JYX JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ

This is a self-archived version of an original article. This version may differ from the original in pagination and typographic details.

Author(s): Sulkunen, Sari; Malin, Antero

Title: Literacy, Age and Recentness of Education Among Nordic Adults

Year: 2018

Version: Published version

Copyright: © 2017 The Author(s).

Rights: CC BY-NC-ND 4.0

Rights url: https://creativecommons.org/licenses/by-nc-nd/4.0/

Please cite the original version:

Sulkunen, S., & Malin, A. (2018). Literacy, Age and Recentness of Education Among Nordic Adults. Scandinavian Journal of Educational Research, 62(5), 929-948. https://doi.org/10.1080/00313831.2017.1324898

Scandinavian Journal of Educational Research

ISSN: 0031-3831 (Print) 1470-1170 (Online) Journal homepage: http://www.tandfonline.com/loi/csje20

Literacy, Age and Recentness of Education Among Nordic Adults

Sari Sulkunen & Antero Malin

To cite this article: Sari Sulkunen & Antero Malin (2018) Literacy, Age and Recentness of Education Among Nordic Adults, Scandinavian Journal of Educational Research, 62:6, 929-948, DOI: 10.1080/00313831.2017.1324898

To link to this article: https://doi.org/10.1080/00313831.2017.1324898

© 2017 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

Published online: 05 Jun 2017.

Submit your article to this journal

Article views: 233

View Crossmark data

Citing articles: 1 View citing articles

Full Terms & Conditions of access and use can be found at
http://www.tandfonline.com/action/journalInformation?journalCode=csje20

SCANDINAVIAN JOURNAL OF EDUCATIONAL RESEARCH
2018, VOL. 62, NO. 6, 929–948
https://doi.org/10.1080/00313831.2017.1324898

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Literacy, Age and Recentness of Education Among Nordic Adults

Sari Sulkunen and Antero Malin

Finnish Institute for Educational Research, University of Jyväskylä, Jyväskylä, Finland

ABSTRACT
The purpose of the present study was to examine the relationship between reading literacy and age in an adult population aged 25 to 65 in Nordic countries using PIAAC 2012 data. More specifically, the study examined to what extent variations in the literacy proficiency of adults are explained by age and the recentness of qualifications when variables related to education, occupation, and skill use are controlled. The statistical method was regression analysis. The recentness of education explained only a part of the performance gap between the oldest adults and others. The significance of the length and scope of initial education in developing literacy proficiency overall, is difficult to compensate. There were insignificant differences between the Nordic countries.

ARTICLE HISTORY
Received 13 November 2015
Accepted 21 March 2017

KEYWORDS
Reading literacy; age; recentness of education; PIAAC 2012

Literacy is seen as an essential key competence in every person's day-to-day life, including situations related to learning, work, and citizenship. The European reference framework for the key competences for lifelong learning (European Commission, 2007), as well as subsequent work defining twenty-first century skills (e.g., Binkley et al., 2012, p. 22), see reading literacy as one of the basic skills relevant to communication, information literacy, and digital competence.

While literacy has always been defined and transformed by the changes and technologies in the surrounding society, during the last two decades, technology has undergone many changes within an extremely short period of time. Particularly, global economic competition, based on the effective use of information and communication and the Internet quickly becoming ubiquitous in people's professional and personal lives, is reflected in, and has been affected by, today's literacy practices (Leu, Kinzer, Coiro, Castek, & Henry, 2013, pp. 1151–1153.) Learning how to master the new literacy strategies, practices, and dispositions is now more challenging than before, since new technologies create and demand new literacies that are multifaceted and constantly changing, while emphasizing new forms of strategic knowledge about information use and communication (Leu et al., 2013, pp. 1158–1162). This is a literacy challenge with which everyone, including adults of different ages, has to deal. Since both technologies and numerous texts encountered in life change continuously, reading skills also need to be defined broadly and developed continuously (Binkley et al., 2012, p. 22). Thus, literacy is not only a tool for, or a key to, lifelong learning, but is also an object of lifelong learning (e.g., Sulkunen, 2013)—now more than ever before.

Solid foundational skills provide a basis for the lifelong development of literacy. International assessments have been established and implemented to determine how well adults of different ages and in various countries are equipped for the current literacy demands and for lifelong and life-wide development of literacy. The most recent and most relevant assessment for adults is the

CONTACT Sari Sulkunen sari.sulkunen@jyu.fi Finnish Institute for Educational Research, P.O. Box 35, FI-40014, Jyväskylä, Finland

© 2017 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (http://creativecommons.org/licenses/by-nc-nd/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way.

Organisation for Economic Co-operation and Development's (OECD) Programme for the International Assessment of Adult Competencies (PIAAC). The PIAAC focuses on assessing the key information-processing skills, among them literacy, of adults aged 16–65 years. The main option for completing the assessment was to do so via computer (OECD, 2013a), which enabled the integration of literacy and new technology matching the current literacy demands.

Adult Literacy in the Nordic Countries

In the context of adult literacy, Nordic countries comprise a particularly interesting group: They share many features, such as the democratic, welfare-state structure having similar values of equity (e.g., Malin, 2005; Mellander & Anderssen, 2015), a relatively high education level, with an above-average share of adults having tertiary education (OECD, 2013a, pp. 57, 2014) and a below-average share of adults with less than an upper-secondary education (European Commission, 2015, p. 19). Each of the countries has a comprehensive, basic education system, which, during the past few decades, has shifted towards decentralized decision making (Yang Hansen, Gustafsson, & Rosén, 2014). Additionally, in Nordic countries, lifelong learning activities are well developed, and adults participate actively in adult education, as demonstrated by an overall participation rate of 65–67% (European Commission, 2015, p. 23; Sulkunen & Malin, 2014, p. 72).

The most recent adult literacy assessment, PIAAC, showed interesting similarities, but also differences, across age groups among the Nordic countries participating in the study (i.e., Denmark, Finland, Norway, and Sweden). Finnish adults outperformed their peers in other Nordic countries in every age group except the one consisting of the oldest individuals (aged 55–65 years) (Gabrielsen & Lundetrae, 2014, pp. 27–28; OECD, 2013a, pp. 107, 272). However, there were large differences in average literacy proficiency among age groups within each country, and the differences in literacy proficiency between the youngest and oldest adults were far greater in Finland than in the other Nordic countries. In every Nordic country, the most proficient age group comprised adults aged 25–34 years, who outperformed even the youngest adults (ages 16–24). Adults beyond 44 years of age, and particularly those older than 54, however, showed a relatively low level of literacy (OECD, 2013a, pp. 104–107, 272). Thus, it seems that in all the Nordic countries, literacy proficiency peaks in the group that has recently finished secondary or tertiary formal education and has already used skills at work and in society. This is consistent with many other countries, as well (e.g., Wheater & Worth, 2014). However, there are some differences in the age-group profiles of the Nordic countries, as the relative difference between Finland and other Nordic countries, particularly Norway and Sweden, diminishes in older age groups.

Previous cross-sectional studies have shown that the main determinant of literacy performance across age groups is educational attainment. This was also the case in the earlier adult literacy study, the International Adult Literacy Survey (IALS), which was implemented in the late-1990s (Linnakylä, Malin, Blomqvist, & Sulkunen, 2000; OECD, 2000, pp. 56–58, 2013a, pp. 190–195; see also Green & Riddell, 2012). Furthermore, Schneeweis, Skirbekk, and Winter-Ebmer (2014) have shown that, in six European countries, longer compulsory schooling improved cognitive performance even four decades later. Education is also one of the factors partly explaining the increased intelligence in population over time, referred to as the Flynn effect (Flynn, 2009). However, educational attainment does not explain all the differences between age groups. After accounting for education level (and language background), based on the PIAAC, there is still a decline in literacy performance among groups, from younger to older. In Denmark, the decline starts with adults at the age of 16, in Finland and Sweden well before the age of 30, and in Norway at the age of 30 (OECD, 2013a, pp. 191–195). When educational attainment and, additionally, gender, type of occupation, and socioeconomic, language, and immigrant backgrounds are accounted for, PIAAC literacy scores have a linear negative relationship with age. The youngest adults show the highest average performance in Denmark, Finland, and Sweden. In Norway, the three age groups (16–44 years) show nearly the same average proficiency (OECD, 2013a, p. 445). Thus, these factors explain the relatively low literacy performance of

the youngest age group (ages 16–24 years). Still, the gap between young and older adults persists, suggesting that there are other reasons for the performance differences between age groups.

