Overeducation and cognitive decline

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Abstract

In this paper we analyse whether overeducated workers are vulnerable for cognitive decline. For our analyses we use longitudinal test data on various aspects of a person's cognitive abilities. Our estimation results show that particularly the extent of overeducation is relevant for cognitive decline. This holds for workers' immediate and delayed recall abilities, as well as for their verbal fluency. These findings indicate that the lower cognitive abilities of overeducated workers found in cross-sectional analyses may be due to cognitive decline instead of *ex ante* heterogeneity. Moreover, our findings indicate that, to some extent, it is the decline of the ability level of the overeducated worker that adjusts the initial mismatch. Our findings add to the relevance of preventing overeducation, and show that being employed at a job level above one's level of education may contribute to lifelong learning.

1. Introduction

There is now a substantial literature on the incidence and effects of overeducation (see Sloane (2003) for a recent overview). Several studies indicate that a substantial proportion of the workforce is employed in a job that does not require their level of education (e.g. Sloane, Battu & Seaman, 1999). Most studies focus on the effects of overeducation on workers' wages (e.g. Groot & Maassen van der Brink, 2000). Other studies focus on the effects of overeducation on career mobility (e.g. Büchel & Mertens, 2004) or workers' job satisfaction (e.g. Allen & Van der Velden, 2001). Overeducation is often seen as a short-term problem resulting from a lack of coordination in the adjustment of schooling requirements and schooling investments between firms and individuals (Duncan & Hofman, 1981).

Many studies found that overeducated workers earn less than equally educated workers who are employed in a job that matches their education, whereas undereducated workers who are employed in a higher level job earn more (e.g. Hartog, 2000). In the literature on overeducation, it is often argued that, apart from the attained level of education, also job characteristics determine a worker's productivity (see e.g. Sicherman, 1991). When higher-skilled workers work in a lower-level job their productivity will therefore be restricted. However, others state that the lower productivity of the overeducated workers can indicate the relatively lower ability of these workers compared to the higher-skilled workers who found a job at a proper level (see e.g. Sloane, 2003). In this paper we add a third explanation: workers who are employed in a job for which they are overeducated are more vulnerable for a decline in their productivity, because they cope with a loss of their cognitive resilience due to non-use (e.g. De Grip & Van Loo, 2002).

The latter argument also implies that it is not only workers' search for a better job that adjusts the match between workers' abilities and the level of their job in the long run (e.g. Groot & Maassen van den Brink, 2003). Instead, it could be that, at least in some situations, the adjustment of the ability level of the worker recovers equilibrium, i.e. the decline of workers' cognitive abilities adjusts the match between workers' abilities and the level of the job.

In this paper, we will go further into these last two arguments. For this purpose we use detailed information on workers' cognitive abilities. We will focus on two related questions:

- Do overeducated workers have lower cognitive abilities?
- Are overeducated workers more vulnerable for cognitive decline than workers who are employed in a job that matches their level of education?

The first question contributes to the literature that argues that overeducation is related to the cognitive heterogeneity of workers with the same educational background (e.g. Green, et al. 1997; Dolton & Silles, 2003)[1]. In these studies, it is argued that overeducated workers are often at the lower end of the ability distribution of the workers at a particular level of education. The second question contributes to the overeducation literature by showing whether overeducation induces long-term effects for individual workers. In this respect, the study builds on the psychological literature on the relation between cognitive decline and intellectual challenge. Staff et al. (2004) argued that suboptimal intellectual challenge can restrict the 'cognitive reserve" of higher educated workers, which may have implications for the rate of age-related cognitive decline. Bosma et al. (2003a and 2003b) found that workers who are employed in jobs with a low mental workload have a higher risk of age-related cognitive decline.

In this study we will analyze whether the latter also holds for overeducated workers. As workers employed in a job below their level of education are not able to apply their skills in the job they have, they may be less able to sustain their cognitive abilities than workers employed in a job that matches their level of education. From this *use-it-or-lose-it* hypothesis, we expect that overeducated workers will face a higher risk of cognitive decline. In this way the study contributes to the literature on skill obsolescence due to the atrophy of a worker's skills by non-use (e.g. Mincer & Ofek, 1982; Krahn & Lowe (1997) and De Grip & Van Loo, 2002).

