Mental Relaxation at the End of Formal Schooling

Andrew Jabara

Abstract

This paper examines whether "mental retirement" effects on cognitive ability upon retirement from the workforce can also be found as "mental relaxation" effects in people upon the end of their formal schooling. I examine data from the Programme for the International Assessment of Adult Competencies (PIAAC) in Britain, Norway, Sweden, and Denmark, taking advantage of different typical graduation ages at the end of tertiary-level schooling to see if these effects are present. After examining these four countries, my results are inconclusive. I do not find any significant evidence of an increase or decrease in cognitive ability caused by the end of formal schooling.

Introduction

Is there evidence of a decrease in cognitive ability following the end of formal schooling? In a paper that motivated my inquiry, Rohweddar and Willis (2007) find evidence of “mental retirement” effects, a sharp decrease in cognitive ability in people who had recently retired from the workforce. The authors hypothesize that this decrease is because people experience less mental stimulation when in retirement than when they are active in the workforce. However, there is no current literature I am aware of that examines effects on cognitive ability by similar transitions earlier on in peoples’ lives.

It is commonly claimed that the broad cognitive demands expected of college or university-level students are more demanding than the more narrowly focused cognitive demands of the workforce. If so, then there may exist “mental retirement” effects seen in people who recently graduate from college, and enter into the workforce. Of course, as sharp a decline in cognitive ability is not necessarily anticipated; Ardila et. al. (2000) find that the 16-30 year range is the time of peak cognitive attainment for more-educated people. Instead, it is more plausible to look for “mental relaxation” effects, a term I coin to refer to either a small decrease or stagnation in cognitive ability.

If these “mental relaxation” effects do indeed show a decrease in cognitive ability following the end of formal college or university-level schooling, then there might exist a disconnect between the expected cognitive capacities of college-educated students and the cognitive demands that they face when converting an investment in education into monetary benefits in the labor force. This can also be understood as a broad underutilization of human capital in countries where these effects are found to exist.

I use a differences-in-differences style methodology to compare the cognitive ability of students and recent graduates in Britain, Norway, Sweden, and Denmark. Using data obtained from the Programme for the International Assessment of Adult Competencies (PIAAC), I test for mental relaxation effects by making use of a "natural experiment" of different typical graduation ages for students who obtain degrees equivalent to a Bachelor's degree in the United States.

Literature Review

This review examines previous literature on the topic of mental retirement and cognitive ability. I discuss the Rohweddar and Willis (2010) paper on the existence of mental retirement effects, the Ratner et. al. (1987) paper that examines links between cognitive ability and cognitive demands, and the Ardila et. al. (2000) paper that discusses the relationship between cognitive ability and age.

Rohweddar and Willis (2010) explore the idea of "mental retirement," where the less cognitively-demanding life of a retiree leads to a sharp decline in his or her cognitive ability. In their study, data is drawn from the U.S. Health and Retirement Study (HRS), English Longitudinal Study of Ageing (ELSA), and the Survey of Health, Ageing and Retirement in Europe (SHARE) to cross-nationally compare older people in the United States, England, and 11 European countries (Sweden, Denmark, the Netherlands, Germany, Switzerland, Austria, France, Belgium, Spain, Italy, and Greece).

Rohweddar and Willis first demonstrate a drop in mean cognitive performance as a function of drop in employment rate by comparing men ages 50-54 and men ages 60-64 in these countries. For the full regression analysis, they use a two-stage regression to examine 60-64 year old people in the selected countries. Their final estimate of the effects of retirement (or "not working for pay" more precisely) corresponds to a reduction in memory score by 4.7 points on a scale from 0 to 20, or an estimated decrease on the magnitude of 1.5 standard deviations. Given the accuracy and magnitude of these estimates, Rohweddar and Willis posit that these mental retirement effects lead to significantly decreased quality-of-life welfare outcomes.

Ratner et. al. (1987) examine cognitive ability through the narrow lens of memory performance. In the study, 64 women were recruited to one of three stratified groups: young adults in college, young adults not in college, and retired adults. All subjects were given four stories, with the control being told to remember the information and the treatment being told to remember the information word-for-word. The authors coded the results by awarding credit for recall of category, content, or both.

By stratifying these three groups, Ratner et. al. find that young adults not in college performed more like the old counterparts than their similar-aged peers, indicating that memory decline in relation to cognitive ability may result as much from cognitive demands in life as from expected biological degradation. The researchers further discuss how schooling influences and stimulates aspects of cognition for those currently obtaining schooling. This discussion acknowledges the fact that there are many outside factors that may lead someone to obtain or not obtain college-level education, but raises the point that whether someone is engaged in the cognitive demands of college or not can possibly affect their cognitive ability. No testing, however, was done to explore the causal effect these college cognitive demands could have on young adults currently in or not in college.