In studies examining the relationship between educational attainment and literacy performance, education is most often measured as the highest level of education (using International Standard Classification of Education (ISCED) classification) (e.g., Linnakylä et al., 2000; OECD, 2000, pp. 56–58, 2013a, pp. 190–195) or as the number of years of schooling (e.g., Green & Riddell, 2012) completed. Other variables related to education have been used less often. For instance, it is unlikely that the content and quality of education (at the same level) has remained unchanged during the decades in which adults participating in PIAAC were educated, considering they were born between 1946 and 1995 (i.e., they represent different birth cohorts). Mellander and Anderssen (2015) have summarized educational reforms in Nordic countries in 1949–1997, pointing out that the reforms have extended the length of basic education and changed the structure of education systems. Also Gustafsson (2016) includes quantity and quality of education among the factors affecting the cognitive achievement of different age cohorts, along with mass media, demographic factors, nutrition, and healthcare. It could be thus expected that the more recent education provides different and, from the perspective of current literacy demands, more relevant, learning outcomes than the earlier one. Hence the year of graduation might be a relevant education-related factor behind literacy performance controlling the changes within education level. Furthermore, the field of education has been shown to have differing effects on cognitive abilities (Cliffordson & Gustafsson, 2008).

In addition to education-related factors, the type of occupation and skill use, particularly at work, have associations with literacy performance. In their recent analysis, Albaek, Fridberg, and Rosdal (2014) studied the relationship between occupation type, skill use, and proficiency and found that in Nordic countries, literacy proficiency has a quadratic negative association with age, even in the occupational group comprising higher-level professions. The study additionally showed that using skills at work is connected to proficiency, since the level of proficiency was higher in the occupational group with a high level of skill use across all age groups. The authors concluded that skill use does not protect older age groups from lower levels of proficiency. The method of analysis, however, was descriptive; for instance, it did not control for education level. Mellander (2014), on the other hand, showed that work experience has a very weak positive relationship with literacy performance in Nordic countries, based on the PIAAC, and concluded that the possibility of making up for education through work experience is minuscule. However, in a longitudinal study, Schooler and colleagues (e.g., Schooler, 2001; Schooler, Mulatu, & Oates, 1999) found positive long-term effects among persons engaged in jobs that required a high degree of cognitive complexity, suggesting that even a decline in skills as the result of ageing can decrease with skill use. Also Schneeweis et al. (2014) have shown that schooling has some protective effect on cognitive decline. These studies provide support for the use-it-or-lose-it hypothesis (e.g., Salthouse, 2006).

When considering the literacy gap between age groups, one possible explanation could be the cognitive decline that occurs as a result of ageing (see Ackerman [2008] for a review). In their longitudinal study, Bynner and Parsons (2006) have shown that young adults' literacy level does not remain stable, but that there are changes in proficiency, typically (but not only) for the better. Also Reder's (2008) study indicated small increases in young adults' proficiency and very small yearly decline for adults from the age of 35. However, it is unlikely that the age gap could be explained by individuals' cognitive decline alone (Ackerman, Kanfer, & Calderwood, 2010; Gabrielsen, Lundetrae, Gustafsson, & Myrberg, 2014), since, in the case of significant cognitive decline, all of the countries could be expected to show a similar pattern when the same birth cohort is followed from one study to another. This is not the case even in Nordic countries, since following the same pseudo-cohort of 16–24-year-olds from the IALS to PIAAC, Wheater and Worth (2014, p. 17) found different patterns in different countries. Finland deviated from other Nordic countries: with respect to the cohort in question, literacy proficiency (based on the PIAAC) when compared to literary proficiency based on the earlier IALS, improved only in Finland. Moreover, research into cognitive abilities and intelligence suggests that there are different developmental pathways to abilities related to fluid intelligence, such as

information processing and problem solving (Salthouse, 1996) and those related to crystallized intelligence, such as verbal abilities (see Ackerman, 2008). The former decline significantly after middle age, and the latter show more modest or delayed decline. This research does not support the aging effect on literacy proficiency, which essentially reflects crystallized intelligence.

Green and Riddell (2012) used two cross-sectional datasets to study the relationship between age and literacy in Canada, Norway, and the USA. Using a combination of IALS data from 1994 and Adult Literacy and Lifeskills (ALL) Survey data from 2003, the authors showed that individual ageing and birth cohort effects are combined, as literacy seems to be acquired mainly through schooling (see also Green & Riddell, 2003) and supported by parental education and non-migrant status; however, after initial formal education, literacy levels do not develop further and start to decline. Green and Riddell (2012) did not include any skill use or occupation-related variables in their analysis, nor did they take into consideration participation in adult education (i.e., the time of graduation). Methodology using two cross-sectional studies, an approach used by Wheater and Worth (2014) and Green and Riddell (2012), relies heavily on the assumptions of two similar measures of literacy (sharing enough common items) and of the representativeness and similarity of samples by age groups. A proper investigation of the relationship between individual ageing and literacy would require longitudinal data on an individual level.

The question that remains, then, is what can we learn from one cross-sectional study about the reasons for the negative association between age and literacy? To cast light on this explorative question, the current study used PIAAC data to investigate the effects of age and the recentness of education on adult literacy proficiency in Nordic countries in the contexts of education and work-life. The current study will contribute to understanding of the factors related to cohort effects on literacy proficiency, particularly the factors related to education. As Gustafsson (2016) concludes, many of the age differences in educational performance in PIAAC derive from cohort effects related to schooling. Thus, consistent with Reder (1994, p. 48) the current study will adopt a cultural approach that highlights the role of context for literacy development.

PIAAC Literacy Framework

The PIAAC assessed 16–65-year-old adults' key information-processing skills (i.e., literacy, numeracy, and problem solving in technology-rich environments). Survey data were collected in 24 countries and regions, including the Nordic countries of Denmark, Finland, Norway, and Sweden, during the period 2011–2012 (OECD, 2013a, pp. 25–26). The current study used PIAAC data on literacy and was therefore based on the PIAAC literacy framework.

The PIAAC literacy assessment concentrates on reading literacy, which is defined as 'the ability to understand, evaluate, use and engage with written texts to participate in society, to achieve one's goals, and to develop one's knowledge and potential' (OECD, 2013a, 59; see also Gabrielsen et al., 2014). The assessment aims to cover current literacy practices as widely as possible, and thus the test materials are drawn from work-related and personal contexts, as well as the contexts of society, community, and education. Likewise, texts used in the assessment include both print-based and digital texts, combining continuous, non-continuous, and multimodal elements (OECD, 2013a, 59). In that sense, the PIAAC framework reflects current literacy practices and demands. The definition of literacy, however, stresses the reading of written texts, both printed and online. Thus, in practice online texts exclusively using modes of representation other than the written word have not been included in the literacy test.

The approach adopted in the PIAAC echoes the functional view of reading that emphasizes the context and particularly the purpose of reading (Linnakylä, 2000; Verhoeven, 1994; Williams, 2006). In the PIAAC assessment this is reflected in materials drawn from authentic reading events and the task descriptions. However, the assessment also has a strong cognitive emphasis—each assessment item measures (one of the) three cognitive strategies: accessing and identifying information; integrating and interpreting; and evaluating and reflecting what has been read (OECD, 2013a, p. 59, 2013b,

pp. 18–19). The cognitive strategies measured in PIAAC are the same across contexts measured. The PIAAC reading-literacy assessment thus integrates these cognitive reading skills and functional literacy practices in multifaceted and multimodal environments, including online settings. In terms of Reder (1994, p. 40), the cultural practices and individual skills paradigms intertwine in adult literacy surveys. Gabrielsen et al. (2014) stress that the PIAAC literacy assessment approaches literacy as a foundation skill needed in everyday contexts rather than a cognitive basic skill on an individual level.

Overall, the PIAAC assessment framework has updated the previous literacy studies to cover the new text modes and reading processes introduced in the societies since the 1990s. The assessment is broader than in previous studies, for example IALS and ALL, as it also includes digital texts. Additionally, the PIAAC framework incorporates the cognitive process of evaluation and reflection, the role of which is pronounced due to the wealth of texts made accessible by new technology. However, according to conceptualizations of online literacy (e.g., Leu et al., 2013), literacy, in the context of the Internet, is perceived as a set of problem-solving practices in navigating the (more or less) relevant texts and information. In the PIAAC, the most complex tasks touching upon online practices are covered by the assessment domain of problem solving in technology-rich environments (OECD, 2013a, pp. 86–90). Hence it is noteworthy that while the literacy framework in PIAAC includes also online reading, the practical assessment is somewhat narrower. The lack of most complex online reading tasks in the literacy assessment may be in favour of older adults aged 55 and beyond, since they are less familiar with online reading than younger adults (OECD, 2013a, p. 316). Intelligence theory suggests that they may also have declined information processing speed (Salthouse, 1996) affecting their performance in a test.

Data and Methods

The purpose of the present study was to examine the relationship between reading literacy and age in an adult population whose members' ages ranged from 25 to 65, in Nordic countries. Specifically, the study addressed the following questions:

(1) To what extent can the variation in adults' literacy proficiency be explained by age and recentness of qualifications when education level, the field of education, the occupation, skill use at work, ICT use, gender, and language background are controlled?
(2) What do the factors explaining variation in literacy proficiency demonstrate about the reasons behind the gap in literacy proficiency between age groups?