In a similar way we expect that workers who are employed in a higher level job face less cognitive decline due to the intellectual challenge of their job for a person with their level of education (e.g. Staff et al., 2004). This *intellectual-challenge* hypothesis contributes to the literature on on-the-job learning (cf. Lindbeck & Snower, 2000).

In our analyses we also take into account the *extent of overeducation*. There are hardly any studies that take account of the 'vertical distance' between workers' job level and their level of education (An exception is Van Eijs & Heijke, 2000). We expect that in a study on cognitive decline it is important to consider the degree in which workers are overeducated for their job, as particularly the workers who work in a job far below their level of education might suffer from atrophy of their cognitive abilities.

For our analyses we use the longitudinal data of the Maastricht Aging Study (Jolles, et al., 1995). From this 'MAAS' dataset we use longitudinal test data on 654 persons who were all employed at baseline measurement in the years 1993-1995, as well as six years later in the

period 1999-2001. These test data allow us to measure the development of various aspects of workers' cognitive abilities in the six-year period between the two measurements.

The remainder of the paper is organized as follows. Section 2 outlines the way in which we measure overeducation and undereducation, and discusses the different measures of cognitive abilities we used. In Section 3 we outline our empirical analyses and report on the estimation results. In the final section we will make some concluding comments.

2. Measures of overeducation and cognitive abilities

Overeducation

In the literature on overeducation, there are three main alternatives in the measurement of overeducation (see e.g. Hartog, 2000 and Sloane, 2003):

- the objective method, which depends on systematic evaluation of the level of jobs in a particular occupational group (e.g. Rumberger, 1987);
- the subjective method, based on workers' self-assessment of their job level (e.g. Sloane, Battu & Seaman, 1999);
- the empirical method, in which overeducation is indicated when a worker's level of education is more than one standard deviation above the mean in a particular occupation (e.g. Groot, 1996).

In this study we will use the first method, which is conceptually superior (Hartog, 2000), although it may overestimate the incidence of overeducation (Van der Velden & Van Smoorenburg, 2000). We qualify the job level of the occupational group in which someone is employed by means of the ARBI code, made by job analysts. This ARBI code contains a classification into seven levels of job complexity, developed by the Dutch Ministry of Social Affairs (see also Hartog & Oosterbeek, 1988). Table 1 gives an overview of the job levels at which workers with a particular level of education are considered to be overeducated for their job.

Insert Table 1 about here

In a similar way, the extent of overeducation can be determined. We here assume that the extent of overeducation is linear across the job level scale. Moreover, we included the degree

of undereducation as negative scores on this measure. Table 2 gives an overview of the degree of overeducation at the various job levels for workers with a particular level of education.

Insert Table 2 about here

Cognitive abilities

In this study, we use test data on workers' cognitive abilities. Several studies show that persons' scores on these tests are highly related to their level of education (e.g. Lezak, 2004). This indicates that these tests are measuring the labour market value of workers' cognitive abilities quite adequately[2].

The cognitive abilities of the respondents have been tested in the period of the baseline measurement (1993-1995), as well as six years later (1999-2001). Both times the same battery of standard neuropsychological tests were used to assess the cognitive domains of verbal memory (immediate and delayed recall), cognitive flexibility (Stroop test), verbal fluency and information processing speed ('letter-digit copying') (Lezak, 2004).

The Word Learning Task (WLT) evaluates the ability to acquire and retain new verbal information (Van der Elst, et al., 2005). In this test a set of fifteen frequently used monosyllabic words is presented in fixed order at a rate of one every two seconds in each of five trials. These tests enable us to measure two aspects of a person's cognitive abilities: their *immediate recall abilities* and their *delayed recall abilities*: After every trial the participant has to reproduce the memorized words (the *immediate recall* test). Twenty minutes after the last trial the participant is asked again to reproduce the set of words (the *delayed recall* test). Recorded are the total of correctly reproduced words on five trials, the maximum score in five trials and the number of correctly reproduced words after 20 minutes.

