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Job-worker mismatch and cognitive decline

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We have used longitudinal test data on various aspects of people's cognitive abilities to analyse whether overeducated workers are more vulnerable to a decline in their cognitive abilities, and undereducated workers are less vulnerable. We found that a job-worker mismatch induces a cognitive decline with respect to immediate and delayed recall abilities, cognitive flexibility and verbal fluency. Our findings indicate that, to some extent, it is the adjustment of the ability level of the overeducated and undereducated workers that adjusts initial job-worker mismatch. This adds to the relevance of preventing overeducation, and shows that being employed in a challenging job contributes to workers' cognitive resilience.

JEL classifications: J24, I19, I29.

1. Introduction

There exists a substantial body of literature on the incidence and effects of overeducation (see Sloane, 2003, for a recent overview). Several studies have indicated that a large proportion of the workforce is employed in a job that does not require their level of education (e.g. Sloane *et al.*, 1999). Most studies focused on the effects of overeducation on workers' wages (e.g. Alba-Ramirez, 1993). Other studies focused on the effects of overeducation on career mobility (e.g. Büchel and Mertens, 2004), or workers' job satisfaction (e.g. Allen and Van der Velden, 2001).

Overeducation is often seen as a short-term problem resulting from a lack of co-ordination in the adjustment of schooling requirements and schooling investments between firms and individuals (Duncan and Hofman, 1981). However, several studies have found that for a large group of workers over-education is a long-term phenomenon (e.g. Sloane *et al.*, 1999; Dolton and Vignoles, 2000).

Many studies have 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 at a job level that is higher than their level of education, earn more (e.g. Hartog, 2000). In the literature on over-education, it is often argued that, apart from the attained level of education, job characteristics also determine a worker's productivity (see e.g. Sicherman, 1991). When higher-skilled workers are employed in a lower-level job, their productivity will be restricted, whereas being employed in a higher-level job contributes to a worker's productivity. However, others state that the lower productivity of the overeducated workers may 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 will add a third explanation: workers who are employed in a job for which they are overeducated, are more vulnerable to a decline in their productivity, because they cope with a loss of their cognitive resilience due to non-use (e.g. De Grip and Van Loo, 2002).[1]

Our argument actually relates the first two explanations of the lower productivity of overeducated workers: when job characteristics restrict the productivity of workers, this may induce the lower cognitive ability of these workers. Moreover, cognitive decline due to overeducation also implies that it is not only the workers' search for a better job that adjusts the match between the workers' abilities and the level of their jobs in the long run (Groot and Maassen van den Brink, 2003). Instead, it may be that, at least in some situations, the decline of workers' cognitive abilities adjusts the match between the workers' performance and the level of the jobs in a potentially damaging way. Obviously, this implies that a mismatch between the employees' level of education and the level of their jobs will have important long-term effects on the functioning of these persons in the labour market.

In this paper we will test two related hypotheses:

(1) The use-it-or-lose-it hypothesis: As workers who are employed in a job at a level below their level of education, are unable 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 face a higher risk of cognitive decline.
(2) The intellectual challenge hypothesis: In a similar way, we expect that workers who are employed in a higher level job face less cognitive decline than workers employed in a job that matches their level of education, due to the intellectual challenge of a job at a level that is beyond a worker's level of education (e.g. Pazy, 2004, and Staff *et al.*, 2004).[2]

[1] This explanation is related to the psychological literature on the relation between an active lifestyle and cognitive decline. A review of these studies is given by Fratiglioni *et al.* (2004).

[2] This effect of the job level on workers' cognitive abilities can be considered as the reverse of the effect of intelligence on job characteristics in Ganzach's (2003) model for the relationships among education, intelligence, job characteristics and job satisfaction.

In our analyses, we will 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 and 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 jobs, as the workers who work in a job far below their level of education may suffer most severely from a loss of their cognitive abilities, whereas those who work far above their level of education are expected to be the least vulnerable to cognitive decline.

Our study 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.*, 1999; Dolton and Silles, 2003).[3] 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. Second, the study relates the overeducation literature to the literature on skills obsolescence. On the one hand, we contribute to the overeducation literature by showing that overeducation induces long-term effects for individual workers. In this respect, our study builds on the psychological literature on the relation between cognitive decline and intellectual challenge (cf. Fratiglioni *et al.*, 2004). On the other hand, the study contributes to the literature on skill obsolescence due to the 'atrophy' of a worker's skills by non-use (e.g. Mincer and Ofek, 1982; Krahn and Lowe, 1997; and De Grip and Van Loo, 2002). Whereas most studies focus on the effects of career interruptions on skill atrophy, we focus on the effects of non-use due to overeducation. Staff *et al.* (2004) argued that suboptimal intellectual challenge may restrict the 'brain reserve' of higher educated workers, which contributes to our understanding of individual differences in the rate of age-related cognitive decline (Schaie, 1994). Bosma *et al.* (2003a,b) found that workers who are employed in jobs with a low mental workload have a higher risk of age-related cognitive decline. We will analyse whether the latter also holds for overeducated workers. Finally, the study contributes to both the psychological literature on 'skill updating' (Kaufman, 1989; Noe and Wilk, 1993; and Pazy, 2004), and the economic literature on 'on-the-job learning' (cf. Sicherman and Galor, 1990; Lindbeck and Snower, 2000) by analysing the effects of being employed in a challenging job on workers' cognitive abilities.

