (Cole, Gay, Click, & Sharp, 1971; Sharp et al, 1979) through emphasis on strategies like recoding, maintenance rehearsal, and chunking (Fahrmeier, 1975; Rogoff, 1981; Sharp et al., 1979; Stevenson et al., 1978). Memory also increases naturally with age. It can be difficult to separate the impacts of schooling and age, as demonstrated by Cahan & Cohen (1989), though the researchers conclude that schooling has twice the impact on cognitive function as age.

Understanding the New Framework

As mentioned before, scholars suggest that executive functioning and general intelligence are fundamentally different measures (Blair, 2006). General intelligence, referred to as *psychometric g*, is represented by a single factor that reflects performance on IQ subtests of fluid and crystallized knowledge. EF involves working memory, inhibitory control, and attention shifting processes (Miyake, Corley, Young, DeFries, & Hewitt, 2006).

Friedman, Miayke, Corley, Young, DeFries, & Hewitt (2006) study the relationship between general intelligence and executive functioning. The measures are as follows: fluid and crystallized intelligence and the Wechsler Adult Intelligence Scale IQ represented general intelligence and inhibitory control, attention shifting, and updating working memory were the three inseparable aspects of executive functioning. Using structural equation models, Friedman et al. determined that 41-48% of variance in intelligence measures matched variance in updating, whereas variance in intelligence measures matched only 2-14% of variance in inhibiting and shifting. Thus, updating working memory was the only element of executive functioning strongly related to general intelligence. Based on Friedman, et al,'s conclusion and various factors that impact IQ scores, we determine that executive functioning provides a clearer picture of schooling's impact on higher order cognition.

Chapter 2

Case Study: Schooling Effects on Executive Functioning in the Ancash Region of the Peruvian Andes

Methods

The Pennsylvania State University, Group for Analysis of Development (GRADE) in Lima, Peru; and the Decision Research Center in Eugene, Oregon collaborated in the effort to determine schooling effects on executive functioning in the Peruvian highlands. We hypothesized that strong schooling effects would exert themselves on measures of EF, even while controlling for demographic information and crystallized intelligence.

The study was conducted in small, rural towns in the Ancash Region of the Peruvian Andes. Carhuaz, which has a population of approximately 13,000, and is located 30 minutes from the region's capital of Huaraz, served as a base for research operations. The town was chosen using data from the Peruvian census, along with another town of similar demographic statistics which was used for the pilot study. Fieldworkers conducted interviews in Carhuaz and in more isolated hamlets within a half hour to two-hour walking radius of the city.

For the most part, people in Carhuaz and surrounding towns support themselves through agriculture, hand farming potato, wheat, bovine, and ovine at subsistence levels, or slightly above. Many homes lack water, sewers, electricity, and access to mass media; and many adults have not attended school (about 30%), or have very basic levels of schooling (Baker, Benavides, & Peters, 2009). A family's wealth relates more to farm size than level of education; thus, compulsory schooling is not strictly adhered to in the highlands, and depends more on non-cognitive reasons like access, money, and gender preference than innate cognitive ability. As a result, we were able to capture schooling effects with ethically permissible natural studies. The IRB approval number for this study is 24840.

Affiliates of Penn State and GRADE trained six Peruvian fieldworkers to conduct cognitive tests and demographic and health surveys for the study. The fieldworker team included two men and four women from the highlands, under the rational that locals would be able to establish easier rapport with the subjects. The fieldworkers selected people to interview in Carhuaz and nearby towns. A total of 247 people, $n = 247$, between the ages of 30 and 60 were interviewed, each in two, two-hour sessions, over two days.

Fieldworkers gathered information on executive functioning, schooling, demographics, and crystallized intelligence. Executive functioning was assessed with four tests: Verbal Fluency, Backward Digit Span, the Raven, and the Tower Test. The Verbal Fluency Test requires subjects to list as many related things possible (i.e. animals) in a limited period of time, evaluating the ability to cluster and shift between ideas (Troyer, Moscovitch, Winocur, Leach, & Freedman, 1998). The Backward Digit Span involves repeating sequences of numbers in reverse, starting with two numbers and progressing to eight. It is a measure of working memory. The Raven's Colored Progressive Matrices require subjects to complete patterns, measuring abstract reasoning and general fluid cognitive ability (Blair, 2006). The Tower Test asks subjects to construct a series of towers by moving five different- sized rings between three pegs, from an initial orientation to a prescribed final orientation, while observing four rules. The Tower Test assesses planning, strategizing, working memory, and attention-shifting.