Selective attention and susceptibility to perceptual interference was measured by the Stroop Colour Word Test (Hammes, 1973; Stroop, 1935). This test indicates a person's *cognitive flexibility*. The test involves naming as fast as possible the colour of the printing ink of one hundred names of colours that do not match the colour of the ink with which these names are printed. The number of seconds to complete the task is recorded. Performance in this test is determined for a large part by the time needed to discard irrelevant but very salient information (verbal), in favour of a less obvious aspect (colour of the printing ink). It should be noted that a higher score (i.e. more seconds) on this test indicates a lower cognitive ability.

A person's *verbal fluency* has been measured by a test in which a person has to produce as many as possible words in a given category within 60 seconds (category fluency). The test can be regarded as a measure for the adequate, strategy-driven retrieval of information from semantic memory. If one is requested to name as many animals as possible within one minute, performance is greatly enhanced when a limited number of categories (such as farm animals or aquarium fish) are systematically searched. This test therefore reflects the organizational level among clusters of meaningfully related words (Luteijn & Van der Ploeg, 1983).

Finally, we used the Letter Digit Copying Test (LDCT). In this paper-and-pencil task, a person has to copy numbers in boxes that are indexed by a letter. The letter refers to nine letter/number combinations at the top of the test sheet In neuropsychological assessment, this test is an often used general measure of the *information processing speed* (Lezak, 2004).

3. Data

For this study we used the data of the Maastricht Aging Study (MAAS) (Jolles *et al.*, 1995; Van Boxtel *et al.*, 1998). The MAAS data include 1,823 individuals who were between 24 and 81 years old at baseline measurement. These persons were screened by a questionnaire for background characteristics (e.g. socio-demographic information and health status) and were tested using an extensive neurocognitive test battery at baseline. After six years, 1,376 (75,5%) were retested with the same test battery. Participants were recruited from the Registration Network of Family Practices (Metsemakers et al., 1992), a database of collaborating general practices in the region of South-Limburg, the Netherlands. Exclusion criteria at baseline were chronic neurological pathology (e.g. evidence of stroke, epilepsy or dementia), mental retardation or chronic psychotropic drug use. Participants were stratified for age (12 age classes, ranging from 25±1 year, 30±1 year, …, to 80±1 year), sex, and level of general ability (two levels, based on the activities in professional life (Van Berkel & Tax, 1990). For this study, only those participants were selected who were 64 years or younger, and who were employed at the moment of the baseline measurement in the years 1993-'95. From this group we further selected the workers who also participated in the cognition tests six years later in the period 1999-2001. This enabled us to use the longitudinal information on workers' cognitive decline. These longitudinal data are available for 654 persons. Of this group 248 were employed in a job for which they were overeducated. This number of

overeducated workers is relatively high (cf. Groot & Maassen van den Brink, 2000), although there are several studies that find comparable rates of overeducation (Sloane, 2003).

4. Estimation results

First, we analyzed whether overeducated workers are the less able persons and undereducated workers are the more able ones. Obviously, higher educated persons are expected to have higher cognitive abilities. In a cross-section analysis on the baseline measurement data we estimated the effects of overeducation and undereducation on workers' cognitive abilities controlled for their level of education. Moreover, we control for two potential covariates of cognitive performance: workers' age[3] and sex, as other studies show that cognitive abilities are negatively related to a person's age and women generally have higher ability scores than men (Lezak, 2004).

Insert Table 3 about here

The estimation results show that overeducated workers do not have lower cognitive abilities than workers with a job that matches their level of education, whereas workers in jobs at a higher level than their own level of education do not have higher abilities. We therefore did not find any evidence for a heterogeneity in workers cognitive abilities, given their educational background. However, when we take into account the extent of overeducation, we find a significant negative relation with the test scores that measure a person's information processing speed, and a weakly significant relation with workers' verbal fluency. This may indicate that the relative match between the attained level of education and the job level is to some extent related to the initial heterogeneity in cognitive abilities of individuals with the same level of education. However, it may also be due to the longitudinal effect of working in a job at a level far below or above one's level of education on a person's cognitive abilities.