Our estimation results show that job-worker mismatches induce cognitive decline, and indicate that, to some extent, it is the adjustment of the ability level of the overeducated and undereducated workers that adjusts initial job-worker mismatch.

For our analyses, we will use the detailed longitudinal information on workers' cognitive abilities from the Maastricht Aging Study (MAAS) (Jolles *et al.*, 1995). From this dataset we have extracted longitudinal test data on 447 persons who were

[3] Carneiro and 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.

all employed at the baseline measurement in the years 1993–5, as well as six years later in the period 1999–2001. These test data allow us to measure the development of various aspects of the 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 measured overeducation and undereducation, and discusses the different measures of cognitive abilities that we have used. In Section 3, we will outline our empirical analyses and report on the estimation results. In the final section we will make some concluding comments.

2. Measures of over- and undereducation and cognitive abilities

2.1 Overeducation and undereducation

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

(a) the objective method, which depends on systematic evaluation of job levels in a particular occupational group (e.g. Rumberger, 1987);
(b) the subjective method, based on workers' self-assessment of their job level (e.g. Sloane *et al.*, 1999);
(c) 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 a conceptually attractive source for defining job requirements, because it is based on systematic job analysis (Hartog, 2000). However, as shown by Van der Velden and Van Smoorenburg (2000), it may overestimate the incidence of overeducation because some job evaluations may have grown obsolete when the skill demands have been upgraded (cf. Borghans and De Grip, 2001).

We qualify the job level of the occupational group in which someone is employed by means of the ARBI code used 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 and 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 or undereducated for their jobs. In our analyses, we will use separate variables for overeducation and undereducation, as well as a combined job-worker mismatch variable with three positions: overeducation, proper match and undereducation. We will assume that the (mis)match is linear across these three positions and consider undereducation as a negative score on this measure.

Table 1 Determining the occurrence and extent of overeducation (+) and undereducation (−) 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	+1	+2	+3	+5	+6
2. Primary education		+1	+2	+4	+5
3. Low-skilled vocational	−1		+1	+3	+4
4. Intermediately skilled	−2	−1		+2	+3
5. Intermediately skilled/comprehensive	−3	−2		+1	+2
6. Higher-skilled vocational	−4	−3	−1		+1
7. Academic education	−5	−4	−2	−1	

The table also indicates the extent of overeducation of the various education-job-level combinations. We here assume that the extent of overeducation is linear across the job level scale and include the degree of undereducation as a negative score on this measure.

2.2 Cognitive abilities

In this study, we have used test data on workers' cognitive abilities. The scores of individuals in these tests are highly related to their level of education (e.g. Lezak, 2004; Van der Elst *et al.*, 2005, 2006a,b). This indicates that these tests measure the labour market value of their cognitive abilities quite well.[4]

The cognitive abilities of the respondents were tested in the period of the baseline measurement (1993–5), as well as six years later (1999–2001). Both times, the same set of standard neuropsychological tests was 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 Substitution Test) (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 15 frequently used monosyllabic words is presented in a 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

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

recall abilities: After every trial, the participant has to reproduce the memorized words (the immediate recall test). Values recorded are the total number of correctly reproduced words in five trials and the maximum score in five trials. Twenty minutes after the last trial, the participant is asked again to reproduce the set of words (the delayed recall test).

Selective attention and susceptibility to perceptual interference was measured by the Stroop Colour Word Test (Stroop, 1935; Hammes, 1973; Van der Elst *et al.*, 2006c). 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 was measured by a test in which a person had to produce as many words in a given category as possible 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, for instance, 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 (Van der Elst *et al.*, 2006a).

Finally, we used the Letter Digit Substitution Test (LDST). In this paper-and-pencil task, a person is asked to copy accurately and as fast as possible numbers in a series of boxes that are indexed by a unique letter. The letter refers to nine letter/number combinations that are displayed in a table at the top of the test sheet. The number of correctly copied numbers after 90 seconds is used as the measure of interest (Van der Elst *et al.*, 2006b). In neuropsychological assessment, this test is often used to obtain a general measure of 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). Participants were recruited from the Registration Network of Family Practices (RNH, Metsemakers *et al.*, 1992), a database of collaborating general family doctors' practices in the region of South-Limburg, the Netherlands. Exclusion criteria at the baseline were chronic neurological pathology (e.g. evidence of strokes, epilepsy or dementia), mental retardation or chronic psychotropic drug use. Participants were stratified for age (12 age categories), gender, and level of general ability (two levels, based on activities in professional life (Van Berkel and Tax, 1990).