The framework for the analysis was designed based on the previous research summarized above showing particularly that (1) level and length of education is the main determinant of literacy proficiency, (2) education level alone does not explain differences between age-groups, and (3) there have been changes in educational provisions and their quality. The main hypothesis, then, was that as a result of changes in the quality of education, recentness of education (i.e., the year of the most recent educational degree) is reflected in the differences between age groups. More specifically, it was expected that within age groups, adults with recent education show higher level of performance than their peers of the same age. It was further expected that adults with a recent degree would show higher performance than younger adults with an older degree.

The dependent variable used in the analysis was literacy proficiency. In addition to the recentness of education, several education-related variables were included in the study. The measure of education typically used in previous studies, the highest level of education completed, is complemented in this study by factors covering the possible changes over time within education levels (decade during which the highest qualification was completed) and the field of study. To study the effects of using the skills at work, and thus the skill development as a result of work experience, the occupation types by skill demand and skill use at work were included in the analyses. The PIAAC data include a variable of work experience in years, but it was left out of the analyses

since it was highly correlated with age group and with the year during which the highest qualification was completed. To control for the familiarity with ICT—since in the computer-based assessment results may be biased against those not familiar with computers—ICT use at home, that is, outside work, was also included in the model. The gender and the language background of the respondents were controlled. Thus, the explanatory variables used in the analyses are age, year of finishing the highest qualification, education level, field of study, occupation, gender, language background, use of reading skills at work, and ICT use at home (Table 1). The variable ICT use at home was chosen since it captures a wider variety of adults' ICT use and thus has a higher correlation to literacy proficiency than ICT use at work. The same was true for reading skills at home. Including all four variables was considered a problematic solution as the home- and work-related variables are highly correlated in this case, complicating interpretation of the results.

Table 1. Background factors used to explain the variation in reading-literacy performance.

Background factor	Variables used to measure	Variable type	
Age at the time of data collection	Age groups in 10-year intervals	Four age categories (years) 25–34 35–44 45–54 55–65	*Note*. New dichotomous variables, combining age and year of completing highest degree, were derived from these two variables. For details see Table 2.
Education	Decade during which highest degree was completed	Five decade categories 1960–1969 1970–1979 1980–1989 1990–1999 2000–2012	
	Highest degree completed	Four categories: Higher education (ISCED 5, 6) General secondary education (ISCED 3A, B, C long, 4) Vocational secondary education (ISCED 3A, B, C long, 4) Basic education (ref.) (ISCED 1, 2, 3C short)	
	Field of education	Nine categories: General programmes* Teacher training and education science Humanities, languages and arts Social sciences, business and law Science, mathematics and computing Engineering, manufacturing and construction Agriculture and veterinary Health and welfare Services (ref.)	
Occupation	Occupation type by skill demand	Four categories: Skilled occupations (ISCO 1–3) Semi-skilled white-collar occupations (ISCO 4–5) Semi-skilled blue-collar occupations (ISCO 6–8) Elementary occupations (ISCO 9) (ref.)	
Gender		Two categories: Female Male (ref.)	
Language background		Two categories: Test language same as native language Test language not same as native language (ref.)	
Use of reading skills	Frequency of using reading skills at work	Continuous index	
Use of ICT skills	Frequency of using ICT skills at home/outside work	Continuous index	

Note: Participants who had a low-level education and who did not have information about the field of study were recoded as having received their education in general programmes. ISCED = International Standard Classification of Education.

Due to the dependence of age at the time of data collection and the year of finishing the highest qualification, these two variables were combined to produce relevant dichotomous variables. Age was divided into four age categories: 25–34, 35–44, 45–54, and 55–65 years. The years during which the highest qualification was completed were divided into five decade categories: 1960–1969, 1970–1979, 1980–1989, 1990–1999, and 2000–2012. As shown in Table 2, 14 dichotomous variables were derived. Those who were aged 25–34 years completed their highest degree during 1990–1999 or 2000–2012, and so on. The oldest age group, those aged 55–65 years, completed their highest degree from each of the five periods. The reference group in the statistical analyses consists of persons who completed their highest degree during 1960–1969, all of whom belong to the oldest age group (ages 55–65 years).

Literacy proficiency, the dependent variable in the statistical analyses of the study, was estimated for each individual represented in the PIAAC by using 10 plausible values. Plausible values are estimated proficiency values based on information from the actual PIAAC literacy test items and information provided in the background questionnaire by each respondent (more about this in OECD, 2013c). The statistical method was a multiple regression model. The statistical analyses were conducted with the use of weights to take the survey design into account. In the statistical model, each plausible value was used as an outcome variable at a time, and the mean of regressions over 10 plausible values was calculated (for further details, see OECD, 2013c, chapters 14–15). To obtain the final standard error, the sampling variance and the imputation variance, due to using the plausible values, are combined (for details, see OECD, 2009).

The general equation for the multiple linear regression model of a dependent variable Y on a set of p independent variables $X_1, X_2, \ldots, X_p$ is as follows:

$$(1)\ Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \ldots + \beta_p X_{ip} + \varepsilon_i$$

The subscript i denotes the observational unit from which the observations on Y and the p independent variables were taken. There are p + 1 parameters β_p (j = 0, … , p) to be estimated since the model includes the intercept β_0. (Aczel, 1999; Rawlings, Pantula, & Dickey, 2001.)

The regression coefficient β_p represents the change in the dependent variable Y for a change of one unit in the independent variable X_p, other independent variables being fixed. When an independent variable is categorical, as most of them are in this study, one category of it has been chosen as a reference group. Then the regression coefficients of the other categories of that variable indicate the literacy score point difference to the reference group. The coefficient of the reference group is always set at 0. For each categorical variable, the chosen reference group is indicated in Table 3 reporting the results of the analyses (ref. in parentheses). In the case of continuous variables, we have only one estimate, and it represents the change in the dependent variable for a change of one unit in the scale of the respective independent variable.

The national PIAAC samples are representative of the adult population, comprising individuals aged 16 to 65 who live in the country. The total sample size in the participating Nordic countries was 22,389 (Denmark: 7,328; Finland: 5,464; Norway: 5,128; and Sweden: 4,469). Adults in the age group

Table 2. Weighted numbers of persons in the four nordic countries according to age and decade during which the highest qualification was completed.

Age at the time of data collection (years)	Decade during which the highest qualification was completed					
	Degree 1960–1969	Degree 1970–1979	Degree 1980–1989	Degree 1990–1999	Degree 2000–2012	Total
25–34				685	3,456	4,140
35–44			901	2,287	1,351	4,539
45–54		994	2,094	862	668	4,619
55–65	1,540	2,010	654	400	242	4,846
Total	1,540	3,004	3,649	4,234	5,716	18,143

consisting of 16–24-year-olds (n = 3,898) were excluded from the study since 66% of them were still in their initial cycle of studies.

It is to be noted that PIAAC data include detailed information about the respondents' education, emphasizing the highest degree completed. Thus, the data include limited information about the educational paths of adults. In this respect, the composition of the groups (by age and recentness of the degree) is unknown, and is possibly a heterogeneous one. This is a limitation of the data. Appendix, Table A1, describes the groups based on the graduation period within the age groups. In Table A1, all four countries are combined since the variation between countries was relatively small.

It is evident that the groups by age and recentness of education differ in many ways (Appendix, Table A1). The length of the basic education in general in Nordic countries has been nine years for many decades. However, in the age group 45–54 years it was still six years for a part of this age group in Finland, due to the transition period after the educational reform in the 1970s (Mellander & Anderssen, 2015). Additionally, for the oldest age group the basic education lasted only six years in Finland and seven years in Denmark. The groups studied also differ in terms of their education level: Within each age group we see that the more recent the graduation period, the more likely the education is at high level. In part this derives from the fact that higher education degrees are longer, also reflected in the higher average age of the groups with more recent degrees. In each age group there are adults who have interrupted their studies for formal qualifications at some point. In the two oldest age groups, the proportion of these adults is somewhat higher among those with more recent degree. Within each age group, those with early qualifications have most likely interrupted medium-level studies and those with more recent qualifications higher-level studies. In general, adults with recent degrees are more likely to work in skilled occupations than their peers of the same age. In the oldest age group, however, those graduated in the 1980s show the highest proportion of skilled workers. The groups with highest proportion of skilled workers also show the most active use of reading at work and ICT outside work. In general, the more recent the completed education, the higher is the proportion of women.

In all, the reference group in the statistical analyses related to the age group and the decade of the latest educational qualifications (i.e., 55–65-year-olds with a formal degree completed during 1960–1969) consists of the low-educated adults in mostly semi-skilled occupations. This choice was made to simplify the interpretations of the relationship between adults' literacy, age, and recentness of the education.

Results

The results of the analyses show that all the background factors in the model have at least some statistically significant associations with reading-literacy proficiency (Table 3). Based on the individual coefficients of determination, the strongest factors explaining the variation in the reading-literacy proficiency of adults in every Nordic country are education level, the combination of age group and the decade of completing the highest degree, and the occupation type by skill demand. In Norway, the occupation type by skill demand even exceeded the role of education level. In all, the model explains about one-third of the variance in reading literacy. The adjusted R-squared[1] statistics for the countries are between 0.32 in Denmark and 0.37 in Norway, with Finland (0.33) and Sweden (0.36) between them.

