Occupational Characteristics and Cognitive Aging in the Glostrup 1914 Cohort

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Objectives. The effect of occupational characteristics on cognitive change over 20 years was examined.

Method. Occupational characteristics—intellectual challenge, physical hazards, and psychological demands—were assessed in the Glostrup 1914 Cohort when aged 60 years, and cognitive ability was assessed by 4 cognitive ability tests at ages 60, 70, and 80.

Results. Individuals in more intellectually challenging occupations had higher cognitive ability (r = .27–.38, p < .01), whereas those in more physically hazardous occupations performed more poorly (r = −.12 and −.13 at ages 50 and 60, p < .05). In growth curve models, intellectual challenge continued to be associated with cognitive ability, controlling for sex, education, and social class. However, the association was reversed after accounting for cognitive ability at age 50; of 2 individuals with the same baseline level of cognitive ability, the one in the more intellectually challenging occupation had lower subsequent cognitive ability. The association of physical hazards with lower cognitive ability level did not remain after adjustment for the basic demographics, and none of the occupational characteristics were associated with cognitive change between age 60 and 80.

Discussion. Notwithstanding the reversal of the effect of occupational intellectual challenge on cognitive ability level after accounting for pre-existing cognitive differences, there was no evidence for long-term effects of occupational characteristics on cognitive change in old age.

Key Words: Cognitive ability—Cognitive aging—Occupational characteristics—Intellectual challenge—Physical hazards—Psychological demands.

GIVEN the proportion of an adult’s waking hours spent working, and the lengthy period of life across which this extends, the potential effects of occupational characteristics on cognitive abilities are underresearched (Finkel, Andel, Gatz, & Pederson, 2009; Marquie et al., 2010; Van der Elst & van Boxtel, 2012). This dearth of research is likely to be more surprising as mental activity across the life course is proposed as central to preserving cognitive abilities in later life, and a key aspect of the occupational environment is the degree of intellectual engagement.

Support for the cognitively protective effect of intellectually challenging work is, however, available (Bosma et al., 2003a; Bosma et al., 2003b; Finkel et al., 2009; Jorm et al., 1998; Marquie et al., 2010; Schooler, Mulatu, & Oates, 1999; Van der Elst & van Boxtel, 2012). The focus on intellectual characteristics is likely a consequence of the ubiquitous “use it or lose it” notion of cognitive aging. In the occupational context, it is proposed that individuals who are more intellectually engaged via their work across the life course are continually exercising and developing their mental skills and abilities, thereby increasing these to a higher level and/or reducing or delaying age-related decline (Avolio & Waldman, 1990). More formally, this would be described as differential preservation: the extent to which some factor is present (intellectual engagement or challenge) differentially affects the trajectory of cognitive change (Salthouse, 2006).

This seam of research is often traced back to the environmental complexity theory of Schooler and colleagues (Schooler, 1984; Schooler et al., 1999; Schooler, Mulatu, & Oates, 2004). Their studies spanning 20–30 years of follow-up reported significant associations between the complexity of an individual’s occupation and their cognitive functioning (Schooler et al., 1999). The theory suggests that in an environment that rewards cognitive effort, individuals will be motivated to improve their abilities and generalize these to other, non-occupational environments and situations. Conversely, less complex environments may not provide the rewards necessary to develop or maintain intellectual function, resulting in a loss of capacity (Schooler, 1984). Nevertheless, the associations reported were reciprocal; though occupational complexity influenced cognitive function, the reverse was apparent also. Although the analyses only considered contemporaneous reciprocal pathways, it is the cross-lagged pathways that are of greater
interest: does occupational complexity significantly affect later cognitive ability?

Furthermore, these findings primarily relied on observer ratings of cognitive ability—termed intellectual flexibility—which was only psychometrically assessed at the final wave. It was not reported whether the observers were blind to the occupation of the participants, thus potentially confounding the ratings. However, studies conducted in which cognitive abilities have been more robustly assessed using psychometric test batteries generally support the protective effect of occupational intellectual demands (e.g., Bosma et al., 2003a; Bosma et al., 2003b; Finkel et al., 2009; Marquie et al., 2010). It has also been reported that the effect of routine, undemanding work is observable at the level of brain processes and functions, though given the cross-sectional design, the possibility that these might be pre-career differences cannot be excluded (Gajewski & Falkenstein, 2011).