Insert Table 4 about here

In order to find evidence for the latter, we analysed whether overeducated workers are more vulnerable for cognitive decline than workers who are employed in a job that matches their level of education, by estimating the longitudinal effects of overeducation on cognitive decline. In these analyses we again controlled for workers' level of education. Here this

variable refers to the so-called 'brain reserve hypothesis' that suggests that educational attainment and cognitive decline are related because both are based on innate or early life cognitive potential. (Plassman, et al. 1995). This control enables us to test whether overeducation constraints the cognitive capacity of an individual, which may have implications for the rate of cognitive decline.

The estimation results show that overeducation generally does not induce cognitive decline. However, we find that workers employed in a job at a higher level than their educational background (i.e. the undereducated workers) face less cognitive decline with respect to their delayed recall abilities and – weakly significant – for their immediate recall abilities and cognitive flexibility. Moreover, the estimation results show that the degree of overeducation is much more relevant in this respect. This means that particularly the workers who work in a job far below their level of education suffer from cognitive decline, whereas the workers employed in a job far above their level of education face much less cognitive decline. Significant negative effects of the extent of overeducation are found on the test scores for immediate recall, delayed recall as well as verbal fluency. These results show that the longitudinal effects on a person's cognitive abilities are worse than reflected in the cross-sectional analyses.

The analyses also show that workers' level of education decreases the risk of cognitive decline in all the fields for which we had test scores. This is in line with the "brain reserve hypothesis" mentioned in Section 1. When we compare the beta-coefficients of this variable with the coefficients of the extent-of-overeducation variable, we find that the extent of overeducation has a substantial effect on workers' cognitive abilities. For a person's intermediate and detailed recall abilities as well as for their verbal fluency, the effects of overeducation are about 50-70% of the effect on a person's cognitive abilities, when someone's level of education would be one level lower than his or her actual level of education.

Insert Table 5 about here

Part of the workers who were employed at baseline measurement were unemployed or out of the labour force six years later. Therefore, it might be that the cognitive decline due to overeducation we found in the previous analysis is mainly due to the loss of work in the meantime. However, we did not find any significant effect of overeducation on the probability to lose employment in the six-year period we analysed[4]. As non-employed persons probably

face higher cognitive decline than employed workers, we might have underestimated the effects of overeducation in the previous analyses, because similar parts of the overeducated workers and workers with a well-matching job may have lost their jobs in the meantime. Therefore, we also estimated the effects of overeducation on cognitive decline for those who remained employed during the six-year period we analysed. For these analyses we had data on 447 workers.

The estimation results show in general similar effects than the previous analyses. Table 5 shows that also for those who remain employed it is the extent of overeducation that matters for cognitive decline. However, as we expected the effects of the degree of overeducation on cognitive decline are larger than in the previous analyses.

Furthermore, we analysed whether the effects of the extent of overeducation on workers' cognitive abilities is modified by workers' age. These interaction terms were only weakly significant for workers' cognitive flexibility and information processing speed. Whereas it is the older workers who face the largest decline of their information processing speed, overeducated younger workers face the largest decline in their cognitive flexibility. In the analyses, including the interaction term between the extent of overeducation and a worker's age, we also find that the extent of overeducation on workers' cognitive flexibility becomes significant[5].

5. Conclusions

In this paper we analysed the effects of overeducation on workers' cognitive abilities. We found that overeducated workers do not have lower cognitive abilities than workers with a job that matches their level of education. Also, undereducated workers do not have significantly higher cognitive abilities. However, when we take into account the extent of overeducation, we find that overeducated workers have less information processing speed and verbal fluency.

The estimation results on the longitudinal effects of overeducation showed that overeducation in general does not induce cognitive decline. Oppositely, undereducated workers do face less cognitive decline with respect to their immediate and delayed recall abilities and their cognitive flexibility. However, here too the degree of overeducation is much more relevant. Particularly the workers with a job far below their level of education suffer from a decline of their cognitive abilities, whereas workers employed in a job far above their level of education face much less cognitive decline. This holds for workers' immediate and delayed recall abilities, as well as for their verbal fluency. Moreover, the effects on workers' cognitive abilities are substantial. These findings support the "use it or lose it"

hypothesis on the effects of overeducation on a worker's cognitive abilities: Moreover, it supports the intellectual challenge hypothesis that working above one's level of education increases a worker's cognitive resilience.