In every country studied, individuals whose native language was the same as the test language clearly demonstrated a better literacy performance than those who were not equally familiar with the test language, all other factors being equal (Table 3). An examination based on education

[1]The coefficient of determination R^2 is a descriptive measure of the strength of the regression relationship, a measure of how well the regression model fits the data. The multiple coefficient of determination R^2 measures the proportion of the variation in the dependent variable that is explained by the combination of the independent variables in the multiple regression model. In other words, the coefficient of determination measures the percentage of variation in Y explained by the X variables.

Table 3. The final model.

	Denmark			Finland			Norway			Sweden		
Explanatory variables	b	se(b)	*P*	b	se(b)	*P*	b	se(b)	*P*	b	se(b)	*P*
Intercept	187.06	5.36	0.000	194.48	10.80	0.000	176.97	8.14	0.000	179.47	8.95	0.000
Age and decade during which highest degree was completed												
Age 25–34 Completed 1990–1999	15.90	6.29	0.011	27.81	5.43	0.000	17.37	6.44	0.007	20.75	6.07	0.001
Age 25–34 Completed 2000 or later	24.54	3.78	0.000	38.42	4.15	0.000	28.02	5.18	0.000	24.17	4.57	0.000
Age 35–44 Completed 1980–1989	17.38	4.66	0.000	24.92	5.10	0.000	15.32	6.00	0.011	19.73	5.49	0.000
Age 35–44 Completed 1990–1999	25.03	3.58	0.000	29.62	4.27	0.000	24.15	4.95	0.000	20.46	4.40	0.000
Age 35–44 Completed 2000 or later	24.18	4.29	0.000	31.41	4.54	0.000	24.80	5.25	0.000	23.94	5.32	0.000
Age 45–54 Completed 1970–1979	6.39	4.43	0.149	16.35	5.02	0.001	15.64	5.95	0.009	9.31	4.46	0.037
Age 45–54 Completed 1980–1989	14.62	3.75	0.000	19.26	4.22	0.000	18.48	5.19	0.000	16.85	4.48	0.000
Age 45–54 Completed 1990–1999	19.73	4.34	0.000	22.89	4.61	0.000	16.67	5.24	0.001	14.26	5.31	0.007
Age 45–54 Completed 2000 or later	9.58	4.86	0.049	21.10	5.11	0.000	11.59	5.56	0.037	13.23	5.60	0.018
Age 55–65 Completed 1960–1969 (ref.)	0			0			0			0		
Age 55–65 Completed 1970–1979	4.11	3.87	0.288	2.35	4.07	0.563	2.23	5.00	0.655	5.68	4.54	0.210
Age 55–65 Completed 1980–1989	5.63	4.47	0.208	7.14	4.85	0.141	5.31	5.84	0.363	5.27	4.89	0.281
Age 55–65 Completed 1990–1999	−1.17	5.48	0.831	1.90	5.57	0.732	−6.03	7.07	0.394	−7.33	7.64	0.338
Age 55–65 Completed 2000 or later	10.71	5.18	0.039	2.88	6.27	0.646	−0.41	8.17	0.960	0.60	7.16	0.933
Education												
Higher education	23.87	3.05	0.000	32.89	7.46	0.000	21.06	3.27	0.000	35.52	4.51	0.000
General secondary education	20.95	3.46	0.000	29.15	4.86	0.000	12.08	3.51	0.001	20.50	3.26	0.000
Vocational secondary education	5.27	3.00	0.079	12.60	7.54	0.095	1.63	3.19	0.609	10.75	3.78	0.004
Basic education (ref.)	0			0			0			0		
Field of study												
General programmes	0.92	2.93	0.753	6.83	7.62	0.371	−4.45	4.89	0.363	9.98	5.56	0.073
Teacher training and education science	−9.39	2.64	0.000	−5.96	4.65	0.200	−5.45	5.10	0.285	2.20	5.06	0.663
Humanities, languages and arts	9.96	3.41	0.004	6.91	4.49	0.124	10.72	5.14	0.037	15.14	5.36	0.005
Social sciences, business and law	3.66	2.64	0.166	0.66	3.30	0.842	2.70	4.33	0.533	14.66	4.54	0.001
Science, mathematics and computing	6.95	3.39	0.041	14.68	4.64	0.002	9.66	5.91	0.102	17.31	6.32	0.006
Engineering, manufacturing and construction	−1.41	2.60	0.588	−1.87	3.00	0.533	−0.60	4.37	0.890	14.67	4.48	0.001
Agriculture and veterinary	−6.32	5.08	0.213	−3.08	4.94	0.533	1.10	8.38	0.895	15.52	6.88	0.024
Health and welfare	−2.28	2.84	0.423	−9.72	3.13	0.002	−7.59	4.38	0.083	4.76	5.24	0.364
Services (ref.)	0			0			0			0		

(*Continued*)

Table 3. Continued.

	Denmark			Finland			Norway			Sweden		
Explanatory variables	b	se(b)	*P*	b	se(b)	*P*	b	se(b)	*P*	b	se(b)	*P*
Intercept	187.06	5.36	0.000	194.48	10.80	0.000	176.97	8.14	0.000	179.47	8.95	0.000
Occupation												
Skilled occupations	15.05	3.85	0.000	19.46	4.80	0.000	38.31	6.25	0.000	20.87	7.25	0.004
Semi-skilled white-collar occupations	8.03	3.76	0.033	10.64	4.75	0.025	25.78	6.29	0.000	14.45	6.95	0.037
Semi-skilled blue-collar occupations	3.06	4.12	0.459	8.38	4.73	0.076	23.40	6.30	0.000	7.65	7.02	0.275
Elementary occupations (ref.)	0			0			0			0		
Gender												
Female	−4.26	1.56	0.006	−0.60	1.99	0.764	−0.97	2.08	0.640	−2.15	2.16	0.319
Male (ref.)	0			0			0			0		
Language background												
Test language same as native language	35.72	2.30	0.000	30.95	6.02	0.000	35.62	2.97	0.000	38.79	3.10	0.000
Test language not same as native language (ref.)	0			0			0			0		
Index of use of reading skills at work	2.53	0.91	0.005	1.44	1.18	0.223	2.03	1.32	0.123	0.83	1.44	0.563
Index of use of ICT skills at home	6.73	0.86	0.000	5.74	1.07	0.000	6.46	1.25	0.000	6.49	1.09	0.000
Adjusted R^2	0.319			0.329			0.365			0.363		

Note: ICT = Information and Communication Technology, **b** = estimate of regression parameter, se(b) = standard error of regression parameter estimate b.

level, when other factors were controlled, shows that a higher level of education produces proficiency that is remarkably better than that produced by a basic education (the reference group for education level), particularly in Sweden and Finland. In Denmark and Finland, general secondary education is associated with almost the same (high) level of proficiency as that associated with higher education. In Sweden alone, however, vocational secondary education produces a level of literacy proficiency that is statistically significantly higher than that produced by a basic education. In terms of vocational secondary education, there appear to be differences between countries in the proficiency gains achieved in Finland and Sweden on one hand, and in Denmark and Norway on the other, but these differences are not statistically significant.

Looking at other education-related factors, there is some variation between the different fields of study but less so than those between education levels (Table 3). Most of the differences in literacy proficiency between the fields of study are not statistically significant. Adults who have degrees in science, mathematics and computing, the humanities, languages, and the arts stand out as they demonstrate the highest level of literacy proficiency in Denmark and Sweden. Also, in Sweden adults with degrees in the fields of social sciences, engineering, and agriculture show a literacy level that is nearly as good as in science and humanities when education level and other factors are controlled. In Finland, only the proficiency level in the field of science differs from the reference group. In Norway, this is true for adults in the field of humanities. Additionally, in Denmark, adults with teacher training show a level of proficiency that is lower than that of the reference group, which in this category consists of adults working in the field of services.

An examination by occupation type (Table 3) indicated that the best performers in each of the countries studied work in skilled occupations; additionally, adults in semi-skilled white-collar occupations show higher levels of proficiency than those in elementary occupations, the reference group for this category. In Norway, the role of occupation type exceeds that of the education level and seems more important than in other Nordic countries; only the difference between Norway and Denmark,

however, is statistically significant. In addition, only in Norway, the literacy-proficiency level of adults in semi-skilled blue-collar occupations is higher than that demonstrated in elementary occupations.

Gender differences in literacy are practically non-existent in the Nordic countries, since the literacy performance of males is slightly better only in Denmark (Table 3). In other Nordic countries, education and work-related factors explain whatever gender difference there may be. In every country, the frequent use of ICT skills outside work is associated with better reading proficiency. One standard deviation increase in ICT skill use outside work produces gains equal to almost one school year (Valk, 2015, p. 109). Only in Denmark, the frequent use of reading skills at work is associated with better reading proficiency when the use of ICT skills and other factors are controlled.