Other studies have taken a more fine-grained approach to occupational intellectual characteristics by separately considering the complexity of work with people, data, and things. Finkel and colleagues (2009) reported that individuals in occupations characterized by higher complexity of work with people had the most favorable aging trajectories on spatial and verbal abilities, though after retirement, those having had more complex occupations experienced greater decline in their spatial ability. As in this example, occupational characteristics are often assigned to, rather than collected from, participants based on predetermined occupational listings (Finkel et al., 2009; Schooler et al., 1999). The assumption that individuals in the same occupation experience the same level of intellectual challenge and engagement may serve to reduce the possible variance in occupational complexity across individuals (Bosma et al., 2003a,b).

Though the evidence is consistent with the differential preservation of cognitive abilities by occupational intellectual engagement, the reported studies cannot prove it versus the likelihood of preserved differentiation (Salthouse, 2006). This alternative suggests that preexisting differences in cognitive ability predict both the level of occupational intellectual challenge achieved and later cognitive ability level and change; an association between occupational characteristics and cognitive ability would therefore be a consequence of their shared predictor, often referred to as reverse causation. For example, in Finkel and colleagues (2009), preserved differentiation was observed as baseline individual differences in processing speed were maintained across time, with those in high- and low-occupational-complexity groups having parallel rates of decline.

Studies rarely mention preexisting individual differences in cognitive ability as a major confound (Jorm et al., 1998; Karp et al., 2004), and fewer still are able to address it (Marquie et al., 2010; Staff, Murray, Deary, & Whalley, 2004; Van der Elst & van Boxtel, 2012). This is partly a consequence of the lack of early or midlife cognitive data, with studies often consisting of two or three assessments over a 3- or 10-year period in late middle or old age. In one of the studies that acknowledged the issue, Marquie and colleagues (2010) reported an association between higher mental stimulation at work and reduced decline over 10 years but concluded the direction of causation could not be established as “people initially exhibiting higher functioning are also more likely to be found in cognitively demanding jobs” (p. 1295). Van der Elst & van Boxtel (2012) attempted to control for prior cognitive ability by using vocabulary as a marker of crystallized ability. The case-control quasi-experimental design, in which teachers were compared with matched nonteachers on the assumption teachers experienced a relatively homogeneous working environment, and the small sample size (N ~ 100), however, limit the applicability of their results.

Occupational characteristics are, however, more diverse than the degree of intellectual challenge or engagement afforded and researchers have highlighted the need for broader assessments (Avolio & Waldman, 1990). Certain characteristics have been proposed as cognitively detrimental, for example, Andel and colleagues (2012) reported that high job strain occupations (characterized by a combination of high demands with low control) increased the risk of vascular dementia, especially if social support at work was also lacking. The explanation was that chronic stress may act via cardiovascular pathways to affect cognitive abilities, though adjustment for cardiovascular diseases did not account for the association (Andel et al., 2012). Earlier work also supported lower control at work as a detrimental factor for later cognitive performance, though that assessment was based solely on an abridged Mini Mental State Exam (MMSE [Andel, Crowe, Kareholt, Wastesson, & Parker, 2011]). These constructs fit within the job strain model developed by Karasek and Theorell (Karasek, 1979; Karasek & Theorell, 1990) to examine the effects of the psychosocial work environment on health outcomes. In addition to these characteristics, greater physical demands at work have been associated with an increased risk of dementia (Smyth et al., 2004). Although the current study does not consider all aspects of the job strain model, for example, occupations characterized by increased psychological demands, a lower level of skill and increased physical demands are likely to lead to the highest levels of psychological stress (Karasek & Theorell, 1990). Examining their effect on normal cognitive aging, not just pathological decline, is therefore warranted.

The aim of the current analysis was to examine the association between occupational characteristics—comprising intellectual complexity or challenge, physical hazards and exposures, and psychological stressors—and cognitive ability level, and whether these characteristics predicted cognitive change over a 20-year follow-up. Occupational characteristics were assessed by participants themselves. Importantly, the study also considered the issue of preserved differentiation versus differential preservation.
by accounting for cognitive ability assessed 10 years before the occupational assessment.