Ardila et. al. (2000) explore the effects of education on cognitive decline during normal aging. Using an 806-subject sample taken from five regions in Mexico, Ardila et. al. separates the subjects into categories by years of schooling, with the final category being 10+ years of education. By administering a neuropsychological test testing verbal ability, motor ability, memory, visual detection, and simple calculation, along with previous data that showed this test's standardized instruction led to very consistent scoring by examiners (correlation coefficients ranged from 0.93 to 1.00), the researchers could calculate an appropriate score of cognitive ability.

This paper has two important takeaways. First, large differences in cognitive performance between the higher and lower education groups are observed, with the 66-85 group displaying 70% of the cognitive ability of the 16-30 group if more highly educated, compared to 49% cognitive ability of the 16-30 group if less educated. Second, Ardila et. al. observe that the 16-30 age group has the highest cognitive performance for more highly educated people and overall, although that the 31-50 age group has the highest cognitive performance for less educated people. While Ardila et. al. focus on Mexico to generalize age-related cognitive decline, the fact that their data is only drawn from one country is an important caveat of the results.

One major problem that Ardila et. al. (2000) face with the first takeaway is the existence of confounding effects of attainment of education; while amount of education is correlated with higher outcomes on many of the neuropsychological test's facets, the researchers acknowledge that the population of those who are able to obtain more education may be very different than those who obtain less education, just like Ratner et. al. (1987). Looking at similar education levels and comparing different age levels helps take some of this into account, but Ardila et. al. also add caveats about cohort effects due to exogenous circumstances over the decades.

For the second takeaway, Ardila et. al. theorize, but do not attempt to prove in their paper, the idea that lower levels of cognitive stimulation result in slower cognitive development. They further comment that people who advance further the education system are usually highly stimulated in tasks that are used in neuropsychological tests of cognitive ability, while those who are not in or out of the educations system do not receive the same stimulation.

Empirical Strategy

Does a person's cognitive ability decrease due to the end of a formal college or university-level schooling? By examining populations of individuals before and after graduating college at their country's typical age of college education attainment, I can detect whether or not a decrease in cognitive ability exists.

Evidence in support of the hypothesis that a decrease in cognitive ability does exist would be empirical evidence that demonstrates a statistically significant decrease in the measured cognitive ability of a person. My hypothesis would be nullified if there was no statistically significant decrease in cognitive ability, or contradicted if there was a statistically significant increase in cognitive ability instead.

My full empirical strategy involves a combined differences-in-differences regression comparing cognitive ability using data on Britain, Norway, Sweden, and Denmark, where the difference in treatment is a difference in typical college graduation age for each of these countries. For a Bachelor's equivalent degree, Britain's typical age is 21, Norway's typical age is 23, Sweden's typical age is 22, and Denmark's typical age is 25-27 ("Typical Graduation Age, by Level of Education").

First, I generate scatterplots to see if there is any visual indication of mental relaxation after the expected graduation age for each country. I create two scatterplots per country, one showing the relationship between a cognitive test of literacy and age, and one showing the relationship between a cognitive test of numeracy and age. People who are no longer in school at or before the age of 20 are excluded from the data to better capture a relationship between people who are still in college, and people who have finished college.

Second, I run a two-stage least squares regression to determine if mental relaxation effects can be found.

For the first part of this two-stage regression, I instrument the variable $I_{ij}^{Still\ in\ School}$ using a dummy variable for whether a person's age is less than or equal to the typical graduation age in their country:

$$I_{ij}^{Still\ in\ School} = \beta_0 + \beta_1 I_{ij}^{age \leq typical\ graduation\ age} + u_{ij}$$

$1 \leq i \leq$ the number of people observed, and $1 \leq j \leq$ the number of countries. Since I am comparing four different countries, j=1 is Denmark, j=2 is Norway, j=3 is Sweden, and j=4 is Britain.

$I_{ij}^{age \leq typical\ graduation\ age}$ serves as a good instrument because whether a person's age is less than or equal to the typical college graduation age of a country is not expected to be correlated with cognitive ability. On the other hand, $I_{ij}^{age \leq typical\ graduation\ age}$ is expected to be correlated with whether someone is still in college or not.