Data on schooling included the highest grade level completed, age during schooling, and reasons for beginning and ending school. Demographic information consisted of age, gender, socio-economic status, native language, religion, and reading and writing ability. Native language serves as an indicator of income, since people born into Quechua-speaking homes often have less education and fewer economic resources. We controlled for these variables when measuring schooling effects. We also used the Peabody Picture Vocabulary Test (PPVT) to control for crystallized intelligence, adapting the Spanish version of the test for Quechua speakers. The following chart contains reliability scores for the PPVT test and applicable measures of executive functioning in this study. It is important to note the low reliability score for the Quechua version of the Tower Test, which likely affected results. The other tests have relatively high levels of reliability:

Table 1-1. Reliability of Executive Functioning Measures

	Backward Digits	Tower Test	Raven	PPVY
Spanish	0.773	0.625	0.832	0.964
Quechua	0.711	0.318	0.808	0.951
Both	0.717	0.613	0.679	0.971

Results

After calculating scores on the EF measures, we ran statistical tests to assess aggregate performance. The means on Verbal Fluency, Backward Digits, and the Tower Test fall substantially below the maximum scores. Since the standard deviations are relatively small, one can assume that the high-performing outliers are unusual in the Ancash region. Though the largest standard deviations occurred on the Raven and PPVT tests, the Raven and PPVT contain more questions than the other tests, providing a greater margin for error and a variation that is proportionally similar to, if not smaller than, that on the other tests.

Table 2-1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Verbal Fluency	246	16.58	4.80	6.00	31.00
Backward Digits	247	3.36	2.08	0.00	10.00
Tower Test	247	6.82	3.66	0.00	21.00
Raven	247	100.00	15.00	64.64	133.37
PPVT/IQ	246	100.00	15.00	55.05	123.18

As far as relationships between schooling, EF tests, and crystallized intelligence, we see that schooling and PPVT have the highest correlation, *r*=.71. This makes sense since PPVT scores are based on factual knowledge and vocabulary that students are taught or exposed to in school. PPVT has strong correlations with all of the EF tests, but the strongest with the Raven test, *r*=.66. The size of this correlation is interesting since the Raven experiences the largest schooling effects (see following paragraph), even after controlling for scores on the PPVT. Schooling and the Raven test have a correlation of *r*=.60. Schooling, the PPVT, and the Raven also highly correlate with the Backward Digits test, the other EF measure which shows statistically significant schooling effects. Meanwhile, the Tower Test has the lowest correlations with schooling, EF measures, and PPVT.

Table 3-1. Correlations between Schooling and Executive Functioning

	Schooling	**Verbal Fluency**	**Backward Digits**	**Tower Test**	**Raven**	**PPVT**
Schooling	1.00					
Verbal Fluency	0.41 (0.00)	1.00				
Backward Digits	0.56 (0.00)	0.39 (0.00)	1.00			
Tower Test	0.24 (0.00)	0.24 (0.00)	0.38 (0.00)	1.00		
Raven	0.60 (0.00)	0.36 (0.00)	0.53 (0.00)	0.34 (0.00)	1.00	
PPVT	0.71 (0.00)	0.47 (0.00)	0.54 (0.00)	0.34 (0.00)	0.66 (0.00)	1.00

We did a linear regression analysis and found significant schooling effects for all of the measures of EF, prior to controlling for personal background and crystallized intelligence. The Raven showed the largest schooling effects with a regression coefficient of r=9.142. Significant schooling effects remained after we controlled for age, gender, area of residence, and native language. The Raven continued to experience the largest effects from education and had a regression coefficient of r=7.575. Controlling for crystallized intelligence, however, yielded statistically significant schooling effects for only two of the EF measures: Backward Digits and the Raven. The regression coefficient for Backward Digits was .105 and, for the Raven, 3.348. The regression coefficients for crystallized intelligence were .1277 and .437, respectively. It is important to note that despite statistical significance, schooling effects on the Backward Digits test are small. Meanwhile, the Verbal Fluency test narrowly missed the .05 significance level with *p*=.066, and the Tower Test had a p-value as high as *p*=9.80.