The relationship between age and literacy proficiency (illustrated in Figures 1a–1d) include, for contrast, both unadjusted and adjusted (for all the background factors in the statistical model) differences between groups by age and recentness of the degree completed. The reference group consists of adults in the oldest age group (55–65-year-olds) who completed their highest degree during 1960–1969. As highlighted in Appendix, Table A1, this group consists of low-educated adults (as do all with early qualifications in each age group). The adjusted associations between the combination of the age and the completion time of the highest degree and reading-literacy proficiency are rather similar in the four Nordic countries when controlling for all the background factors in the model (Figures 1a–1d, Table 3). The association with reading-literacy proficiency is also relatively strong,

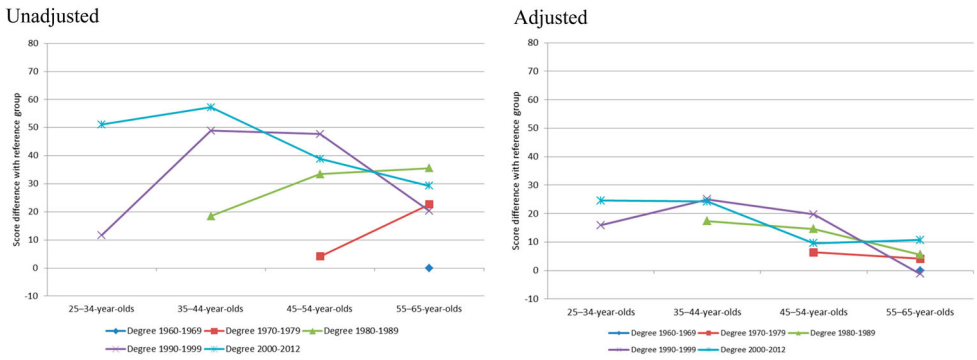

Figure 1a. Denmark: Unadjusted and adjusted associations of the combination of the age and the period during which the highest degree was completed with reading-literacy proficiency.

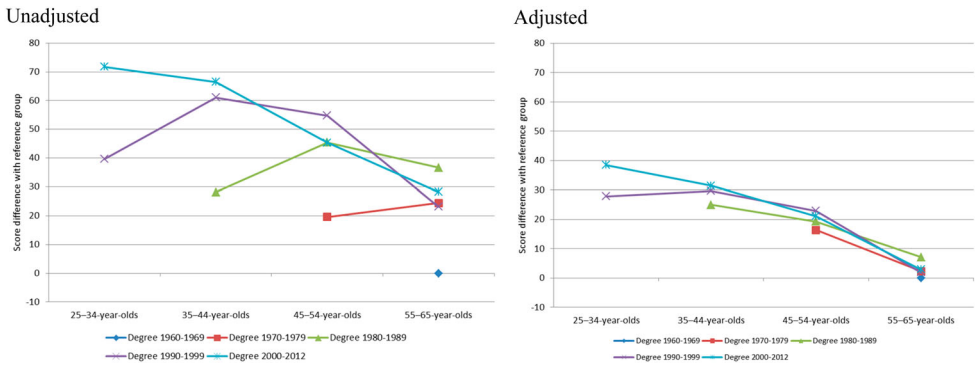

Figure 1b. Finland: Unadjusted and adjusted associations of the combination of the age and the period during which the highest degree was completed with reading-literacy proficiency.

Note: Adjusted associations are adjusted for education level, field of education, occupation, use of reading skills at work, use of ICT skills at home, gender, and language background.

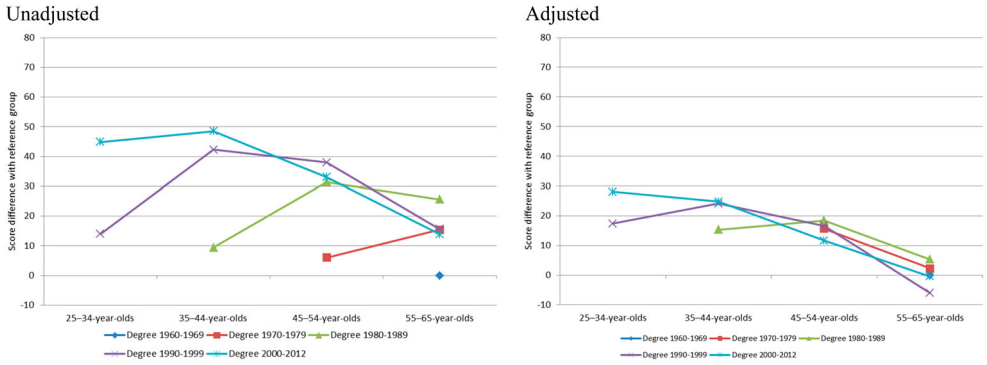

Figure 1c. Norway: Unadjusted and adjusted associations of the combination of the age and the period during which the highest degree was completed with reading-literacy proficiency.

Note: Adjusted associations are adjusted for education level, field of education, occupation, use of reading skills at work, use of ICT skills at home, gender, and language background.

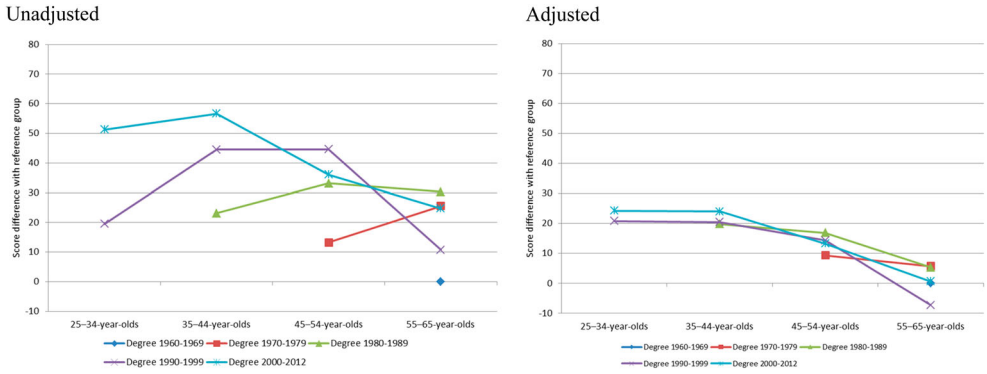

Figure 1d. Sweden: Unadjusted and adjusted associations of the combination of the age and the period during which the highest degree was completed with reading-literacy proficiency.

Note: Adjusted associations are adjusted for education level, field of education, occupation, use of reading skills at work, use of ICT skills at home, gender, and language background.

as the score differences between the reference group and the youngest adult groups, in particular, are still rather large, all other factors in the model being equal.

In all four countries, based on the completion time of the highest degree, the oldest adults show a level of reading-literacy proficiency that is lower than that of the younger adults in all categories, although not all the differences are statistically significant. Within graduation periods, there are statistically significant differences in the unadjusted results between age groups, but only among those who graduated in the 1990s or 2000s in every country studied, and among those graduated in the 1970s in Denmark and in the 1980s in Norway. In the adjusted results, however, the only statistically significant differences are among those who completed their degrees in the 1990s and after 2000. Differences between age groups comprising those who graduated prior to the 1990s in Denmark and Norway and in Denmark during the 2000s can be explained by the factors in the model.

In Denmark, the only statistically significant differences remaining in the adjusted results can be found among adults who graduated in the 1990s, as those aged 35–44 and 45–54 show the highest level of proficiency, differing from that of the oldest group. However, the proficiency level of the youngest age group (25–34) is not statistically significantly different from that of the other age groups. In Finland, during the same degree period, all three of the youngest age groups have a

significantly higher level of reading literacy than that of the oldest age group, while there are no differences between these three groups. Also, among those who graduated during 2000–2012, the two youngest age groups clearly demonstrate a reading-literacy level that is higher than that of the oldest, while other differences are not statistically significant. In Norway, among those who graduated during the 1990s, only the age group 35–44 shows a level of reading-literacy proficiency that is higher than the oldest group, and among those who graduated after 2000, the youngest age group has a level of proficiency that is higher than that of the oldest. In Sweden, the two youngest age groups among those who graduated during the 1990s show a level of reading-literacy proficiency that is higher than that of the oldest age group, and among those who graduated during the 2000s, the youngest age group has a proficiency level that is higher than that of the oldest group.

Thus, differences remain between age groups within graduation decades, but there are country-specific variations in the age groups that differ statistically significantly from the oldest adults. Among those who graduated in the 1990s, the adults below age 55 in Denmark and Finland, and below 45 in Norway and Sweden, show a level of proficiency that is higher than that of the oldest adults, which is consistent with those who graduated after 2000 and who are below the age of 45 or 35, respectively. Consistently across countries, the oldest age group shows a lower level of proficiency in literacy, even in the adjusted results. It is noteworthy, however, that in Denmark and Norway among those graduated during the 1990s, the youngest adults (ages 25–34) show a proficiency level equal to that of the oldest adults. In Denmark, this is also true for those who completed their highest degree after 2000.