For the second stage of this two-stage regression, I run the regression

$$TESTSCORE_{ij} = B_0 + B_1 \hat{I}_{ij}^{Still\ in\ School} + \mathbf{I}_{j}^{Country}\gamma + \mathbf{I}_{i}^{Age}\alpha + \varepsilon_{ij}$$

TESTSCORE is the dependent variable in this regression that can be replaced with any particular test of cognitive ability that could be used to measure differences in cognitive ability. For example, a test in numeracy or a test in literacy could be used as the dependent variable TESTSCORE. Using these tests, I run two second-stage regressions: one for a cognitive test of numeracy, and one for a cognitive test of literacy. The two equations would then be

$$LITERACY_{ij} = B_0 + B_1 \hat{I}_{ij}^{Still\ in\ School} + \mathbf{I}_{j}^{Country}\gamma + \mathbf{I}_{i}^{Age}\alpha + \varepsilon_{ij} \text{ and}$$

$$NUMERACY_{ij} = B_0 + B_1 \hat{I}_{ij}^{Still\ in\ School} + \mathbf{I}_{j}^{Country}\gamma + \mathbf{I}_{i}^{Age}\alpha + \varepsilon_{ij}$$

where $LITERACY_{ij}$ is the test score in literacy for every person i from country j, and $NUMERACY_{ij}$ is the test score in numeracy for every person i from country j.

$\hat{I}_{ij}^{Still\ in\ School}$ consists of the predicted values of $I_{ij}^{Still\ in\ School}$ from the first stage of the regression, for every person i from country j.

$\mathbf{I}_{\boldsymbol{j}}^{\boldsymbol{Country}}$ is a set of dummy variables for each country j. Country 1 is Denmark, Country 2 is Norway, Country 3 is Sweden, and Country 4 is Britain.

$\mathbf{I}_{\boldsymbol{i}}^{\boldsymbol{Age}}$ is a set of dummy variables for each possible age in the data used to run this regression. This set of variables is designed to act as a set of control variables in this regression.

Data

The ideal data for testing my hypothesis would be two sets of data from populations that are effectively perfect controls for one another, with the only difference being that one population's expected end of formal schooling for a college-level degree is at least two years less than the second population. This would allow for a simple differences-in-differences to determine if the end of college-level schooling, and formal schooling overall, led to a decrease in cognitive ability, or at least an overall stagnation in cognitive ability.

Necessary data to run my empirical strategy include a variable to identify which country a person is from, the typical college-level graduation age in each country, one test score that serves as a measure of cognitive ability, an indicator variable for whether or not a person is currently in school, the highest level of schooling a person completed, and the current age of the person.

Data that would be good to have, but is not absolutely necessary, include additional measures of cognitive ability as dependent variables in the regression and a set of background variables that confirm the countries are near-perfect controls for one another.

Since I do not have idyllic data, I draw my data from the Programme for the International Assessment of Adult Competencies (PIAAC) instead, with some insight from the International Standard Classification of Education (ISCED) 2011 as well.

ISCED 2011 is a standardized education level system across countries for comparison purposes. In this paper, I am most immediately concerned with people who have completed United States high-school equivalent education (ISCED level 3) and who have completed or are completing the equivalent of a Bachelor's degree in the United States (ISCED level 6).

The PIAAC, also known as the "Survey of Adult Skills," is a multinational survey of adults that collects many background variables, and attempts to gauge key cognitive skills for societal and economic prosperity. Over 40 countries are on track to be surveyed or have been surveyed by the PIAAC during its next iteration, and over 150,000 adults were tested in 24 countries during the first round of testing ("About PIAAC"). Adults ages 16-65 were surveyed in their homes, with administered tests focusing on literacy and numeracy. The survey was designed to be cross-culturally and cross-nationally valid, and able to be repeated over time ("Technical Report of the Survey of Adult Skills (PIAAC)"). The first round, from 2008-2013, has data from nearly a dozen European countries to draw from for the purposes of my paper.

In particular, I focus on the countries of Britain, Sweden, Norway, and Denmark. Although a major disadvantage of the PIAAC relative to my ideal data is that it does not have enough background variables to clearly demonstrate that Britain, Norway, Sweden, and Denmark can be considered good "controls" for one another, some online sociodemographic data lends credence to the belief that many variables, including GDP per capita, gender ratios, age demographics, and "K-12" equivalent education duration are reasonably close in these four countries ("Country Facts").

From each country's data profile, I first use the following variables:

Table 1: Variables from PIAAC Datasets

Variable Name	Description	Variable Type
CNTRYID	Country ID	Categorical (Denmark = 208, Norway=578, Sweden=752, Britain=826)
AGE_R	Current age of an individual	Integer (16-65)
B_Q02A	Indication whether or not an individual is currently enrolled in school or not	String (Yes="1"/No="2")
EDCAT8	An education qualification variable that corresponds to ISCED levels of education	String ("1" to "9")
PVLIT*	A set of ten plausible derived scores of proficiency in literacy	Numeric (0-500)
PVNUM*	A set of ten plausible derived scores of proficiency in numeracy	Numeric (0-500)