Table 4-1 to 4-4. Regression Analysis

Table 4-1. Schooling Effects on Verbal Fluency

	Verbal Fluency	**p-value**	**Standardized Coefficient**
Schooling	1.991	0.000	0.407
Schooling Demographics	1.985	0.000	0.406
Schooling PPVT Demographics	0.759 0.127	0.066 0.000	0.156 0.397

Table 4-2. Schooling Effects on Backward Digits

	Backward Digits	**p-value**	**Standardized Coefficient**
Schooling	1.198	0.000	0.564
Schooling Demographics	1.082	0.000	0.510
Schooling PPVT Demographics	0.105 0.035	0.000 0.000	0.224 0.531

Table 4-3. Schooling Effects on Tower Test

	Tower Test	p-value	Standardized Coefficient
Schooling	0.879	0.000	0.235
Schooling Demographics	0.818	0.002	0.219
Schooling PPVT Demographics	-0.008 0.085	0.980 0.000	-0.002 0.349

Table 4-4. Schooling Effects on Raven

	Raven	p-value	Standardized Coefficient
Schooling	9.142	0.000	0.598
Schooling Demographics	7.575	0.000	0.495
Schooling PPVT Demographics	3.348 0.437	0.001 0.000	0.219 0.437

Chapter 3
Conclusion

Schooling and Executive Functioning in the Peruvian Highlands

The results show moderate schooling effects on the EF measures used in Peru, given that two of the four had statistically significant results, and only the Raven had a high regression coefficient. Consequently, we can only partially accept the hypothesis that education would have a large impact on executive functioning. We unpack the meaning of such significance and lack of significance as follows:

First, how much stock can we put in the Raven test as a tool to evaluate executive functioning? Prabhakaran, Smith, Desmond, Glover, & Gabrieli (1997) provide convincing evidence for the superiority of the Raven as a measure of EF. Using numerous brain scans, Prabhakaran, et al. show how "brain regions critical for verbal working memory are also powerfully engaged when reasoning analytically about nonverbal visual patterns" like in the Raven test. Prabhakaran, et al. suggest that Raven tests activate most of the working memory systems, providing an ideal forecasting tool. Other cognitive functioning tests probe one or two working memory systems, which does not represent real-world stimulation or cognitive demands (Prabhakaran, 1997). While working memory is only one of the three commonly recognized elements of executive functioning (the others being inhibitory control and attention shifting), cognitive functions share neural pathways (Prabhakaran, 1997), and dominance in any of the areas is noteworthy. Based on information above, we can deduce that the strong regression coefficient for the Raven test overrules the weaker one for the Backward Digits, since they both measure working memory.

Explanations also exist for the EF tests which did not experience significant schooling effects. For Verbal Fluency, it is important to note that subjects were tape recorded so fieldworkers could listen to subjects' answers more than once if they spoke quickly. Some people chose not to be recorded, which meant that fieldworkers recorded answers as they were supplied, with no way to verify what was said. Other subjects agreed to be recorded, but were visibly nervous about the recording device. Fieldworkers reported such anxiety in their observations, and it could have affected thought processing.

The results of the Tower Test may have been compromised by language, since the tests given in Quechua had lower reliability than those given in Spanish. We eliminated some of the Quechua tests in calibrating the scores for the Tower Test, which could have reduced the sample size enough to change the significance level. If the Quechua instructions were unclear, then people who normally could have completed the task but remained in the sample, could also have affected this measure. The Tower Test was also the only test given out of order or on different days, since fieldworkers sometimes forgot materials. Applying the Tower Test at the end of another session, such that one session would be shorter than usual and the other longer, may have created a cognitive overload. If interviewers returned on third day, fieldworkers may have had trouble attracting subjects' attention, since subject motivation and attention span could have waned. It is also possible that this test generated more confusion than the other tests, which impeded performance. Several subjects required the instructions to be repeated more often than usual, and others successfully created the towers and followed the rules, but put the tower on the wrong peg. These issues should be taken into account next time a study like this is conducted.