The MAAS data include 1,823 individuals who were between 24 and 81 years old at the baseline measurement. On average, participants in MAAS were higher educated than in the original RNH sample frame, but there were no differences with respect to sex or health status (Jolles *et al.*, 1995). These persons were screened by means of a questionnaire for background characteristics (e.g. socio-demographic information and health status) and were tested using an extensive neurocognitive test battery at baseline. 1,333 persons were younger than 65 years, which is the age of mandatory retirement. From this group we selected 815 persons who were employed. Most of the others were out of the labour force for various reasons. After six years, 673 (82.6%) were retested with the same test battery. From these retested persons 447 persons remained employed at the moment of the follow-up measurement in the years 1999–2001. For this group we could use the longitudinal information on the workers' cognitive decline, excluding the possible effects of non-employment. Compared to the group with no continuous employment, this group was younger, higher educated and contained more males. Obviously, those with a weaker labour market position lost their employment. Of this group, 164 were employed in a job for which they were overeducated, whereas 88 were undereducated with respect to their job level. Sixteen of the workers who were overeducated at baseline measurement were no longer overeducated 6 years later, whereas seven of the undereducated at baseline measurement were no longer undereducated at the moment of the follow-up measurement. The number of overeducated workers is relatively high, which may be due to the relatively high rate of unemployment in the regional labour market. However, several other studies found comparable rates of overeducation (See Sloane, 2003, for an overview).

4. Estimation results

First, we analysed whether overeducated workers are the less able persons and undereducated workers are those with higher abilities. In a cross-section analysis on the baseline measurement data, we estimated the relations between being overeducated or undereducated and workers' cognitive abilities controlled for their level of education, as higher educated persons are expected to have better cognitive abilities.[5] Moreover, we controlled for two potential covariates of cognitive performance: workers' age[6] and gender (male = 1; female = 2), as other studies

[5] We also did estimations including seven dummy variables for the various levels of education. These estimations show similar results for the job-worker mismatch variables. In other analyses we added education-square terms. These square terms were not significant. This indicates the linearity of the effects of workers' level of education on cognitive abilities.

[6] 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.

have shown that cognitive abilities are negatively related to a person's age and women generally have different ability scores than men (Schaie, 1994; Lezak, 2004). In his overview study, Schaie (1994) for instance concluded that women usually have higher sores with respect to verbal meaning and inductive reasoning, whereas men have higher scores for number and spatial orientation. Van der Elst *et al.* (2005, 2006a,b,c) discuss the tests and the effects of age and gender on the test scores we use in this paper.

Obviously, these cross-section analyses do not indicate the direction of causality between the job-worker mismatch and a worker's cognitive abilities. However, the estimation results presented in Table 2 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. Neither did we find any significant relation between the job-worker mismatch variable and workers' cognitive abilities.[7] This also means that we did not find any evidence for the presumption that, due to the selection by employers, the job-worker mismatch is related to the heterogeneity in the workers' cognitive abilities of workers with the same level of education.

Our hypotheses on the effects of being employed at a job level that does not match a worker's level of education were tested by estimating the longitudinal effects of overeducation and undereducation on cognitive decline. For this purpose, we estimated the following two equations for the five different measures of workers' cognitive abilities:

$$CA_{ijt+6} = \alpha_{1i} + \beta_{1i}O_{jt} + \delta_{1i}U_{jt} + \gamma'_{1i}X_{jt} + \mu_{1i}CA_{ijt} + \varepsilon_{1ij} \quad (1)$$

$$CA_{ijt+6} = \alpha_{2i} + \beta_{2i}M_{jt} + \gamma'_{2i}X_{jt} + \mu_{2i}CA_{ijt} + \varepsilon_{2ij} \quad (2)$$

CA_{ij} = cognitive ability i of worker j; O_j = overeducation of worker j; U_i = undereducation of worker j; M_{jt} = job-worker mismatch of worker j; X_j = control variables (level of education, age and sex); α, β, δ, γ', μ = (vectors of) coefficients; ε_{lij}, ε_{2ij} = error terms; t = time.[8]

By including the baseline test scores at the right-hand side of the equation, these analyses explain the change of the workers' cognitive abilities between the baseline measurement in 1993–5 and the follow-up measurement six years later. Here, the control for the workers' level of education refers to the so-called 'brain reserve hypothesis', which suggests that educational attainment and cognitive decline

[7] 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.