Our findings on the longitudinal effects of overeducation on a person's cognitive abilities indicate that the lower cognitive abilities of overeducated workers found in cross-sectional analyses are not necessarily due to the heterogeneity of workers with the same educational background, as the lower cognitive abilities of the overeducated workers may also be due to cognitive decline.

Moreover, our findings indicate that disequilibria in the allocation in the labour market with respect to workers' job level, not necessarily induce labour market adjustments via job search, as has been shown in the literature (e.g. Groot & Maassen van den Brink, 2003). Instead, being overeducated for one's job may also have its repercussions on workers' human capital assents, due to the atrophy of their cognitive abilities. Then, it is the ability level of the overeducated worker that adjusts to the equilibrium.

However, not all longitudinal effects we found were reflected in the cross-section analyses on the effects of the extent of overeducation on workers' cognitive abilities at baseline measurement. This might be explained by the fact that overeducated workers have a higher rate of upward mobility (Sicherman, 1991). Therefore, the situation of overeducation is restricted in time when workers succeed in finding a better matching job if the labour market becomes more tight. However, it may also be due to a selection effect as a result of the long-term effects of overeducation on labour market participation. Although we did not find any effect of overeducation on job loss within the six-year period we analysed, overeducation may threaten workers' employability in the long term.

As our estimation results showed that in particular workers' recall abilities and verbal fluency are at risk when workers are overeducated. It is obvious that this adds to the relevance to prevent overeducation in the labour market. Moreover, it shows that employing workers at higher job levels than the jobs that directly match with their level of education may contribute to lifelong learning by learning by doing (cf. Arrow, 1962).

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Table 1

Determining the occurrence of overeducation and undereducation by workers' job level and level of education in the Netherlands.

Level of education					
Job level (ARBI code)	Primary school	Junior vocational + lower general education	Intermediate vocational + higher general education	Higher vocational education	University
(1) Unskilled	Overeducation	Overeducation	Overeducation	Overeducation	Overeducation
(2) Primary education	-	Overeducation	Overeducation	Overeducation	Overeducation
(3) Low-skilled vocational	Undereducation	-	Overeducation	Overeducation	Overeducation
(4+5) Intermediately skilled vocational	Undereducation	Undereducation	-	Overeducation	Overeducation
(6) Higher-skilled vocational	Undereducation	Undereducation	Undereducation	-	Overeducation
(7) Academic education	Undereducation	Undereducation	Undereducation	Undereducation	-

Table 2.
Determining the degree of overeducation by workers' job level and level of education in the Netherlands.

	Level of education				
Job level	Primary school	Junior vocational + lower general education	Intermediate vocational + higher general education	Higher vocational education	University
(1) Unskilled	Overeducation 1	Overeducation 2	Overeducation 3	Overeducation 5	Overeducation 6
(2) Primary education		Overeducation 1	Overeducation 2	Overeducation 4	Overeducation 5
(3) Low-skilled vocational	Overeducation - 1		Overeducation 1	Overeducation 3	Overeducation 4
(4) Intermediately skilled	Overeducation - 2	Overeducation -1		Overeducation 2	Overeducation 3
(5) Intermediately skilled/comprehensive	Overeducation -3	Overeducation -2		Overeducation 1	Overeducation 2
(6) Higher-skilled vocational	Overeducation -4	Overeducation -3	Overeducation -1		Overeducation 1
(7) Academic education	Overeducation -5	Overeducation -4	Overeducation -2	Overeducation -1	

Table 3

Relation between overeducation and cognitive abilities among working population (24-64 years old)at baseline measurement (1993-1995)