Now that we have established a relationship between schooling and some EF measures, we address the question of significance:

Schooling, Cognition, and Health

The other half of the story is a strong correlation between schooling, cognition, and health outcomes. Though statistical proof lies beyond the scope of this study, the following two sections will corroborate this relationship, and, from there, provide context for the value of schooling effects on EF.

O'Toole (1990) demonstrates the relationship between schooling, cognition, and health using the Australian Veterans Health Studies (AVHS). The men in the AVHS were 18 years old upon enlistment (between June 1965 and February 1971), signing up to serve in Vietnam. By January 1982, 523 men (1.2% of the cohort) had died for non-service-related reasons. Close to half of the deaths (217) resulted from motor vehicle accidents, where 80% were drivers. Medical, psychological, and personal records show that the decedents had lower scores on the army intelligence test and less education. It is important to note that age may have been a confounding variable in the study, since the youngest members of the cohort were more likely to die in motor vehicle accidents.

Handling risky situations can be a complex process, and Gottfredson (1997) determines that general intelligence (g) is a strong predictor of performance in complex situations. One of our most significant complex responsibilities is managing personal health, which Gottfredson (2004) connects to g. g helps determine how quickly people incorporate new health knowledge (Gregson, Waddell, & Chandiwana, 2001), how much they practice preventative care (Adler, Boyce, Chesney, Folkman, & Syme, 1993; Goldenberg, Patterson, & Freese, 1992), and how effectively they comply with doctor recommendations. Interestingly, greater distribution of health information does not weaken the relationship between cognitive ability and health, but strengthens it (see *The Black Report* by Townsend & Davidson, 1982; Link & Phelan, 1995, p. 86; Marmot, Kogevinas, & Elston, 1987, p. 132; Susser, Watson, & Hopper, 1985, p. 237).

Hart, Taylor, Smith, Whalley, Starr, Hole, Wilson, & Deary (2003) analyze childhood IQ, social class, deprivation, and their relationships with mortality and morbidity risk. Using the Scottish Mental Survey 1932 (SMS1932), Hart et al. identified 549 men and 373 women with complete data. During the 25 year follow-up of the study, 282 men and 140 women died, and the risk of dying was 17% higher for each standard deviation decrease in childhood IQ. After controlling for social class and deprivation, the risk was reduced to 12%, a statistically significant change ($p < .05$). The relationships between IQ and social class or deprivation were tested with a Cox regression model, with IQ and social class showing a non-significant interaction ($p = .73$) and IQ and deprivation showing a significant interaction ($p = .026$). High deprivation and IQ exhibited a significant negative relationship, while low deprivation and IQ showed a "flatter, non-significant, negative relationship." A structural equation model demonstrated that "there is a small direct effect of IQ on death, a second effect this is indirect, via deprivation, and a third that is indirect, via social class and deprivation." Overall, Hart et al. demonstrated that deprivation and social class can explain some but not all of the relationship between childhood IQ and mortality risk.

Lubinski (2009) supports Hart et al.'s finding that general cognitive ability has a greater effect on health than socioeconomic status. Lubinski identified the top 1% of students on a measure of cognitive ability for each gender, along with the top 1% of students on a measure of SES from a stratified random sample of U.S. 10^{th} graders. The highly intelligent and wealthy students both exhibited greater levels of cognitive ability and SES than the norm. Lubinski controlled for the overlap between cognitive ability and SES ($r \approx .40$) by studying siblings, in which one in the pair falls in a "normal" IQ range, and the other falls above or below that. The highly intelligent students were closer to the norm on SES than to the wealthy; and the wealthy were closer to the norm on cognitive ability than to the highly intelligent. Overall, both the intellectually gifted and environmentally privileged groups had better health outcomes than the norm. However, "medical and physical well-being appear to be more highly associated with extreme levels of intellectual giftedness than extreme levels of SES privilege."