[8] Furthermore, we included dummy variables for the few overeducated and undereducated workers who were no longer in this position at the follow-up measurement. However, these dummy variables did not have any effect on the significance of the other variables.

Table 2 Relation between job-worker mismatch and cognitive abilities among working population (24–64 years old) at baseline measurement (1993–5)

	Overeducation/Undereducation		Job-worker mismatch	
	B	Se	B	Se
Immediate recall				
Intercept	47.56***	2.31	47.42***	2.23
Age	−0.22***	0.04	−0.22***	0.04
Gender (female)	3.53***	0.75	3.54***	0.75
Educational level	1.33***	0.22	1.34***	0.22
Overeducation	0.36	0.80		
Undereducation	−0.65	1.00		
Job-worker mismatch			0.48	0.50
	Adjusted $R^2 = 0.22$		Adjusted $R^2 = 0.22$	
Delayed recall				
Intercept	11.02***	0.77	10.93***	0.73
Age	−0.08***	0.01	−0.08***	0.01
Gender (female)	0.94***	0.25	0.95***	0.25
Educational level	0.36***	0.07	0.37***	0.07
Overeducation	0.06	0.26		
Undereducation	−0.24	0.33		
Job-worker mismatch			0.14	0.17
	Adjusted $R^2 = 0.19$		Adjusted $R^2 = 0.20$	
Cognitive flexibility[#]				
Intercept	90.19***	5.54	88.37***	5.28
Age	0.51***	0.09	0.51***	0.09
Gender (female)	−7.67***	1.78	−7.44***	1.78
Educational level	−3.47***	0.52	−3.37***	0.51
Overeducation	−1.90	1.89		
Undereducation	−1.89	2.37		
Job-worker mismatch			−0.32	1.19
	Adjusted $R^2 = 0.21$		Adjusted $R^2 = 0.21$	
Verbal fluency				
Intercept	23.44***	1.97	23.23***	1.88
Age	−0.06**	0.03	−0.06**	0.03
Gender (female)	0.63	0.63	0.66	0.63
Educational level	0.99***	0.18	1.00***	0.18
Overeducation	−0.49	0.67		
Undereducation	0.06	0.84		
Job-worker mismatch			−0.31	0.42
	Adjusted $R^2 = 0.08$		Adjusted $R^2 = 0.08$	
Information processing speed				
Intercept	56.76***	2.67	57.59***	2.59
Age	−0.32***	0.04	−0.32***	0.04
Gender (female)	2.45***	0.87	2.30***	0.87
Educational level	1.71***	0.25	1.65***	0.25
Overeducation	0.86	0.92		
Undereducation	1.61	1.16		
Job-worker mismatch			−0.17	0.58
	Adjusted $R^2 = 0.24$		Adjusted $R^2 = 0.23$	

Notes: n = 447. *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.

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 constrains the cognitive capacity of an individual with a particular level of education, which may have implications for the rate of cognitive decline.

Table 3 presents the estimation results of the longitudinal analyses. The results show that, apart from a weakly significant negative effect on the workers' fluency, the effects of overeducation on cognitive decline are usually not significant, although the effects found are relatively high. However, we found that undereducated workers face less cognitive decline with respect to their delayed recall abilities and—weakly significant—for their cognitive flexibility.

When we combined the overeducation and undereducation variables into a single job-worker mismatch variable which indicates the match between the workers' level of education and the level of the job in which they are employed (see Section 3), we found that job-worker mismatch is highly relevant for a worker's cognitive development. This holds for almost all cognitive domains we tested: the workers' immediate and delayed recall abilities, their cognitive flexibility, and their verbal fluency. Only the effect of the job-worker mismatch on the workers' information processing speed was not significant. These results support the 'use-it-or-lose-it' and intellectual challenge hypotheses, although we cannot distinguish between the two hypotheses. Moreover, the longitudinal analyses show that the longitudinal effects on a person's cognitive abilities are much more substantial than reflected in the cross-sectional analyses.

The estimation results also show that workers' level of education decreases the risk of cognitive decline in all the domains for which we had test scores. This is in line with the 'brain reserve hypothesis' mentioned above. When we compare the beta coefficients of this variable with the coefficients of the job-worker mismatch variable, we find that a mismatch has a substantial effect on the workers' cognitive abilities. For a person's intermediate and delayed recall abilities, as well as for his or her verbal fluency, the effects of a job-worker mismatch are about 60–100% of the effect on a person's cognitive abilities, if the level of education would be one level lower or higher than his or her actual level of education.