	Overeducation		Extent of overeducation	
	Immediate recall			
	B	Se	B	Se
Intercept	45.42***	1.91	45.88***	1.82
Age	-0.20***	0.03	-0.21***	0.03
Sex	3.99***	0.62	4.01***	0.61
Educational level	1.47***	0.19	1.47***	0.19
Overeducation	0.65	0.66		
Undereducation	0.16	0.85		
Extent of overeducation			-0.03	0.27
	Adjusted R^2= 0.22		Adjusted R^2= 0.22	
	Delayed recall			
Intercept	10.37***	0.61	10.35***	0.58
Age	-0.07***	0.01	-0.07***	0.01
Sex	1.12***	0.20	1.15***	0.20
Educational level	0.37***	0.06	0.38***	0.06
Overeducation	0.04	0.21		
Undereducation	-0.14	0.27		
Extent of overeducation			-0.03	0.09
	Adjusted R^2= 0.19		Adjusted R^2 = 0.20	
	Cognitive flexibility[#]			
Intercept	88.85***	4.34	87.83***	4.12
Age	0.45***	0.07	0.47***	0.07
Sex	-6.42***	1.40	-6.49***	1.39
Educational level	- 3.20***	0.43	-3.25***	0.42
Overeducation	-.556	1.51		
Undereducation	-1.17	1.93		
Extent of overeducation			0.70	0.62
	Adjusted R^2= 0.19		Adjusted R^2 = 0.19	
	Verbal fluency			
Intercept	22.82***	1.53	22.53***	1.46
Age	-0.05**	0.02	-0.05**	0.02
Sex	0.84*	0.50	0.88*	0.49
Educational level	1.05***	0.15	1.08***	0.15
Overeducation	-0.81	0.53		
Undereducation	0.17	0.68		
Extent of overeducation			-0.37*	0.22
	Adjusted R^2= 0.09		Adjusted R^2= 0.09	
	Information processing speed			
Intercept	57.67***	2.17	58.50***	2.06
Age	-0.33***	0.03	-0.34***	0.03
Sex	2.23***	0.70	2.27***	0.70
Educational level	1.66***	0.21	1.70***	0.21
Overeducation	0.30	0.75		
Undereducation	1.13	0.96		
Extent of overeducation			-0.64**	0.31
	Adjusted R^2 = 0.24		Adjusted R^2 = 0.24	

n=654 * p<0.10, ** p<0.05, *** p<0.01

As mentioned in Section 3, a higher score on this Stroop-inference test indicates lower cognitive abilities

Table 4
Relation between overeducation and cognitive decline during six year period among working population (24-64 years old) at baseline measurement (1993-1995).

	Overeducation		Extent of overeducation	
	Immediate recall			
	B	Se	B	Se
Intercept	25.21***	2.22	25.83***	2.17
Baseline cognitive score	0.57***	0.03	0.57***	0.03
Age	-0.08***	0.03	-0.09***	0.03
Sex	0.83	0.54	0.78	0.54
Educational level	0.68***	0.17	0.68***	0.17
Overeducation	-0.30	0.56		
Undereducation	1.40*	0.72		
Extent of overeducation			-0.51**	0.23
	Adjusted R^2= 0.44		Adjusted R^2= 0.44	
	Delayed recall			
Intercept	5.19***	0.64	5.71***	0.63
Baseline cognitive score	0.55***	0.04	0.55***	0.04
Age	-0.03***	0.01	-0.03***	0.01
Sex	0.37**	0.18	0.31*	0.18
Educational level	0.20***	0.05	0.18***	0.05
Overeducation	0.16	0.24		
Undereducation	0.86***	0.19		
Extent of overeducation			-0.17**	0.08
	Adjusted R^2= 0.39		Adjusted R^2= 0.39	
	Cognitive flexibility[#]			
Intercept	14.43***	3.19	13.64***	3.09
Baseline cognitive score	0.76***	0.02	0.76***	0.03
Age	0.26***	0.04	0.26***	0.04
Sex	-1.32	0.82	-1.12	0.81
Educational level	-0.95***	0.25	-0.87***	0.25
Overeducation	0.20	0.86		
Undereducation	-2.06*	1.11		
Extent of overeducation			0.29	0.36
	Adjusted R^2= 0.73		Adjusted R^2= 0.73	
	Verbal fluency			
Intercept	13.58***	1.35	13.50***	1.29
Baseline cognitive score	0.50***	0.03	0.50***	0.03
Age	-0.07***	0.02	-0.07***	0.02
Sex	0.28	0.38	0.31	0.37
Educational level	0.32***	0.12	0.35***	0.12
Overeducation	-0.56	0.41		
Undereducation	0.28	0.52		
Extent of overeducation			-0.37**	0.17
	Adjusted R^2= 0.37		Adjusted R^2= 0.37	