It is noteworthy that the recentness of the degree does not exceed the effect of age group in the analysis. Contrary to our hypothesis, adults with a recent degree do not show higher performance than younger adults with older degree. Only adults aged 35–44 who graduated in 2000 or later have higher coefficients in the analysis (Table 3) than 25–34-year-olds with an older degree, other factors being equal. However, the difference between the two groups is not statistically significant (Appendix, Table A2).

Within age groups, there are clear differences based on the completion time of the highest degree in the unadjusted results, as hypothesized. In the adjusted results, however, these differences disappear, including the ones in the oldest age group. The only exception can be found in Denmark, where 55–65-year-olds with recent degrees (completed during 2000–2012) showed a proficiency level (11 score points) higher than those of the same age who completed their degree in the 1960s, also in the adjusted results (Appendix, Table A2). Some of the score differences between graduation decades within the age groups are quite big in the adjusted results, but due to the small number of cases in some groups, the standard errors, and hence the confidence intervals, are quite large, and the differences are not statistically significant.

The contrast between the unadjusted and adjusted associations between the combination of age group and recentness of the graduation and the literacy proficiency shows that a significant number, but not all, of the literacy proficiency differences between the age groups can be explained by education and work-related factors, as well as by general background factors. However, the education- and skill-use-related factors explain the differences within age groups, contrary to what was hypothesized.

Discussion and Conclusion

The current study examined to what extent the variation in adults' literacy proficiency could be explained by age and the recentness of the qualifications, given that many of the education- and work-related factors were controlled. The study focused on comparisons between the four Nordic countries of Denmark, Finland, Sweden, and Norway; however, the differences between the four countries were somewhat insignificant and the adjusted associations of age and the period during which the highest degree was completed with reading-literacy proficiency were very similar.

The main hypothesis of the study was that as a result of changes in the quality of education, recentness of education would be reflected in the differences between age groups. More specifically,

it was expected that within age groups, adults with recent education would show higher level of performance than their peers of the same age. It was further expected that adults with a recent degree would show higher performance than younger adults with older degree. The results of the analyses did not support the hypotheses, and they are discussed in detail below.

First, the results showed that language background, education and work- and skill-use-related factors partly explain the differences in literacy performance between age groups, since the adjusted age-group differences are clearly smaller than the unadjusted ones. It is, however, noteworthy that age group still has an independent association to literacy. The consistent feature is that the oldest adults are among those whose levels of proficiency are significantly lower than others. This contrast remains and cannot be explained merely by the factors considered in this study. Additionally, across countries, age-group differences within graduation periods persist among those who graduated during the 1990s and 2000s.

These results coincide with changes in the Nordic educational systems, particularly those related to the development of comprehensive basic education offering similar learning opportunities for all students. Several studies (Cliffordson & Gustafsson, 2008; Gustafsson, 2016; Schneeweis et al., 2014) have shown that changes in education systems have consequences for the educational achievement of different age cohorts, arguing for the significance of cohort effects rather than age effects in adult literacy. Gustafsson (2016), for instance, showed that the achievement levels at the end of compulsory schooling are reflected in differences among different age cohorts, and concludes that the age-related differences in a cross-sectional study like PIAAC express primarily cohort effects deriving from educational changes and wider societal developments. Basic education in Nordic countries has for many decades comprised nine-year comprehensive school that offers similar opportunities for all to learn (Mellander & Anderssen, 2015, p. 46). The current systems were established by the late-1970s after reforms being implemented in the 1960s in Sweden and Norway and in the 1970s in Denmark and Finland. The oldest adults in this study, 55–65-year-olds, showing relatively low level of proficiency had completed their basic education by the early-1970s, when even the earliest reforms have had a limited effect on these age groups and their cognitive abilities, particularly in Denmark and Finland. Thus, their proficiency level most likely reflects their basic education, which prior to the reforms was only 4–7 years in these Nordic countries, considering that the level of post-compulsory education (by highest degree) was controlled in the analyses.

As the age group differences within graduation periods persist only among those graduated during 1990s and 2000s, education- and work-related factors explained the differences among those graduated during 1980s or earlier, including mostly adults older than 44 (Appendix, Table A1). This suggest that among those groups of adults, particularly in Denmark and Norway, the background variables included in the study were more important than among other groups, reflecting the varying educational and other contextual opportunities between groups. This may derive from the basic education, which prior to the reforms guided students to different tracks and in some few cases required tuition fees (Mellander & Anderssen, 2015, pp. 45–47). In the reforms these were abolished and equal opportunities for learning to all students and special attention to students from disadvantaged families were offered (Hautamäki & Hautamäki, 2008). Thus, factors related to the structure of the educational system determined the educational choices and cognitive achievement more so than after the reforms among those with more recently completed degrees.

The results also show, perhaps surprisingly, that while there are great differences within the age groups based on the time of graduation in the unadjusted results, these can be explained by the factors in the model, contrary to our hypothesis. In the adjusted results there are practically no statistically significant differences within the age groups according to the graduation decade. Moreover, contrary to our hypothesis, adults with a recent degree do not show higher performance than younger adults with an older degree. Hence, the recentness of the degree does not exceed the effect of age group in the analysis. As the recentness of the degree relates to the highest degree completed and the level of the education has been controlled in the analyses, this further underlines the significance of basic education and initial formal education. This is consistent with Gustafsson (2016), who

has shown that proficiency at the end of basic education remains in adulthood, and with Green and Riddell (2012), who have shown that initial schooling contributes significantly to the literacy proficiency of adults.

There are also societal developments that may be reflected in the independent association that age has to literacy but that have not been measured by the factors considered in this study. For instance, adults' literacy practices have been different in different times due to different textual worlds and changes caused by technological development (Leu et al., 2013). Thus, adults of different ages have had, in part, different opportunities to practice their literacy, which is likely to result in different proficiency profiles (Reder, 1994). Moreover, in discussing the Flynn effect, Flynn (2009) refers to the scientific way of thinking that has pervaded all areas of life in (post-)industrial societies and also, for instance, the mass media. In considering the effects of these contextual factors for intelligence in the population, he concludes that trends between age cohorts underline the meaning of environmental factors rather than that of genes.

Moreover, an alternative explanation lies at least partly in age-related cognitive decline, which is well supported in prior research (Ackerman, 2008; Reder, 2008). However, reading skills have been considered to reflect crystallized intelligence rather than fluid intelligence (Ackerman, 2008; Salthouse, 1996), and one would expect to see only a modest decline by age. Yet current literacy tasks, particularly those related to online reading, include elements of problem solving (Leu et al., 2013). As these have been included in the PIAAC reading test, the age-group differences in PIAAC literacy may reflect an age-decline at least to some extent. However, with one cross-sectional data the possibility of cognitive decline by age remains unconfirmed.

Furthermore, those seeking a more recent, updated education are a very heterogeneous group of adults, not all of whom are disadvantaged. In each age group, many of the adults have at some point in their life interrupted their studies (Appendix, Table A1). The share of these adults was somewhat pronounced in the two oldest age groups among those with a more recent degree. This suggests that these adults have resumed their studies to either update their degree or make up for opportunities lost or unavailable in their youth. However, Nordic adults showing a high level of participation in formal adult education also include those with high educational qualifications and occupational status (Sulkunen & Malin, 2014). In each Nordic country, approximately 20% of adults with tertiary degree and 15–20% of those in skilled occupations have participated in formal adult education. These adults are in an advantaged position in which their foundational skills for lifelong learning are good and their work may inspire or require continuous professional development. These adults also have high level of average proficiency. The effects of the factors related to the educational paths of adults were accounted for in the analyses by variables other the recentness of education, and thus very little explanatory power was left for this variable.

Overall, the current study shows that the significance of the length and scope of initial education in developing literacy proficiency overall is difficult to compensate, and the role of basic education cannot be ignored even after completing secondary and tertiary degrees. In Nordic countries, education level proved to be the main determinant of adult literacy among age and education- and work-related factors. This is consistent with earlier studies (Linnakylä et al., 2000; OECD, 2000, pp. 56–58, 2013a, pp. 190–195; see also Green & Riddell, 2012). In Norway, however, occupation has an even greater bearing on literacy proficiency (see also Mellander [2014] on work experience and literacy). This may be due to the differences in the interface between education and work. In Norway, for instance, adult education and vocational education include extensive practical internships and have a long tradition of apprenticeship, as well as experience-based trade certificates of practice (Norwegian Ministry of Education and Research, 2015; Skule, Stuart, & Nyen, 2002). Thus, in Norway, work-based learning has a major emphasis while other Nordic countries seem to have more school-based systems with extensive investments in adult education in all Nordic countries (Mellander & Anderssen, 2015, p. 49).