Finally, we analysed whether the extent of overeducation (and undereducation) is relevant for cognitive decline. As mentioned above, this measure is a linear one across the job level scale, which indicates whether workers who work in a job far below their level of education face more cognitive decline than workers who only work one level below their level of education, and whether workers employed in a job far above their level of education face much less cognitive decline. Table 4 shows that there are indeed significant negative effects of the extent of overeducation on cognitive decline with respect to the test scores for immediate recall, delayed recall, and the workers' verbal fluency. In additional analyses, we added quadratic terms of the extent of overeducation. However, these square terms were not significant, which indicates that the effects of the extent of overeducation on cognitive decline are truly linear.

Table 3 Relation between job-worker mismatch and cognitive abilities of working population six years later (1999–2001)

	Overeducation/undereducation		Job-worker mismatch	
	B	Se	B	Se
Immediate recall				
Intercept	24.29***	2.87	24.58***	2.79
Baseline cognitive score	0.60***	0.04	0.60***	0.04
Age	−0.09***	0.03	−0.09***	0.03
Gender (female)	0.90	0.68	0.87	0.68
Educational level	0.59***	0.20	0.58***	0.20
Overeducation	−0.51	0.70		
Undereducation	1.09	0.89		
Job-worker mismatch			−0.76*	0.44
	Adjusted $R^2 = 0.44$		Adjusted $R^2 = 0.44$	
Delayed recall				
Intercept	5.03***	0.80	5.37***	0.78
Baseline cognitive score	0.58***	0.04	0.58***	0.04
Age	−0.03**	0.01	−0.03**	0.01
Gender (female)	0.37	0.22	0.33	0.22
Educational level	0.19**	0.06	0.17***	0.06
Overeducation	−0.12	0.23		
Undereducation	0.82***	0.28		
Job-worker mismatch			−0.41***	0.14
	Adjusted $R^2 = 0.41$		Adjusted $R^2 = 0.41$	
Cognitive flexibility[#]				
Intercept	16.64***	4.01	15.81***	3.86
Baseline cognitive score	0.76***	0.03	0.76***	0.03
Age	0.26***	0.05	0.26***	0.05
Gender (female)	−2.70***	1.04	−2.60**	1.03
Educational level	−1.02***	0.31	−0.98***	0.30
Overeducation	0.89	1.08		
Undereducation	−2.40*	1.36		
Job-worker mismatch			1.52**	0.68
	Adjusted $R^2 = 0.73$		Adjusted $R^2 = 0.73$	
Verbal fluency				
Intercept	12.52***	1.65		
Baseline cognitive score	0.49***	0.04	12.72***	1.59
Age	−0.06**	0.02	0.49***	0.04
Gender (female)	0.66	0.46	−0.06***	0.02
Educational level	0.41***	0.14	0.64	0.46
Overeducation	−0.52*	0.49	0.40***	0.14
Undereducation	0.92	0.61		
Job-worker mismatch			−0.69**	0.31
	Adjusted $R^2 = 0.38$		Adjusted $R^2 = 0.38$	
Information processing speed				
Intercept	8.68***	2.19	8.92***	2.16
Baseline cognitive score	0.88***	0.03	0.88***	0.03
Age	−0.05*	0.03	−0.05*	0.03
Gender (female)	0.71	0.50	0.67	0.50
Educational level	0.42***	0.15	0.41***	0.15
Overeducation	0.17	0.53		
Undereducation	0.47	0.66		
Job-worker mismatch			−0.10	0.33
	Adjusted $R^2 = 0.78$		Adjusted $R^2 = 0.78$	

Notes: n = 447.
*p < 0.10, **p < 0.05, ***p < 0.01.
[#]See Table 2.

Table 4 Relation between the extent of overeducation and cognitive abilities of working population six years later (1999–2001)

	Extent of overeducation		
	B		Se
Immediate recall			
Intercept	24.63***		2.79
Baseline cognitive score	0.60***		0.04
Age	−0.09***		0.03
Gender (female)	0.90		0.67
Educational level	0.62***		0.20
Extent of overeducation	−0.56**		0.28
		Adjusted $R^2 = 0.44$	
Delayed recall			
Intercept	5.40***		0.78
Baseline cognitive score	0.57***		0.04
Age	−0.03**		0.01
Gender (female)	0.33		0.22
Educational level	0.18***		0.06
Extent of overeducation	−0.26***		0.09
		Adjusted $R^2 = 0.41$	
Cognitive flexibility[#]			
Intercept	15.29***		3.88
Baseline cognitive score	0.76***		0.03
Age	0.27***		0.05
Gender (female)	−2.44**		1.03
Educational level	−0.94***		0.31
Extent of overeducation	0.54		0.44
		Adjusted $R^2 = 0.73$	
Verbal fluency			
Intercept	12.67***		1.60
Baseline cognitive score	0.49***		0.04
Age	−0.06***		0.02
Gender (female)	0.63		0.46
Educational level	0.42***		0.14
Extent of overeducation	−0.45**		0.20
		Adjusted $R^2 = 0.38$	
Information processing speed			
Intercept	9.17***		2.16
Baseline cognitive score	0.88***		0.03
Age	−0.05**		0.03
Gender (female)	0.70		0.50
Educational level	0.43***		0.15
Extent of overeducation	−0.19		0.21
		Adjusted $R^2 = 0.78$	

Notes: n = 447.
*p < 0.10, **p < 0.05, ***p < 0.01.
[#]See Table 2.