	Information processing speed			
Intercept	10.59***	1.83	10.78***	1.80
Baseline cognitive score	0.87***	0.02	0.87***	0.02
Age	-0.07***	0.02	-0.07***	0.02
Sex	0.60	0.41	0.62	0.41
Educational level	0.32**	0.13	0.33***	0.13
Overeducation	0.07	0.44		
Undereducation	0.17	0.56		
Extent of overeducation			-0.11	0.18
	Adjusted R^2= 0.77		Adjusted R^2= 0.77	

n=654

* p<0.10, ** p<0.05, *** p<0.01

See Table 3

Table 5

Relation between overeducation and cognitive decline during six year period among working population (24-64 years old) at baseline (1993-1995) as well as follow-up measurement (1999-2001).

	Overeducation		Extent of overeducation	
	Immediate recall			
	B	Se	B	Se
Intercept	24.21***	2.85	24.67***	2.77
Baseline cognitive score	0.60***	0.04	0.60***	0.04
Age	-0.09***	0.03	-0.09***	0.03
Sex	0.91	0.68	0.90	0.67
Educational level	0.59***	0.20	0.62***	0.20
Overeducation	-0.52	0.70		
Undereducation	1.09	0.88		
Extent of overeducation			-0.56**	0.28
	Adjusted R^2= 0.44		Adjusted R^2= 0.44	
	Delayed recall			
Intercept	5.07***	0.79	5.46***	0.77
Baseline cognitive score	0.58***	0.04	0.57***	0.04
Age	-0.03**	0.01	-0.03**	0.01
Sex	0.37	0.22	0.33	0.22
Educational level	0.19**	0.06	0.18***	0.06
Overeducation	-0.12	0.23		
Undereducation	0.83***	0.28		
Extent of overeducation			-0.26***	0.09
	Adjusted R^2= 0.41		Adjusted R^2= 0.39	
	Cognitive flexibility[#]			
Intercept	16.90***	3.97	16.35***	3.83
Baseline cognitive score	0.76***	0.03	0.76***	0.03
Age	0.26***	0.05	0.25***	0.05
Sex	-2.73***	1.04	-2.48**	1.03
Educational level	-1.02***	0.31	-0.97***	0.31
Overeducation	0.90	1.08		
Undereducation	-2.39*	1.36		
Extent of overeducation			0.54	0.44
	Adjusted R^2= 0.73		Adjusted R^2= 0.73	
	Verbal fluency			
Intercept	12.47***	1.63	12.67***	1.57
Baseline cognitive score	0.49***	0.04	0.49***	0.04
Age	-0.06**	0.02	-0.06***	0.02
Sex	0.67	0.46	0.63	0.46
Educational level	0.41***	0.14	0.42***	0.14
Overeducation	-0.52*	0.49		
Undereducation	0.92	0.61		
Extent of overeducation			-0.45**	0.20
	Adjusted R^2= 0.38		Adjusted R^2= 0.38	

	Information processing speed			
Intercept	8.71***	2.16	9.05***	2.13
Baseline cognitive score	0.88***	0.03	0.88***	0.03
Age	-0.05*	0.03	-0.05**	0.03
Sex	0.70	0.50	0.70	0.50
Educational level	0.42***	0.15	0.43***	0.15
Overeducation	0.17	0.53		
Undereducation	0.47	0.66		
Extent of overeducation			-0.19	0.21
	R2= 0.78		R2= 0.78	

n=496

* p<0.10, ** p<0.05, *** p<0.01

See Table 3

Notes

[1] Carneiro & Heckman (2003), however, argued that the heterogeneity of workers with a particular level of education does not merely refer to differences in cognitive abilities, but may also refer to non-cognitive abilities, as a worker's motivation and reliability.

[2] Unfortunately, we did not have the wage data to test the impact of workers' test results on their earnings.

[3] We also estimated the regression analyses presented in this paper including age square terms. These age square variables were only very occasionally significant, whereas the estimation results for the overeducation and undereducation variables remained similar after additional control for the age square term.

[4] Estimation results can be obtained from the authors on request.

[5] Estimation results can be obtained from the authors on request.