Leigh (1983) approaches the relationship between schooling and health differently, hoping to show intervening effects from occupation and lifestyle. Leigh posits that higher levels of education qualify people for safer, healthier jobs. He also sets out to test Grossman's (1975; 1982) arguments that educated people favor healthy habits (i.e. exercise) over unhealthy ones (i.e. smoking) and are more "efficient producers of health." Using data from the University of Michigan's Quality of Employment Surveys (QES) for 1973 and 1977, Leigh finds that in the 1973 QES schooling is "strongly and negatively associated with smoking and holding a dangerous job;" and in the 1977 QES, "schooling is strongly and positively associated with exercising but negatively associated with holding a dangerous job." After running a regression, Leigh determines that occupation and lifestyle are important intervening variables in the relationship between schooling and health.

Kemna (1987) refutes Leigh's finding that occupation is a significant intervening variable. Using data from the 1980 *Health Interview Study* (HIS) and information from the *Dictionary of Occupational Titles,* Kemna shows through regression analysis that the direct effect of schooling is the most potent. The direct effect of schooling explains 70-90% of the total effect of schooling on health, while occupation explains less than 10% for most of the sample.

Education's Social Vaccine

After demonstrating the relationships between schooling, cognition, and health, we move to final task of the paper: tying up loose ends. Why does it matter if schooling, cognition, and health are related? Some scholars and policymakers suggest that education is a "social vaccine" against diseases like AIDS. This argument would substantiate the claims of and need for school-based interventions in developing countries. The reality regarding the role of education in health interventions is more complex:

Vandemoortele & Delamonica (2000) posit that at the beginning of the AIDS epidemic, those with more education and higher SES and mobility are more susceptible to the disease, but that the relationship does not persist through time, as the aforementioned people adjust their behaviors to manage the risk. While this transition has taken place in developed countries like the United States and those in Europe, the protective nature of education has yet to fully assert itself in developing countries, particularly those in Africa (Gregson, Zhuwau, Anderson, & Chandiwana, 1998, Gregson, et al, 2001; Vandemoortele & Delamonica, 2000; and Fylkesnes, Musonda, Sichone, Ndhlovu, Tembo, & Monze, 2001).

Rindermann & Meisenberg (2009) has since found a strong negative effect of cognitive ability (presumably influenced by education) and small positive effects of GDP and modernity on HIV prevalence in sub-Saharan Africa. Rindermann's & Meisenberg's path model yielded the following betas: βCA → HIV= -.69; βGDP → HIV= .07; and βMod → HIV= .21. However, these effects are not yet widespread.

Oesterdiekhoff & Rindermann (2007) suggest that one of the reasons education has been less successful at slowing the spread of AIDS in the developing world, particularly in Africa, is that people interpret the risk with a pre-operational, rather than formal operational, mindset.

Members of the developed world move out of Piaget's pre-operational stage at the end of childhood, but lack of formal education in Africa relegates people to this stage for a longer or indefinite time. A pre-operational mindset involves limited understanding of concepts like causality, probability, and chance; thus, people do not associate risky sexual behaviors with greater vulnerability to the disease. Instead, many view AIDS as a mystical phenomenon. They believe that uttering the name of the disease can summon it and that its infection is a punishment from magical powers ("god, devil, CIA, white man, the West"). As a result, education which involves speaking about the disease is "not understood as first step to the removal of the misery but as a direct path to hell." Nevertheless, Oesterdiekhoff & Rindermann attest that education and cognitive ability can reduce the prevalence of HIV, and such a relationship already exists in some parts of the world.

All considered, research suggests that the role of education in health interventions is complex and beneficial through time. Education enhances executive functioning (fluid intelligence) and crystallized intelligence, with growth in EF cognitive processes facilitating healthier decision making and positive health outcomes. We successfully showed some of the schooling effects on cognition in the case study in Peru, which suggests that education-based intervention programs could play a significant role in improving health around the world. While more research is needed on the relationship between schooling, executive functioning, and health outcomes; it is exciting to identify a feasible way to address the universal issue of ill health.

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