**Method**

**Participants**

Participants were drawn from the Glostrup 1914 Cohort (Osler, Linneberg, Glumer, & Jørgensen, 2010), a longitudinal study initiated to identify risk factors for coronary heart disease. Recruited from 976 individuals who were born in 1914 and living in the Glostrup area of Denmark, 802 participants (436 men and 366 women) completed the baseline assessment in 1964 when aged 50 years (Schroll, 1982, 2003). At that time, the cohort did not differ from the general Danish population in terms of sex and occupational social class (Schroll, 1982). Follow-up assessments were conducted at ages 60 and 70, and then every 5 years up to age 90 (Osler et al., 2010). The occupational characteristics analyzed in the current study were collected at the age 60 assessment when 483 participants provided complete data (see the following paragraphs). These participants comprise the analytical sample, resulting in sample sizes of 450 at age 50, 256 at age 70, and 154 at age 80. Of the four measurement occasions being analyzed currently—chosen because of the availability of consistent cognitive tests across occasions—participants attended a mean of 2.8 (0.9) assessments, ranging from 1 (5.4% of the sample) to 4 (22.4%).

**Cognitive Ability**

The assessment of cognitive ability has been described previously (Krabbe et al., 2009; Mortensen & Høgh, 2001; Mortensen & Kleven, 1993). Participants completed 11 subtests from the Danish translation of the Wechsler Adult Intelligence Scale (W AIS [Wechsler, 1955]) used for descriptive purposes only. Principal component analysis (PCA) was used to provide summary scores from the eight items assessing occupational characteristics. PCA was also used to provide general cognitive ability scores from the four cognitive tests completed at each age (Gow et al., 2012), used for descriptive purposes only. Growth curve models (Curran & Hussong, 2003) were implemented in Mplus Version 5.2 (Muthén & Muthén, Los Angeles, CA) to examine cognitive ability and change from age 60 to 80 (the age 50 cognitive assessment was considered later in the analytical process, described in the following paragraphs). The basic model has been described in detail (Gow et al., 2012). In summary, general cognitive ability was showing significant decline between subsequent testing occasions (Gow, Mortensen, & Avlund, 2012).

**Occupational Characteristics**

At the age 60 assessment, participants were asked eight questions concerning the characteristics of their current or last occupation, including whether this was intellectual versus manual, whether there were physical exposures or hazards in the environment, or whether they had had an accident/were injured at work. The eight characteristics assessed are given in Table 1.

**Covariates**

The following covariates known to be associated with cognitive ability or decline, or occupational characteristics, were included: sex, education, and social class. Participants provided details of their school education and vocational training, which were coded on 3-point (primary to upper secondary) and 5-point (no vocational training to academic) scales, respectively, and combined into an overall education score (Mortensen & Høgh, 2001). Social class was assigned on a six-category system from occupational information (Svalastoga, 1959).

**Statistical Analyses**

Descriptive analyses were performed in IBM SPSS Statistics Version 19.0 (IBM, Somers, NY). Principal component analysis (PCA) was used to provide summary scores from the eight items assessing occupational characteristics. PCA was also used to provide general cognitive ability scores from the four cognitive tests completed at each age (Gow et al., 2012), used for descriptive purposes only.

Growth curve models (Curran & Hussong, 2003) were implemented in Mplus Version 5.2 (Muthén & Muthén, Los Angeles, CA) to examine cognitive ability and change from age 60 to 80 (the age 50 cognitive assessment was considered later in the analytical process, described in the following paragraphs). The basic model has been described in detail (Gow et al., 2012). In summary, general cognitive ability was

**Table 1. Occupational Characteristics in the Glostrup 1914 Cohort (N = 483)**

<table>
<thead>
<tr>
<th></th>
<th>Descriptives</th>
<th>Two-factor solution</th>
<th>Three-factor solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Mental demands</td>
</tr>
<tr>
<td>Varied</td>
<td>345 (71.4%)</td>
<td>138 (28.6%)</td>
<td>0.56</td>
</tr>
<tr>
<td>Routine</td>
<td>424 (87.8%)</td>
<td>59 (12.2%)</td>
<td>0.57</td>
</tr>
<tr>
<td>Intellectual (vs manual)</td>
<td>143 (29.6%)</td>
<td>340 (70.4%)</td>
<td>0.68</td>
</tr>
<tr>
<td>Piecework</td>
<td>33 (6.8%)</td>
<td>450 (93.2%)</td>
<td>−0.18</td>
</tr>
<tr>
<td>Psychologically demanding/stressful</td>
<td>120 (24.8%)</td>
<td>363 (75.2%)</td>
<td>0.66</td>
</tr>
<tr>
<td>Speed problems</td>
<td>133 (27.5%)</td>
<td>350 (72.5%)</td>
<td>0.47</td>
</tr>
<tr>
<td>Physical inconveniences</td>
<td>94 (19.5%)</td>
<td>389 (80.5%)</td>
<td>−0.02</td>
</tr>
<tr>
<td>Accidents/injuries</td>
<td>81 (16.8%)</td>
<td>402 (83.2%)</td>
<td>−0.14</td>
</tr>
</tbody>
</table>