Moreover, we analysed whether the effects of the extent of overeducation on workers' cognitive abilities is modified by their age. These interaction terms were only weakly significant for the workers' cognitive flexibility and information processing speed. Whereas it was the older overeducated workers who faced the largest decline of their information processing speed, overeducated younger workers faced the largest decline in their cognitive flexibility.[9]

5. Conclusion and discussion

In this paper, we first analysed the relation between overeducation and workers' cognitive abilities in a cross-sectional analysis. 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.

The estimation results on the longitudinal effects of overeducation showed that overeducation, in general, did not induce cognitive decline in a period of six years. On the other hand, undereducated workers faced less cognitive decline with respect to their delayed recall abilities and their cognitive flexibility. However, when we combined the two separate variables into a single job-worker mismatch variable, we found that the job-worker mismatch was highly relevant for workers' cognitive development in almost all the fields analysed. Moreover, we found linear relations between the extent of overeducation and undereducation and the decline of the workers' cognitive abilities. This held both for the workers' immediate and delayed recall abilities and for their verbal fluency. The effects on the workers' cognitive abilities appeared to be substantial. These findings support the 'use-it-or-lose-it' hypothesis on the effects of overeducation on a worker's cognitive abilities and the intellectual challenge hypothesis that working above one's level of education increases a worker's cognitive resilience, although we cannot distinguish between the two hypotheses.

However, our findings on the longitudinal effects of the job-worker mismatch on a person's cognitive abilities are not reflected in the cross-section analyses on the relations between the job-worker mismatch and workers' cognitive at the baseline measurement. Therefore, we did not find any evidence for the presumption that the job-worker mismatch is related to the heterogeneity in workers' cognitive abilities of workers with the same level of education. However, these results may also be due to a higher rate of upward mobility among overeducated workers (Sicherman, 1991). When workers succeed in finding a better matching job if the labour market becomes tighter, the situation of overeducation is restricted in time. As mentioned, we found that in six years time about 10% of the overeducated workers who remained employed found a higher level job, whereas 8% of those undereducated were employed in a lower level job. On the other hand, the results

[9] The estimation results of these analyses can be obtained from the authors on request.

of the cross-section analyses may also be due to a selection effect, because of the negative long-term effects of overeducation on labour market participation. In this respect, it should be noted that when we applied the cross-section analysis to all respondents who once had a job, we found various significant relations between the job-worker mismatch and the level of a person's cognitive abilities.[10] Furthermore, the question remains to what extent cognitive decline due to a job-worker mismatch is reversible. On this point, Schaie (1994) concluded that (re)training can be effective for individuals with cognitive decline prior to the intervention, although the effects differ between different kinds of abilities.

From our results, we may also conclude that mismatches between workers' abilities and their job level, need not necessarily induce labour market adjustments via job search (e.g. Groot and Maassen van den Brink, 2003). Instead, as our analyses demonstrate, being overeducated for one's job has repercussions for workers' human capital assets, due to the loss of their cognitive abilities. Then, it is actually the ability level of the overeducated worker that adjusts the match between the job level and the worker's cognitive abilities. Obviously, this shows that the effects of overeducation are much more negative than suggested by the studies that argue that mismatches between workers' abilities and their job level will disappear by further job search.

As our estimation results show, in particular workers' recall abilities, cognitive flexibility and verbal fluency are at risk when workers are overeducated. In as little as six years time, the decline of these cognitive domains becomes noticeable. It is obvious that this adds to the relevance of preventing overeducation in the labour market. Moreover, it shows that employing workers at higher job levels than the jobs that directly match their level of education may contribute to lifelong learning in challenging jobs. Here, it is the ability level of the worker that adjust the match between the job level and the worker's cognitive abilities in a positive way.

Unfortunately, our data do not allow us to analyse the effects on labour market outcomes, such as workers' wages. However, building on the returns to education found by Oosterbeek and Webbink (1996) for the period we analysed, we can roughly estimate that a worker's cognitive decline or gain due to negative or positive job-worker mismatches causes a wage penalty or wage gain of 10–17%.[11] Our finding that assignments of employees in jobs below and above their level of education will affect their future cognitive performance therefore explains a substantial part of the long-term effects of over- and undereducation on workers' wages found in economic literature (Sloane, 2003).