I then generate several new variables for the regression analysis. CNTRYID and AGE_R will remain as they are, but I change the rest of the variables into more usable data. I convert B_Q02A into a numeric indicator variable named INSCHOOL, and I convert EDCAT8 into a numeric variable named EDCAT, both for ease of identification purposes and to change the data to numeric values. I take the average of PVLIT* and the average of PVNUM* for each person to create two numeric variables that serve as tests of cognitive ability, named PVLIT and PVNUM, respectively. I create an indicator variable CUTOFF, which indicates whether and person from a certain country is below the typical college-level graduation age or not. I use AGE_R to create a full set of indicator variables for the range of ages in the dataset, named ISAGE*. Finally, I will create a full set of indicator variables for the range of countries in the dataset, named COUNTRY*. Each individual is assigned a value of 1 for the country they are a part of, and a value of 0 for the other country dummy variables.

The full list of variables I use is below:

Table 2: Variables used for Empirical Analysis

Variable Name	Description	Variable Type
CNTRYID	Country ID	Categorical (Denmark = 208, Norway=578, Sweden=752, Britain=826)
AGE_R	Current age of an individual	Integer (16-65)
INSCHOOL	Indication whether or not an individual is currently enrolled in school or not	Numeric (0=No, 1=Yes)
EDCAT	An education qualification variable that corresponds to ISCED levels of education	Numeric (1-9)
PVLIT	The average of ten plausible derived scores of proficiency in literacy	Numeric (0-500)
PVNUM	The average of ten plausible derived scores of proficiency in numeracy	Numeric (0-500)
CUTOFF	An indicator variable for whether or not a person in a certain country is above or below the typical college-level graduation age	Numeric (0=above age cutoff, 1=below age cutoff)
ISAGE*	A full set of indicator variables for each possible age of a person in the cleaned data	Numeric (0=not this age, 1 = is this age)
COUNTRY*	A full set of indicator variables for each possible country a person could be from	Numeric (Denmark=1, Norway=2, Sweden=3, Britain=4)

Descriptive statistics for variables from the cleaned and combined data can be found in Table 4. These statistics include number of observations, missing observations, and basic descriptive statistics (mean, standard deviation, min, max) when relevant. Overall, I use 3,132 observations from four countries to run my empirical strategy, with one observation that is missing a person's test scores omitted from the final regression. One interesting discovery is the wide range of PVLIT and PVNUM scores, which are scored on a 0-500 point scale for all countries ("Key facts about the Survey of Adult Skills"). For PVLIT, scores ranged from 91.85 to 408.11 with a standard deviation of 41.56 points, and for PVNUM, scores ranged from 84.65 to 444.13, with a standard deviation of 46.25 points.