Note. In the principal component analysis, routine is coded such that a higher value denotes less routine work. Item loadings over 0.30 are highlighted in bold.
defined at each age as a latent factor from the four cognitive tests completed (illustrated in Figure 1). Latent terms are generated for the level of cognitive ability (intercept) and the change in this over time (slope). With three occasions of measurement, intercept represents a composite of overall cognitive ability level across ages 60, 70, and 80. Before the occupational characteristics were included, it was tested whether one- or two-slope parameters best described cognitive change over time. In the two-slope solution (with each slope describing 10-year cognitive change from 60 to 70 or 70 to 80 years), the first slope from age 60 to 70 years was not significant. Furthermore, as the addition of a second slope parameter led to only a slight improvement in model fit (in the one-slope model, Comparative Fit Index [CFI] = 0.97, Akaike Information Criterion [AIC] = 7775.96, and root mean square error of approximation [RMSEA] = 0.042 [90% CI = 0.029–0.054]), compared with the two-slope model where CFI = 0.98, AIC = 7764.65, and RMSEA = 0.035 [90% CI = 0.020–0.049]), the more parsimonious one-slope model was chosen. The occupational characteristics were included as predictor variables, and associations between these and the intercept and slope terms were examined. The covariates sex, education, and social class were included in an intermediate set of models. In a final model, and to account for the confounding effect of prior ability on occupational characteristics, age 50 general cognitive ability was also considered (by saving the standardized residual from a regression with the occupational characteristic as dependent variable and general cognitive ability at 50 as a predictor).

The models were run for the full sample and separately for men; the sample size became too small over waves to run the models in women only. Participants with data at baseline were included even if they were missing data at later waves using full information maximum likelihood, under the assumption this missingness was at random (Arbuckle, 1996). All continuous variables were standardized prior to analysis.

Results

Sample Characteristics

Of the 483 participants in the analytical sample, 317 (65.6%) were men. Participants had a mean education score of 3.7 (1.7) and social class of 6.5 (1.1). Compared with those who did not provide occupational data at age 60, participants in the analytical sample were more likely to be men (t(364.4) = 11.04, p < .001) and have more education (t(627) = −4.16, p < .001), but did not differ in terms of social class (t(570) = 0.15, p = .880).

Occupational Characteristics

Table 1 gives the number of participants responding yes/no for each of the occupational characteristics assessed. To produce summary scores, the eight items were analyzed by PCA. The “eigenvalues greater than 1” criterion and
examination of the scree plot suggested two or three factors, respectively, which were extracted by varimax rotation. The item loadings for these solutions are reported in Table 1.

In the two-factor solution, the first factor explained 22.6% of the variance and was mainly defined by a combination of items covering the psychological or intellectual demands of the occupation, labeled mental demands. The second factor, explaining 18.5% of the variance, was primarily defined by items reflecting the likelihood of encountering physical stressors or dangers in the workplace, and was labeled physical demands. Though parsimonious, the two-factor solution confounded the measurement of what might be considered the beneficial and detrimental aspects of mental challenge (though not necessarily opposite ends of a continuum): engagement versus stress. These components were essentially separately defined in the three-factor solution in which the first factor (20.4% of the variance) was defined purely by items assessing the intellectually engaging nature of the occupation and was therefore labeled intellectual challenge. The second factor (16.7% of the variance) was defined by items generally describing the dangers or hazards encountered in the workplace, labeled physical hazards. The third factor (16.2% of the variance) combined items describing the speeded or stressful nature of the occupation, and was labeled psychological demands.