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

[11] Oosterbeek and Webbink (1996) found a rate of return for a year of education required of about 8.5% (9.2% for males and 7.9% for females). As mentioned in Section 4, the effects of worker-mismatch we found are about 60–100% of the effect of an additional level of education, which is on average equal to two years of education, i.e. 60–100% of $2 \times 8{,}5\% = 10$–17%.

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References

Alba-Ramirez, A. (1993) Mismatch in the Spanish labor market: overeducation? *Journal of Human Resources*, **27**, 259–78.

Allen, J. and Van der Velden, R. (2001) Educational mismatches versus skill mismatches: effects on wages, job satisfaction, and on-the-job search, *Oxford Economic Papers*, **53**, 434–52.

Borghans, L. and De Grip, A. (2001) Skills and low pay: upgrading or overeducation? in M. Gregory and W. Salverda (eds), *Labour Market Inequalities. Problems and Policies of Low-Wage Employment in International Perspective*, Oxford University Press, Oxford, 198–223.

Bosma, H., Van Boxtel, M., Ponds, R.,. Houx, P., Burdorf, A., and Jolles, J. (2003a) Mental work demands protect against cognitive impairment: MAAS prospective cohort study, *Experimental Aging Research*, **29**, 33–45.

Bosma, H., Van Boxtel, M.P.J., Ponds, R.W.H.M., Houx, P.J.H., and Jolles, J. (2003b) Education and age-related cognitive decline: the contribution of mental workload, *Educational Gerontology*, **29**, 165–73.

Büchel, F. and Mertens, A. (2004) Overeducation, undereducation, and the theory of career mobility, *Applied Economics*, **36**, 803–16.

Carneiro, P. and Heckman, J. (2003) Human capital policy, Working Paper 9495, National Bureau of Economic Research, Cambridge, MA.

De Grip, A. and Van Loo, J. (2002) The economics of skills obsolescence: a review, in A. De Grip, J. Van Loo, and K. Mayhew (eds), *The Economics of Skills Obsolescence*, *Research in Labor Economics 21*, JAI Press, Amsterdam, 1–26.

Dolton, P. and Silles, M. (2003) The determination and consequences of graduate overeducation, in F. Büchel, A. de Grip, and A. Mertens (eds), *Overeducation in Europe. Current Issues in Theory and Policy*, Edward Elgar, Cheltenham, 189–216.

Dolton, P. and Vignoles, A. (2000) Incidence and effects of overeducation in the UK graduate labour market, *Economics of Education Review*, **19**, 179–98.

Duncan, G. and Hoffman, S.D. (1981) The incidence and wage effects of overeducation, *Economics of Education Review*, **1**, 75–86.

Fratiglioni, L., Paillard-Borg, S., and Winblad, B. (2004) An active and socially integrated lifestyle in late life might protect against dementia, *The Lancet Neurology*, **3**, 343–53.

Ganzach, Y. (2003) Intelligence, education, and facets of job satisfaction, *Work and Occupations*, **30**, 97–122.

Green, F., McIntosh, S., and Vignoles, A. (1999) *Overeducation and Skills: Clarifying the Concepts*, Discussion Paper 435, Centre for Economic Performance, London.

Groot, W. (1996) The incidence and returns to overeducation in the UK, *Applied Economics*, **28**, 1345–50.

Groot, W. and Maassen van den Brink, H. (2003) The dynamics of skill mismatches in the Dutch labour market, in F. Büchel, A. de Grip, and A. Mertens (eds), *Overeducation in Europe. Current Issues in theory and Policy*, Edward Elgar, Cheltenham, 49–63.

Hammes, J. (1973) De Stroop kleur-woord test: Handleiding [The Stroop Colour-Word Test: Manual], Swets and Zeitlinger, Amsterdam.

Hartog, J. (2000) Over-education and earnings: where are we, where should we go? *Economics of Education Review*, **19**, 131–47.

Hartog, J. and Oosterbeek, H. (1988) Education, allocation and earnings in the Netherlands: overschooling? *Economics of Education Review*, **7**,185–94.

Kaufman, H. G. (1989) Obsolescence of technical professionals: a measure and a model, *Applied Psychology: An International Review*, **38**, 73–85.

Jolles, J., Houx, P.J., Van Boxtel, M.P.J., and Ponds, R.W.H.M. (1995) *Maastricht Aging Study: Determinants of Cognitive Aging*, Neuropsych Publishers, Maastricht.

Krahn, H. and Lowe, G.S. (1997) *Literacy Utilization in Canadian Workplaces*, Statistics Canada, Ottawa.

Lezak, M. D. (2004) *Neuropsychological Assessment* (4th ed.), Oxford University Press, New York.

Lindbeck, A. and Snower, D. (2000) Multi-task learning and the reorganisation of work, from Tayloristic to holistic organization, *Journal of Labour Economics*, **18**, 353–76.