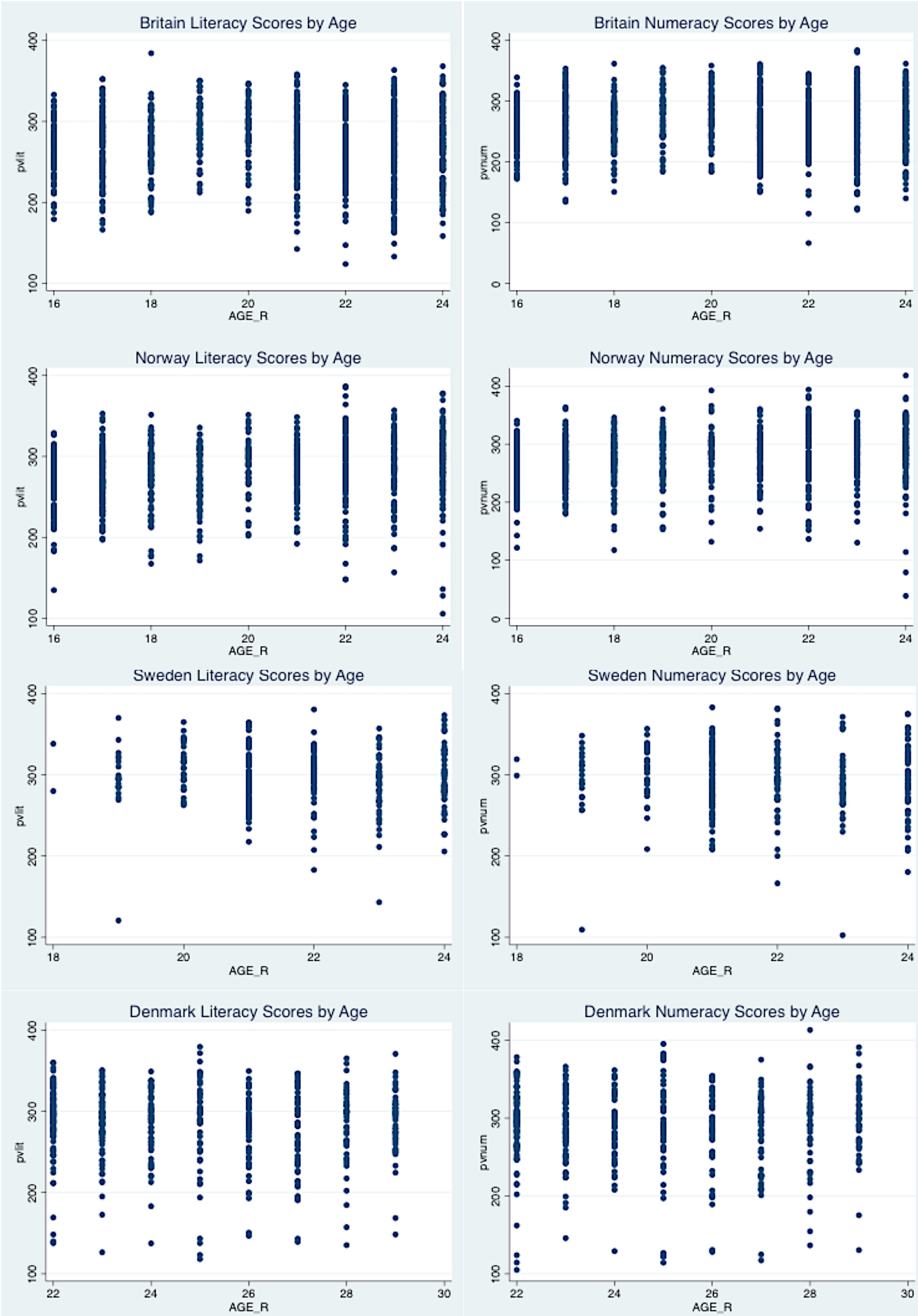
There are several assumptions I must make with this data. Most pressing, as I mentioned before, is the assumption that I can compare Britain, Norway, Sweden, and Denmark to each other. The PIAAC does not provide enough useful statistics to compare these countries' inhabitants, so I use large-scale statistics of these countries to claim that they are fine comparisons (see Table 3 for the a list of these statistics). To further strengthen this argument, the PIAAC data was specifically designed with a cross-national validity of results in mind, especially important when considering the literacy test of cognitive ability.

A second assumption to note is that the people who were tested in the PIAAC were from the country they were recorded in, and went through that country's education system. For example, I am assuming that a person recorded by the PIAAC in Norway and given the "Norway" designation in the Country ID variable is from Norway, and went through Norway's education system (or at least higher education system).

Evidence

After creating two scatterplots for each country, there is some visual evidence for a decrease in the rate of cognitive ability, or at least a slowdown and stagnation in the increase in cognitive ability, immediately following the typical college-level graduation age. Each scatterplot removes observations where a person at or below the age of 20 is no longer enrolled in formal education, sets age as the x variable, and one of two measures of cognitive ability (literacy or numeracy) as the y variable. The scatterplots are grouped together by country and by type of cognitive ability test in Figure 1 below:

Figure 1: Literacy and Numeracy Scores by Age for Four Countries



As seen in Figure 1, in Britain, there appears to be a stagnation of both literacy and numeracy scores right at the typical college graduation age of 21, but more noticeable after a year during age 22. In Norway, there appears to be a more marked, albeit small, decline in ability from age 22 to the typical graduation age of 23, followed by an increase in average cognitive ability at age 24. In Sweden, there appears to be stagnation in literacy ability from age 21 to age 22, and stagnation in numeracy also appears evident. Finally, Denmark shows a decline in test scores on both cognitive tests of literacy and numeracy from the age of 25 to the average typical graduation age of 26.

For the first-stage instrumental variables regression, I run a probit regression on INSCHOOL using CUTOFF as the instrument (see Figure 2 for the first-stage regression output). To confirm that using the dummy variable CUTOFF is a reasonable instrument for INSCHOOL, I calculate correlations. CUTOFF has a correlation of -0.0278 with PVLIT, and a correlation of 0.0031 with PVNUM; both of these values effectively demonstrate no correlation. On the other hand, the correlation between CUTOFF and INSCHOOL is 0.3706, indicating that it CUTOFF indeed correlated with whether or not someone is in school.

To run the second-stage regressions, I use a modified 2SLS regression as recommended by Wooldridge (2002) to take into account my use of a probit regression in the first stage. After running the first-stage instrumental regression with a probit model, I use STATA's ivreg function to regress a test of cognitive ability with the ISAGE* and COUNTRY* variables in addition to the predicted INSCHOOL values.