Given the split of the different components of mental demands and no item cross-loadings over 0.30, the three-factor solution was preferred. The standardized residuals were saved as factor scores to be used in the subsequent analyses, computed such that: higher intellectual challenge scores represented more varied, intellectually engaging occupations; higher physical hazards scores represented exposure to more risks or physical dangers; and higher psychological demands scores represented occupations requiring speeded completion or stressful demands.

Men reported higher intellectual challenge ($t(481) = 4.24, p < .001$) and physical hazards ($t(457.7) = 5.29, p < .001$) than women, although there was no difference for psychological demands ($t(481) = 0.50, p = .616$). The associations between the occupational characteristics and education and social class are shown in Table 2. The significant associations were small to moderate, ranging in magnitude from 0.18 to 0.40, such that individuals with more education or in more professional occupations had higher intellectual and lower physical demands, though there were no significant associations with psychological demands.

**Occupational Characteristics and Cognitive Ability**

The associations between the occupational characteristics and cognitive ability are shown in Table 2. Participants in more intellectually challenging occupations had higher cognitive ability at each occasion of assessment, with correlations ranging from .27 to .38 ($p < .01$). Higher physical

<table>
<thead>
<tr>
<th></th>
<th>Intellectual challenge</th>
<th>Physical hazards</th>
<th>Psychological demands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>0.40***</td>
<td>−0.18***</td>
<td>0.08</td>
</tr>
<tr>
<td>Social class</td>
<td>−0.39***</td>
<td>0.29***</td>
<td>−0.09</td>
</tr>
<tr>
<td>General cognitive ability 50</td>
<td>0.38***</td>
<td>−0.12*</td>
<td>0.09</td>
</tr>
<tr>
<td>General cognitive ability 60</td>
<td>0.33***</td>
<td>−0.13**</td>
<td>0.08</td>
</tr>
<tr>
<td>General cognitive ability 70</td>
<td>0.31***</td>
<td>−0.11</td>
<td>0.09</td>
</tr>
<tr>
<td>General cognitive ability 80</td>
<td>0.27**</td>
<td>0.01</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Notes. Education was an overall score combining school education on a 3-point scale (primary to upper secondary) and vocational training on a 5-point scale (no vocational training to academic). Higher scores represent more education/training. Social class was coded according to Svalastoga (1959), producing six categories labeled strata 3 (most professional) to 8 (unskilled occupations). General cognitive ability was the first unrotated component derived from principal component analysis of the four cognitive tests. $N = 415$ at age 50, 425 at age 60, 256 at age 70, and 138 at age 50.

* $p < .05$. ** $p < .01$. *** $p < .001$.

hazards scores were significantly associated with poorer cognitive function at ages 50 and 60 ($r = −.12$ and $−.13, p < .05$). Psychological demands were not significantly associated with cognitive ability.

To examine the effect of occupational characteristics on cognitive change, the growth curve models were implemented. Firstly, the model suggested there was significant decline in cognitive ability from age 60 to 80 ($−0.004, p < .001$), and that the variance in this was small but significant ($<0.001, p < .001$). To this basic model, each of the occupational characteristics was added separately and their associations with the intercept (level of cognitive ability) and slope (cognitive change) terms are given in Table 3. Intellectual challenge was positively associated with intercept in the unadjusted model ($0.38, p < .001$), such that those with more intellectually engaging occupations had a higher level of cognitive ability. When the demographics (sex, education, and social class) were included (Model 2), the association remained but was decreased in magnitude ($0.16, p = .001$). In the final model in which intellectual challenge was adjusted for general cognitive ability at age 50, the direction of the association was reversed ($−0.16, p < .001$); once a prior measure of cognitive ability was accounted for, those in more mentally challenging occupations had a lower level of cognitive ability.

Physical hazards were negatively associated with intercept in the unadjusted model ($−0.11, p = .023$); individuals in more dangerous work environments had a lower level of cognitive ability. This association was no longer significant after the demographics were included in the model ($−0.04, p = .390$). There was no association between psychological demands and cognitive ability, nor were any of the occupational characteristics associated with cognitive change (slope) from age 60 to 80. The models were repeated entering the three occupational characteristics simultaneously, which produced results almost identical to those in the individual models (lower half of Table 3).
Table 3. Summary of Latent Growth Curve Models of Occupational Characteristics Predicting Cognitive Ability and Change From Age 60 to 80