Metsemakers, J.F.M., Höppener, P., Knottnerus, J.A., Kocken, R.J.J., and Limonard, C.B.G. (1992) Computerized health information in the Netherlands: a registration network of family practices, *British Journal of General Practice*, **42**, 102–6.

Mincer, J. and Ofek, H. (1982) Interrupted work careers: depreciation and restoration of human capital, *Journal of Human Resources*, **17**, 3–24.

Noe, R.A. and Wilk, S.L. (1993) Investigation of the factors that influence employees' participation in development activities, *Journal of Applied Psychology*, **78**, 291–302.

Oosterbeek, H. and Webbink, D. (1996) Over scholing, overscholing en inkomen, *Economisch- Statistische Berichten*, **81**, 240–1.

Pazy, A. (2004) Updating in response to the experience of lacking knowledge, *Journal of Applied Psychology*, **53**, 436–52.

Plassman, B.L., Welsh, K.A., Helms, M., Brandt, J., Page, W.F., and Breitner, J.C.S. (1995) Intelligence and education as predictors of cognitive state in late life: a 50-year follow-up, *Neurology*, **43**, 13–20.

Rumberger, R.W. (1987) The impact of surplus schooling on productivity and earnings, *Journal of Human Resources*, **22**, 24–50.

Schaie, K.W. (1994) The course of adult intellectual development, *American Psychologist*, **49**, 304–13.

Sicherman, N. and Galor, O. (1990) A theory of career mobility, *Journal of Political Economy*, **98**, 169–92.

Sicherman, N. (1991) Overeducation in the labor market, *Journal of Labor Economics*, **9**, 101–22.

Sloane, P.J., Battu, H., and Seaman, P.T. (1999) Overeducation, undereducation and the British labour market, *Applied Economics*, **31**, 1437–53.

Sloane, P.J. (2003) Much ado about nothing? What does the overeducation literature really tell us, in F. Büchel, A. de Grip, and A. Mertens (eds), *Overeducation in Europe. Current Issues in Theory and Policy*, Edward Elgar, Cheltenham, 11–45.

Staff, R.T., Murray, A.D., Deary, I.J., and Whalley, L.J. (2004) What provides cerebral reserve? *Brain*, 127, 1191–9.

Stroop, J.R. (1935) Studies of interference in serial verbal reactions, *Journal of Experimental Psychology*, **18**, 643–62.

Van Berkel, A.B. and Tax, B. (1990) Naar een standaardoperationalisatie van social-economische status voor epidemiologisch en sociaal-medisch onderzoek [Towards a standard operationalization of socio-economical status for epidemiological and socio-economical research], Ministerie van Welzijn, Volksgezondheid en Cultuur, Den Haag.

Van Boxtel, M.P.J., Buntinx, F., Houx, P.J., Metsemakers, J.F.M., Knottnerus, J.A., and Jolles, J. (1998) The relation between morbidity and cognitive performance in a normal aging population, *Journal of Gerontology*, **53A**, M146–54.

Van Eijs, P. and Heijke, H. (2000) Mismatch between occupation and education and the costs and benefits of job-related training, in H. Heijke and J. Muysken (eds) *Education and Training in a Knowledge-Based Economy*, MacMillan Press, Houndsmill, and St. Martin's Press, New York, 159–89.

Van der Elst, W., Van Boxtel, M.P.J., Van Breukelen, G.J.P., and Jolles, J. (2005) Rey's verbal learning test: normative data for 1,855 healthy participants aged 24–81 years and the influence of age, sex, education, and mode of presentation, *Journal of the International Neuropsychological Society*, **11**, 290–302.

Van der Elst, W., van Boxtel, M.P.J., van Breukelen, G.J.P., and Jolles, J. (2006a) Normative data for the animal, profession and letter M naming verbal fluency tests for Dutch speaking participants and the effects of age, education, and sex, *Jounal of the International Neuropsychological Society*, **12**, 80–9.

Van der Elst, W., van Boxtel, M.P.J., van Breukelen, G.J.P., and Jolles, J. (2006b) The letter digit substitution test: normative data for 1,858 healthy participants aged 24–81 from the Maastricht Aging Study (MAAS): influence of age, education, and sex, *Journal of Clinical and Experimental Neuropsychology*, **28**, 998–1009.

Van der Elst, W., van Boxtel, M.P., van Breukelen, G.J., and Jolles, J. (2006c) The Stroop color-word test: influence of age, sex, and education; and normative data for a large sample across the adult age range, *Assessment*, **13**, 62–79.

Van der Velden, R. and Van Smoorenburg, M. (2000) The measurement of overeducation and undereducation: self-report vs. job-analyst method, Serie Séminaire 00–2, Lasmas-IdL CNRS IRESCO, Paris.