For the second-stage regression on literacy I run, I use the four European countries to test for a difference in differences in measures of literacy using the PVLIT variable (see Figure 3). The coefficient on the instrumented INSCHOOL variable is 11.66592 points, or, when standardized, 11.66592/41.56545 = 0.281 standard deviations. However, the p-value of 0.461 is very large. This coefficient corresponds to a fairly large decrease in literacy score by 0.281 standard deviations for someone who is recently out of school versus someone who is still in school, but with a p-value of 0.461 it is clear that this result is not significant at any acceptable alpha level. Thus, using literacy scores, there is not enough evidence to claim the treatment on treated effect of finishing your formal college-level schooling is significantly different from 0.

For the second-stage regressions on numeracy I run, I again use the four European countries to test for a difference in differences, this time measuring cognitive ability in numeracy using the PVNUM variable (see Figure 4). The coefficient on the predicted INSCHOOL variable is 20.36389 points, or, when standardized, 20.36389/46.25094 = 0.440 standard deviations but the p-value of 0.245 is large. This coefficient corresponds to a large decrease in numeracy score by 0.44 standard deviations for someone who is recently out of school versus someone who is still in school, but with a p-value of 0.245 this result does not appear to be significant at any acceptable alpha level. Using numeracy scores, there is also not enough evidence to claim the treatment on treated effect of finishing your formal college-level schooling is significantly different from 0.

Although the coefficients are not statistically significant, there are a few important takeaways to discuss. First, there is no clear indication for whether the end of formal schooling causes an increase or decrease in scores of cognitive ability. Because the coefficient of the predicted INSCHOOL variable is interpreted as the increase in amount of points due to still being in school versus being done formal schooling, a significant positive coefficient in these regressions would have provided causal evidence of “mental relaxation” effects, and a significant negative coefficient in these regressions would have provided causal evidence of continued improvement in cognitive ability due to the completion of formal schooling. Unfortunately, the high p-values mean that we cannot be certain of the true coefficient and its sign: the 95% confidence interval has a range of -19.37715 to 42.70899 points for the effect of INSCHOOL on literacy, and a range of -13.99771 to 54.72549 points for the effect of INSCHOOL on numeracy. It is important to note that 0 is included in both these intervals, and that a "true" coefficient of 0 would imply that whether or not someone is in or has finished with their formal tertiary-level schooling has no effect on their cognitive ability.

Examining the statistical significance of these regressions, the p-values of 0.245 and 0.461 for the effect of completing formal schooling on numeracy and literacy, respectively, are fairly large. This points to two possibilities: either the relatively small data size makes it hard to obtain significant conclusions, or there is truly no effect to be found. If the latter case is true, then whether you have completed your formal schooling does not change your cognitive ability.

This inconclusive evidence regarding whether or not there is an increase in cognitive ability after the end of formal schooling could have implications on different forms of schooling that people may seek after the end of their formal schooling. If indeed the inconclusive evidence means that there truly is no change in cognitive ability whether you are in school or recently finished with formal schooling, then this could increase interest in continued educational development programs, such as massive open online courses (MOOCs) or university programs for professional development, both of which provide structured programs. If the end of formal schooling leads to a stagnation in cognitive ability, then it is possible that new graduates in the 16-30 age range may benefit from additional structured programs to increase their cognitive development, which could translate into higher productivity and thus welfare-enhancing benefits overall.

Conclusion

Based on the PIAAC data from Britain, Norway, Sweden, and Denmark, there is not enough evidence to say whether there is an increase or decrease in cognitive ability immediately following the end of formal schooling. In both literacy and numeracy, people who are no longer engaged in the formal schooling system following the end of their tertiary-level schooling corresponds to a coefficient indicating a decline in cognitive ability, but with high p-values this result is not statistically significant.

There are several caveats to these inconclusive results I have found. First, I make an educated assumption that all four countries are good controls when measuring cognitive ability in different age groups. Second, these results only pertain to the countries I have used, and more narrowly to students in these countries who are in or have completed tertiary-level ISCED 6 schooling. Third, with only about 3,000 observations pooled from four countries, my data size is fairly small, and could be a contributing factor to inconclusive evidence. Fourth, I do not stratify people by job occupation after completion of formal schooling, which could be an interesting avenue to pursue for further research. It is possible that future studies will provide more clear evidence of a positive or negative effect on cognitive ability at the end of formal schooling, and evidence of this effect in other countries as well.

Although I cannot draw clear conclusions from my data, it is worth noting some possible results should future studies more precisely determine an effect. If the true effect on cognitive ability at the end of formal schooling is actually significant and indicates a decline in cognitive ability, then the theory of mental retirement as postulated by Rohweddar and Willis has implications far earlier in peoples' lives. The idea that retirement leads to a decrease in tasks as cognitively demanding as being active in the paid workforce could be applied to the common notion that the cognitive demands of work are less demanding than the cognitive demands placed on people while in college. If the true effect of completing formal schooling on cognitive ability is in fact a precisely estimated zero, then there exists no causal effect between completion of formal schooling and cognitive ability.