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Model</th>
<th>Intercept path coefficient (β)</th>
<th>Slope path coefficient (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intellectual challenge</td>
<td>1</td>
<td>0.38 (p&lt;.001)</td>
<td>−0.13 (.112)</td>
</tr>
<tr>
<td>analysis</td>
<td>2</td>
<td>0.16 (.001)</td>
<td>−0.13 (.156)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>−0.16 (&lt;.001)</td>
<td>−0.02 (.819)</td>
</tr>
<tr>
<td>Physical hazards</td>
<td>1</td>
<td>−0.11 (.023)</td>
<td>0.09 (.387)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>−0.04 (.390)</td>
<td>0.09 (.397)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.05 (.339)</td>
<td>0.06 (.594)</td>
</tr>
<tr>
<td>Psychological demands</td>
<td>1</td>
<td>0.08 (.133)</td>
<td>−0.10 (.254)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.02 (.581)</td>
<td>−0.10 (.266)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>−0.02 (.469)</td>
<td>0.00 (.378)</td>
</tr>
<tr>
<td>Joint</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intellectual challenge</td>
<td>1</td>
<td>0.38 (&lt;.001)</td>
<td>−0.13 (.134)</td>
</tr>
<tr>
<td>analysis</td>
<td>2</td>
<td>0.17 (.001)</td>
<td>−0.14 (.153)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>−0.17 (&lt;.001)</td>
<td>−0.02 (.845)</td>
</tr>
<tr>
<td>Physical hazards</td>
<td>1</td>
<td>−0.13 (.008)</td>
<td>0.09 (.359)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>−0.06 (.207)</td>
<td>0.11 (.328)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.07 (.182)</td>
<td>0.06 (.398)</td>
</tr>
<tr>
<td>Psychological demands</td>
<td>1</td>
<td>0.07 (.161)</td>
<td>−0.10 (.270)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.03 (.522)</td>
<td>−0.10 (.265)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>−0.04 (.416)</td>
<td>−0.08 (.394)</td>
</tr>
</tbody>
</table>

Notes. Figures are the standardized path coefficients from the listed variable to the intercept and slope parameters (represented by paths a and b in Figure 1, respectively). The latent general cognitive ability factors at ages 60, 70, and 80 were defined by four cognitive tests on each occasion. Model 1 included only the listed occupational characteristic; in Model 2, the covariates sex, education, and social class were also included; in the final model, the occupational characteristic was adjusted for general cognitive ability at age 50. In the joint analysis, the three occupational characteristics were entered in the same model. Significant effects are highlighted in bold.

When the analyses were run including men only, the results were essentially the same as for the full sample (available on request): intellectual demands were positively associated with higher cognitive ability level, although this was reduced by the inclusion of the demographics and reversed after adjustment for earlier cognitive ability; physical hazards were negatively associated with cognitive ability level, but the association was no longer significant once the demographics were included; there were no associations between psychological demands and cognitive ability or with any of the occupational characteristics and cognitive change.

DISCUSSION

In the Glostrup 1914 Cohort, individuals who had occupations characterized by higher intellectual challenge had higher cognitive ability, and sex, education, and social class only partly accounted for this effect. These results were broadly consistent to those reported previously (Bosma et al., 2003; Bosma et al., 2003; Finkel et al., 2009; Jorm et al., 1998; Marquie et al., 2010; Schooler et al., 1999; Van der Elst & van Boxtel, 2012). Even in the basic model, however, there was no association between occupational intellectual challenge and cognitive change over 20 years, extending the period over which this has been examined. This is consistent with Finkel and colleagues (2009) who concluded that “although occupational complexity was related to a higher level of cognitive performance, there was no evidence that occupational complexity protected against cognitive decline after retirement in any cognitive domain” (p. 571). Although supportive of those results, the current study could not consider retirement in any detail, as Finkel and colleagues (2009) were able to do; the period of follow-up will, however, have included this transition and does not suggest a long-term effect on cognitive change of the occupational factors into old age. Marquie and colleagues (2010) had noted that longer studies were required to examine the potential for long-lasting effects. The analyses of Schooler and colleagues (1999) were not able to consider this as their studies included only those in employment so that it was not possible to estimate the continuing effect of substantively complex work beyond retirement into old age.