The current study has its limitations, many of which derive from the restrictions of the data. First, recentness of education was used as a proxy for changes in education over time. This is a relatively

weak measure and as such does not provide a solid foundation for interpretations about the relationship between education, age, and literacy proficiency. Additionally, recentness of education and age was combined for the analysis due to their interdependence. This resulted in rough age groups in 10-year intervals for both age and graduation periods. Consequently, some details may have been lost in the analyses.

Another restriction of the data was related to the educational choices of adults. The PIAAC data include detailed information only about the respondents' highest degree completed. This meant that no information about the degrees completed prior to the current highest degree is available. In the case of several degrees on the same level, or adults having, for instance, completed a vocational secondary degree before the tertiary one, a realistic possibility in the Nordic context, the data cover only the latest one. In this respect, the composition of the groups (by age and recentness of the degree) is an unknown and possibly heterogeneous one. Appendix, Table A1, was attached to describe the group composition with the available data, but the information available is limited. This also means that it was impossible to address or control the selection mechanism for formal adult education. Finally, cross-sectional data offers no possibilities to study the effect of age-related cognitive decline on adults' literacy proficiency, excluding a potentially significant explanatory factor from the study.

Acknowledgements

The research reported in this article is a part of the project 'Skill Acquisition, Skill Loss, and Age: A Comparative Study of Cognitive Foundation Skills in Denmark, Finland, Norway and Sweden.'

Funding

This work was supported by NordForsk, research programme 'Education for Tomorrow' [grant number 54861].

ORCID

Sari Sulkunen http://orcid.org/0000-0003-2790-8951

References

Ackerman, P. L. (2008). Knowledge and cognitive ageing. In F. Craik & T. Salthouse (Eds.), *The handbook of aging and cognition* (3rd ed., pp. 445–489). New York, NY: Psychology Press.

Ackerman, P. L., Kanfer, R., & Calderwood, C. (2010). Use it or lose it? Wii brain exercise practice and reading for domain knowledge. *Psychology and Aging, 25*, 753–766. doi:10.1037/a0019277.

Aczel, A. D. (1999). *Complete business statistics* (4th ed.). Boston, MA: Irwin McGraw-Hill.

Albaek, K., Fridberg, T., & Rosdal, A. (2014). Use of skills at work, cognitive foundation skills, and age. In A. Malin (Ed.), *Associations between age and cognitive foundation skills in the Nordic countries: A closer look at the data* (pp. 49–68). Jyväskylä: Finnish Institute for Educational Research.

Binkley, M., Erstad, O., Herman J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and Teaching of 21st Century Skills* (pp. 17–66). New York, NY: Springer.

Bynner, J., & Parsons, S. (2006). *New light on literacy and numeracy*. London: NRDC.

Cliffordson, C., & Gustafsson, J. E. (2008). Effects of age and schooling on intellectual performance: Estimates obtained from analysis of continuous variation in age and length of schooling. *Intelligence, 36*(2), 143–152. doi:10.1016/j.intell.2007.03.006.

European Commission. (2007). *Key competences for lifelong learning: European reference framework*. Luxembourg: European Communities, Education and Culture DG.

European Commission. (2015). *Adult education and training in Europe: Widening access to learning opportunities. Eurydice Report*. Luxembourg: Publications Office of the European Union.

Flynn, J. R. (2009). *What Is Intelligence? Beyond the Flynn Effect*. Cambridge: Cambridge University Press.

Gabrielsen, E., & Lundetrae, K. (2014). Distribution of skills in the Nordic countries: A comparison. In A. Malin (Ed.), *Associations between age and cognitive foundation skills in the Nordic countries: A closer look at the data* (pp. 25–48). Jyväskylä: Finnish Institute for Educational Research.

Gabrielsen, E., Lundetrae, K., Gustafsson, J.-E., & Myrberg, M. (2014). Background. In A. Malin (Ed.), *Associations between age and cognitive foundation skills in the Nordic countries: A closer look at the data* (pp. 9–24). Jyväskylä: Finnish Institute for Educational Research.

Green, D. A., & Riddell, W. C. (2003). Literacy and earnings: An investigation of the interaction of cognitive and unobserved skills in earnings generation. *Labour Economics, 10*, 165–184. doi:10.1016/S0927-5371(03)00008-3.

Green, D. A., & Riddell, W. C. (2012). Ageing and literacy skills: Evidence from Canada, Norway and the United States. *Labour Economics, 22*, 16–29. doi:10.1016/j.labeco.2012.08.011.

Gustafsson, J. E. (2016). Lasting effects of quality of schooling: Evidence from PISA and PIAAC. *Intelligence*, *57*, 66–72. doi:10.1016/j.intell.2016.05.004.

Hautamäki, J., & Hautamäki, A. (2008). Reforming Finnish education 1968–2004. In J. Hautamäki, E. Harjunen, A. Hautamäki, T. Karjalainen, S. Kupiainen, S. Laaksonen … P. Scheinin (Eds.), *PISA06 Finland: Analyses, reflections and explanations* (pp. 27–33). Helsinki: Ministry of Education and Culture.

Leu, D. J., Kinzer, C. K., Coiro, J., Castek, J., & Henry, L. A. (2013). New literacies: A dual-level theory of the changing nature of literacy, instruction, and assessment. In D. E. Alvermann, N. J. Unrau, & R. B. Ruddell (Eds.), *Theoretical models and processes of reading* (6th ed., pp. 1150–1181). Newark, DE: International Reading Association.

Linnakylä, P. (2000). Lukutaito tiedon ja oppimisen yhteiskunnassa [Literacy in the society of knowledge and learning]. In K. Sajavaara & A. Piirainen-Marsh (Eds.), *Kieli, diskurssi ja yhteisö* (pp. 107–132). Jyväskylä: University of Jyväskylä, Centre for Applied Linguistics.

Linnakylä, P., Malin, A., Blomqvist, I., & Sulkunen, S. (2000). *Lukutaito työssä ja arjessa. Aikuisten kansainvälinen lukutaitotutkimus Suomessa* [International adult literacy survey in Finland]. Jyväskylä: Finnish Institute for Educational Research.

Malin, A. (2005). *School differences and inequities in educational outcomes: PISA 2000 results of reading literacy in Finland*. Jyväskylä: Institute for Educational Research.

Mellander, E. (2014). The role of work experience for skills: Findings for the Nordic countries based on the PIAAC survey. In A. Malin (Ed.), *Associations between age and cognitive foundation skills in the Nordic countries: A closer look at the data* (pp. 131–170). Jyväskylä: Finnish Institute for Educational Research.

Mellander, E., & Anderssen, A. F. (2015). An overview of the characteristics of the Nordic region. In T. Fridberg, A. Rosdahl, V. Halapuu, A. Valk, A. Malin, R. Hämäläinen, A. F. Anderssen … E. Mellander (Eds.), *Adult skills in the Nordic region: Key information-processing skills among adults in the Nordic region* (pp. 39–52). TemaNord 2015: 535. Copenhagen: Nordic Council of Ministers.

Norwegian Ministry of Education and Research. (2015). *Education*. Retrieved from: https://www.regjeringen.no/en/topics/education/id930/

Organisation for Economic Co-operation and Development (OECD). (2000). *Literacy in the Information Age: Final report of the International Adult Literacy Survey*. Paris: OECD & Statistics Canada.

Organisation for Economic Co-operation and Development (OECD). (2009). *PIAAC literacy: A conceptual framework*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development (OECD). (2013a). *OECD skills outlook 2013: First results from the survey of adult skills*. Paris: OECD Publishing. doi:10.1787/9789264204256-en

Organisation for Economic Co-operation and Development (OECD). (2013b). *The survey of adult skills: Reader's companion*. Paris: OECD Publishing.

Organisation for Economic Co-operation and Development (OECD). (2013c). *Technical report of the survey of adult skills (PIAAC)*. Retrieved from http: http://www.oecd.org/site/piaac/_Technical%20Report_17OCT13.pdf

Organisation for Economic Co-operation and Development (OECD). (2014). *Educational attainment in OECD Factbook 2014: Economic, Environmental and Social Statistics*. Paris: OECD Publishing. doi:10.1787/factbook-2014-80-en

Rawlings, J. O., Pantula, S. G., & Dickey, D. A. (2001). *Applied regression analysis: A research tool* (2nd ed.). New York, NY: Springer.

Reder, S. (1994). Practice-engagement theory: A sociocultural approach to literacy across languages and cultures. In B. M. Ferdman, R. M. Weber, & A. G. Ramirez (Eds.), *Literacy across languages and cultures* (pp. 33–74). Albany: State University of New York Press.

Reder, S. (2008). The development of literacy and numeracy in adult life. In S. Reder & J. Bynner (Eds.), *Tracking adult literacy and numeracy skills: Findings from longitudinal research* (pp. 59–84). London: Routledge.