Since they are inconclusive, my results suggest that the end of formal schooling does not have a causal effect on cognitive ability, and thus may not be very important in discussions of differences in educational systems across countries. If more conclusive evidence confirms a decline or stagnation in cognitive ability, contrary to my results and common notions of cognitive growth continuing after schooling, then the end of formal schooling instead may have major implications for human capital accumulation and decline, as well as for how countries structure their schooling systems and workforce.

Table 3: Comparative Facts for Denmark, Norway, Sweden, and Britain

	Denmark	Norway	Sweden	Britain (UK)
2015 GDP per Capita (100k)	51,989.29	74,400.37	50,579.67	43,875.97
Gender Ratio (males/female)	0.97	1.01	1	0.99
Age 15-64 years	64.16%	65.7%	62.77%	64.47%
Life Expectancy	80 years	81 years	82 years	81 years
% Urban Population	88%	80%	86%	82%
% Internet Users	96.33%	96.81%	90.61%	92%
“K-12” Equivalent Education Duration	13 years	13 years	12 years	13 years
Unemployment Rate	6.6%	3.4%	8.0%	6.3%

Source: “Country Facts”

Table 4: Statistics on Variables used for Regression

Variable Name	Brief Description	Number of Observations (# Obs=1)	Missing Obs.	Mean	Std. Dev.	Min	Max
AGE_R	Current age	3132	0	24.5	NA	18	29
CNTRYID	Country ID	3132	0	NA	NA	NA	NA
CUTOFF	Younger than typical college graduation age (1) or not (0)	3132 (1226)	0	NA	NA	0	1
EDCAT	Education level	3132	0	NA	NA	NA	NA
INSCHOOL	In school (1) or not (0)	3132 (1297)	0	NA	NA	0	1
PVLIT	Literacy score	3131	1	288.22	41.56	91.85	408.11
PVNUM	Numeracy score	3131	1	283.31	46.25	84.65	444.13
ISAGE*	Age 18	3132 (87)	0	NA	NA	0	1
ISAGE*	Age 19	3132 (132)	0	NA	NA	0	1
ISAGE*	Age 20	3132 (157)	0	NA	NA	0	1
ISAGE*	Age 21	3132 (330)	0	NA	NA	0	1
ISAGE*	Age 22	3132 (303)	0	NA	NA	0	1
ISAGE*	Age 23	3132 (316)	0	NA	NA	0	1
ISAGE*	Age 24	3132 (284)	0	NA	NA	0	1
ISAGE*	Age 25	3132 (251)	0	NA	NA	0	1
ISAGE*	Age 26	3132 (278)	0	NA	NA	0	1
ISAGE*	Age 27	3132 (248)	0	NA	NA	0	1
ISAGE*	Age 28	3132 (240)	0	NA	NA	0	1
ISAGE*	Age 29	3132 (245)	0	NA	NA	0	1
COUNTRY*	Denmark (=1)	3132 (652)	0	NA	NA	0	1
COUNTRY*	Norway (=2)	3132 (641)	0	NA	NA	0	1
COUNTRY*	Sweden (=3)	3132 (536)	0	NA	NA	0	1
COUNTRY*	Britain (=4)	3132 (1303)	0	NA	NA	0	1

Source: PIAAC Round 1 Data (2008-2013).
For the third column, the total number of observations for indicator variables are listed, with the number in parentheses being the number of observations for which the specific indicator variable is active. As an example, "3132 (87)" means that, out of 3,132 observations, 87 were age 18 when they filled out the survey.

Figure 2: First-Stage Instrumental Variable Regression

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. probit inschool cutoff

Iteration 0:   log likelihood = -2124.4995
Iteration 1:   log likelihood = -1766.3744
Iteration 2:   log likelihood = -1765.2568
Iteration 3:   log likelihood = -1765.2568

Probit regression                               Number of obs     =      3,132
                                                LR chi2(1)        =     718.49
                                                Prob > chi2       =     0.0000
Log likelihood = -1765.2568                     Pseudo R2         =     0.1691
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inschool	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
cutoff	1.286231	.0493709	26.05	0.000	1.189466	1.382996
_cons	-.7481749	.0318275	-23.51	0.000	-.8105556	-.6857941

This regression output was generated using STATA software. INSCHOOL is an indicator variable for whether or not someone is still in school or not. CUTOFF is an indicator variable for whether someone is younger than the typical graduation age in their respective country or not.

Figure 3: Second-Stage Regression using Literacy Score Data

Instrumental variables (2SLS) regression

Source	SS	df	MS
Model	248744.365	16	15546.5228
Residual	5158915.99	3,114	1656.68465
Total	5407660.35	3,130	1727.68701

Number of obs	=	3,131
F(16, 3114)	=	3.67
Prob > F	=	0.0000
R-squared	=	0.0460
Adj R-squared	=	0.0411
Root MSE	=	40.702

pvlit	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
inschool	11.66592	15.83244	0.74	0.461	-19.37715	42.70899
isage18	-12.70994	14.56729	-0.87	0.383	-41.27241	15.85253
isage19	-3.025338	13.66574	-0.22	0.825	-29.82011	23.76944
isage20	4.134477	13.33496	0.31	0.757	-22.01172	30.28067
isage21	-.5069363	6.23109	-0.08	0.935	-12.7244	11.71052
isage22	.8979788	5.757877	0.16	0.876	-10.39164	12.1876
isage23	-2.076685	5.220047	-0.40	0.691	-12.31177	8.158397
isage24	3.260856	4.772625	0.68	0.495	-6.096954	12.61867
isage25	2.268189	3.907457	0.58	0.562	-5.393264	9.929643
isage26	5.1766	3.666305	1.41	0.158	-2.012019	12.36522
isage27	-.4484126	3.675553	-0.12	0.903	-7.655165	6.758339
isage28	6.339876	3.668568	1.73	0.084	-.8531804	13.53293
isage29	8.908077	3.63659	2.45	0.014	1.77772	16.03843
country1	-13.60362	4.091946	-3.32	0.001	-21.6268	-5.580435
country2	-2.744198	2.629157	-1.04	0.297	-7.899254	2.410858
country3	0	(omitted)				
country4	-7.80889	2.223318	-3.51	0.000	-12.16821	-3.449571
_cons	288.4047	3.852767	74.86	0.000	280.8505	295.9589

This regression output was generated using STATA software. INSCHOOL in this regression contains the predicted values of whether or not someone is still in school obtained in a first-stage IV regression using an indicator variable for whether someone is younger than typical graduation age in each country or not (CUTOFF) as the instrument. ISAGE* and COUNTRY* are both full sets of indicator variables for each age and country in the dataset, respectively. PVLIT is a measure of cognitive ability via proficiency in literacy.

Figure 4: Second-Stage Regression using Numeracy Score Data

Instrumental variables (2SLS) regression

Source	SS	df	MS			
				Number of obs	=	3,131
				F(16, 3114)	=	6.48
Model	374682.959	16	23417.685	Prob > F	=	0.0000
Residual	6320855.15	3,114	2029.81861	R-squared	=	0.0560
				Adj R-squared	=	0.0511
Total	6695538.11	3,130	2139.14955	Root MSE	=	45.054

pvnum	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
inschool	20.36389	17.52493	1.16	0.245	-13.99771	54.72549
isage18	-21.49273	16.12455	-1.33	0.183	-53.10855	10.12309
isage19	-8.588049	15.12662	-0.57	0.570	-38.24721	21.07111
isage20	-3.86418	14.76047	-0.26	0.793	-32.80543	25.07707
isage21	-4.061012	6.897198	-0.59	0.556	-17.58453	9.462504
isage22	1.367893	6.373398	0.21	0.830	-11.1286	13.86438
isage23	-.5704454	5.778074	-0.10	0.921	-11.89967	10.75877
isage24	2.490196	5.282822	0.47	0.637	-7.867971	12.84836
isage25	3.83757	4.325167	0.89	0.375	-4.642899	12.31804
isage26	4.253565	4.058235	1.05	0.295	-3.703523	12.21065
isage27	-1.453507	4.068472	-0.36	0.721	-9.430667	6.523652
isage28	6.573891	4.06074	1.62	0.106	-1.388109	14.53589
isage29	9.308487	4.025344	2.31	0.021	1.415889	17.20108
country1	-11.65803	4.529378	-2.57	0.010	-20.5389	-2.777158
country2	-5.68393	2.910215	-1.95	0.051	-11.39007	.0222057
country3	0	(omitted)				
country4	-16.81427	2.460993	-6.83	0.000	-21.6396	-11.98894
_cons	284.9442	4.26463	66.82	0.000	276.5824	293.306

This regression output was generated using STATA software. INSCHOOL in this regression contains the predicted values of whether or not someone is still in school obtained in a first-stage IV regression using an indicator variable for whether someone is younger than typical graduation age in each country or not (CUTOFF) as the instrument. ISAGE* and COUNTRY* are both full sets of indicator variables for each age and country in the dataset, respectively. PVNUM is a measure of cognitive ability via proficiency in numeracy.

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