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review, 103*, 403–428. doi:10.1037/0033-295X.103.3.403

Salthouse, T. A. (2006). Mental exercise and mental aging evaluating the validity of the "use it or lose it" hypothesis. *Perspectives on Psychological Science*, *1*, 68–87. doi:10.1111/j.1745-6916.2006.00005.x

Schneeweis, N., Skirbekk, V., & Winter-Ebmer, R. (2014). Does education improve cognitive performance four decades after school completion? *Demography*, *51*(2), 619–643. doi:10.1007/s13524-014-0281-1

Schooler, C. (2001). The intellectual effects of the demands of the work environment. In R. J. Sternberg & E. L. Gigorenko (Eds.), *Environmental effects on cognitive abilities* (pp. 363–380). Mahwah, NJ: Erlbaum.

Schooler, C., Mulatu, M. S., & Oates, G. (1999). The continuing effects of substantively complex work on the intellectual functioning of older workers. *Psychology and Aging, 14*, 483–506.

Skule, S., Stuart, M., & Nyen, T. (2002). International briefing 12: Training and development in Norway. *International Journal of Training and Development*, *6*(4), 263–276. doi:10.1111/1468-2419.00164

Sulkunen, S. (2013). Adolescent literacy in Europe: An urgent call for action. *European Journal of Education, 48*, 528–542. doi:10.1111/ejed.12052

Sulkunen, S., & Malin, A. (2014). Adult education and training in the Nordic countries. In A. Malin (Ed.), *Associations between age and cognitive foundation skills in the Nordic countries: A closer look at the data* (pp. 69–93). Jyväskylä: Finnish Institute for Educational Research.

Valk, A. (2015). Differences and inequities in the distributions of information-processing skills in the Nordic Countries. In T. Fridberg, A. Rosdahl, V. Halapuu, A. Valk, A. Malin, R. Hämäläinen … E. Mellander (Eds.), *Adult Skills in the Nordic Region: Key information–processing skills among adults in the Nordic Region* (pp. 83–120). TemaNord 2015:535. Copenhagen: Nordic Council of Ministers.

Verhoeven, L. T. (1994). Modeling and promoting functional literacy. In L. Verhoeven (Ed.), *Functional literacy: Theoretical issues and educational implication* (pp. 3–34). Amsterdam: John Benjamins.

Wheater, R., & Worth, J. (2014). *Young adults' skills gain in the International Survey of Adult Skills 2012* (BIS Research Paper 182). London: Department of Business, Innovation and Skills).

Williams, E. (2006). Literacy studies. In A. Davies & C. Elder (Eds.), *The handbook of applied linguistics* (pp. 576–603). Oxford: Blackwell.

Yang Hansen, K., Gustafsson, J.-E., & Rosén, M. (2014). School performance differences and policy variations in Finland, Norway, and Sweden. In K. Yang Hansen, J. Gustafsson, M. Rosén, S. Sulkunen, K. Nissinen, P. Kupari … A. Hole (Eds.), *Northern lights on TIMSS and PIRLS 2011: Differences and similarities in the Nordic countries* (pp. 25–47). Copenhagen: Nordic Council of Ministers.

Appendix. Descriptive statistical information of adults in Nordic countries, based on PIAAC

Table A1. Descriptive statistics of adults in Nordic countries by graduation period within age groups, based on a PIAAC sample.

Age (years)	25–34		35–44			45–54				55–65				
Range of birth year	1977–1986		1967–1976			1957–1966				1946–1956				
Period of completing education	1990–1999	2000–2012	1980–1989	1990–1999	2000–2012	1970–1979	1980–1989	1990–1999	2000–2012	1960–1969	1970–1979	1980–1989	1990–1999	2000–2012
Mean age	32	29	42	39	39	52	49	49	49	62	59	59	60	58
Length of basic education (years)*	9	9	9	9	9	9	9	9	9	9	9	9	9	9
						FI 9/6	FI 9/6	FI 9/6	FI 9/6	DK 7 FI 6	DK 7 FI 6	DK 7 FI 6	DK 7 FI 6	DK 7 FI 6
Highest level of education** (%)														
Low	38	7	38	8	3	55	11	5	6	58	17	7	12	12
Medium vocational	37	22	37	29	16	30	36	22	28	27	33	22	29	32
Medium general	17	12	15	13	3	9	11	4	3	6	9	6	7	6
High	4	54	6	45	73	4	36	64	57	6	38	62	47	47
Mean age when completing highest education	18	24	18	23	32	17	22	31	43	17	22	32	43	51
Occupation** (%)														
Skilled	18	48	24	48	66	20	45	59	54	17	42	58	45	41
Semi-skilled white-collar	29	26	25	22	18	24	23	17	26	22	21	17	30	34
Semi-skilled blue-collar	29	14	32	18	8	33	19	11	9	25	18	8	7	9
Elementary	12	6	8	5	3	10	5	2	5	9	6	4	4	7
Proportion of females (%)	39	51	41	47	58	42	46	51	70	47	46	50	71	71
Proportion of native language speakers (%)	77	85	82	87	84	89	90	89	89	94	94	92	92	91
Mean of using reading skills at work	1.95	2.21	2.09	2.30	2.40	1.94	2.28	2.48	2.39	1.82	2.27	2.45	2.27	2.31
Mean of using ICT skills at home/outside work	2.02	2.36	1.73	2.15	2.32	1.63	1.95	2.18	2.18	1.48	1.87	2.09	1.89	2.00
Proportion of adults who have interrupted their studies for formal qualification (%)	37	25	26	26	28	21	21	26	24	13	19	23	24	24
Level of uncompleted qualification (%)														
Low (Isced 0, 1, 2, 3c short)	10	4	16	6	3	13	9	7	6	19	5	6	10	16
Medium	69	51	59	48	36	64	49	38	45	61	47	30	45	39
High (Isced 5, 6,)	21	45	25	46	60	23	43	54	49	20	48	64	45	46
N	685	3,456	901	2,287	1,351	994	2,094	862	668	1,540	2,010	654	400	242

Note: FI = Finland, DK = Denmark, ISCED = International Standard Classification of Education, *based on Mellander and Anderssen (2015), **due to missing values some of the column sums may not add up to 100%.

Table A2. Parameter estimates with 95% confidence intervals for the combined variables of age and decade during which the highest qualification was completed in the final model.

Denmark	Decade during which highest qualification was completed									
	Degree 1960–1969		Degree 1970–1979		Degree 1980–1989		Degree 1990–1999		Degree 2000–2012	
Age (years)	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI
25–34							15.9	(3.6, 28.2)	24.5	(17.1, 32.0)
35–44					17.4	(8.2, 26.5)	25.0	(18.0, 32.0)	24.2	(15.8, 32.6)
45–54			6.4	(−2.3,15.1)	14.6	(7.3, 22.0)	19.7	(11.2, 28.2)	9.6	(0.0, 19.1)
55–65	0.0		4.1	(−3.5, 11.7)	5.6	(−3.1, 14.4)	−1.2	(−11.9, 9.6)	10.7	(0.6, 20.9)
Finland	Decade during which highest qualification was completed									
	Degree 1960–1969		Degree 1970–1979		Degree 1980–1989		Degree 1990–1999		Degree 2000–2012	
Age	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI
25–34							27.8	(17.2, 38.5)	38.4	(30.3, 46.6)
35–44					24.9	(14.9, 34.9)	29.6	(21.3, 38.0)	31.4	(22.5, 40.3)
45–54			16.3	(6.5, 26.2)	19.3	(11.0, 27.5)	22.9	(13.9, 31.9)	21.1	(11.1, 31.1)
55–65	0.0		2.4	(−5.6, 10.3)	7.1	(−2.4, 16.7)	1.9	(−9.0, 12.8)	2.9	(−9.4, 15.2)
Norway	Decade during which highest qualification was completed									
	Degree 1960–1969		Degree 1970–1979		Degree 1980–1989		Degree 1990–1999		Degree 2000–2012	
Age	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI
25–34							17.4	(4.7, 30.0)	28.0	(17.9, 38.2)
35–44					15.3	(3.6, 27.1)	24.2	(14.5, 33.8)	24.8	(14.5, 35.1)
45–54			15.6	(4.0, 27.3)	18.5	(8.3, 28.7)	16.7	(6.4, 26.9)	11.6	(0.7, 22.5)
55–65	0		2.2	(−7.6, 12.0)	5.3	(−6.1, 16.8)	−6.0	(−19.9, 7.8)	−0.4	(−16.4, 15.6)
Sweden	Decade during which highest qualification was completed									
	Degree 1960–1969		Degree 1970–1979		Degree 1980–1989		Degree 1990–1999		Degree 2000–2012	
Age	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI	Estimate	95%CI
25–34							20.7	(8.9, 32.6)	24.2	(15.2, 33.1)
35–44					19.7	(9.0, 30.5)	20.5	(11.8, 29.1)	23.9	(13.5, 34.4)
45–54			9.3	(0.6, 18.1)	16.9	(8.1, 25.6)	14.3	(3.9, 24.7)	13.2	(2.3, 24.2)
55–65	0.0		5.7	(−3.2, 14.6)	5.3	(−4.3, 14.9)	−7.3	(−22.3, 7.7)	0.6	(−13.4, 14.6)