The benefit of an intellectually challenging occupation would appear to be in increasing cognitive ability to a higher level earlier in the life span, or at least that challenging occupations are selected according to cognitive ability and then protect against cognitive decline from early adulthood to age 50, rather than altering the course of decline in old age. This would have been the conclusion if the analysis had not considered the confounding effect of preexisting differences in cognition. Perhaps the most intriguing result reported, therefore, was the reversal in the effect of intellectual challenge on cognitive ability level after accounting for an earlier measure of cognitive ability. This suggests that of two individuals starting at the same cognitive ability level at age 50 (matched for gender, and educational and social class background), it is the individual with the more intellectually demanding job who will have a lower subsequent level of cognitive ability (the composite level over age 60–80). What can explain this counterintuitive effect? Job–worker mismatch would be one possibility (de Grip, Bosma, Willems, & van Boxtel, 2008) though this would predict the opposite effect: more intellectually challenging occupations are beneficial even if the educational level of the individual is below that required. de Grip and colleagues (2008) were not able to account for prior cognitive ability so it is not possible to predict the effect of including that. Alternatively, the detrimental effect of retirement for those previously in more complex jobs could explain the observed results (Finkel et al., 2009; Schaie, 2005). If those in more complex occupations were retiring earlier, then it might be expected their cognitive decline would also be observed earlier (decline from an albeit higher level). Retirement data were not collected until the age 70 assessment, and therefore attempts to include this would markedly reduce sample size. This account therefore remains speculative and worthy of further study, though the results highlight the need to include prior cognitive ability to avoid reporting potentially unrepresentative unadjusted effects.

Across the analyses reported in this sample, psychological demands (composed of psychological stress and speed
problems) were not associated with cognitive ability level or change. It might have been expected that such characteristics would be cognitively detrimental given their negative impact on health (Karasek & Theorell, 1990), though the lack of an effect is consistent with previous work (Andel et al., 2012). The psychological demands factor was similar to that defined as job demands by Andel and colleagues (2011, 2012), which indexed “work load stressors (e.g., intense, hectic work schedule; extreme work load)” (p. 62) and which was not associated with cognitive impairment or dementia risk. Only when job demands were combined with job control to indicate level of job strain did the effect become significant, or indeed when job control was considered individually (Andel et al., 2011, 2012). Taken together, these results suggest that the demands themselves may not be cognitively detrimental if they are placed within the context of the individual being able to exert control over their tasks (Karasek & Theorell, 1990). Indeed, stressful demands are as likely to occur in complex occupations as they are in more routine occupations (Andel et al., 2012).

Similarly, though there was a negative effect of physical hazards on cognitive ability level—perhaps as a result of increased toxic exposure in these individuals (Dartigues et al., 1992; Frisoni, Rozzini, Bianchetti, & Trabucchi, 1993; Qiu et al., 2003; Seidler et al., 2004)—the association was accounted for by the educational background and social status of participants. Those with less education are more likely to attain lower status, more physically hazardous jobs, and it appears this is what explains the association between physical demands and cognition, rather than there being a detrimental effect per se. Individuals working in more hazardous conditions may simply do more poorly on psychometric tests as a result of the mismatch between the skills required on their job and those necessary for the completion of cognitive tests (Helmer et al., 2001). The current analyses cannot rule out short-term detrimental effects that might dissipate over time (as for psychological demands), given the long-term nature of the follow-up. It is also possible that these occupational characteristics are important for aspects of health or quality of life not considered here.

**Strengths and Limitations**

The current study benefited from the combination of a relatively large, well-characterized cohort with a long period of follow-up. Three- to six-year follow-up intervals are not uncommon in the literature (de Grip et al., 2008; Van der Elst & van Boxtel, 2012), though longer studies have been conducted (Schooler et al., 1999); the current study examined much longer-term effects of occupational characteristics than was perhaps previously possible. Though the occupational characteristics assessed were limited, they did cover key domains: intellectual, physical, and psychological demands. These assessments were also based on self-reports and were thus derived from the participants’ perceptions and experiences. This is an advantage over relying on standardized survey data, for example, but can also introduce self-reporting errors or biases (Marquie et al., 2010). Furthermore, the chosen factor solution accounted for more than 50% of the variance in the occupational characteristics assessed, suggesting some loss of information. The assessment was at least close to or during the participants’ working lives, collected at the age 60 assessment, and therefore recall bias is potentially less of an issue than retrospective data collection. It was not possible, however, to consider all aspects of the job strain model, for example, level of control, demands, and support, which have been linked to cognitive impairment and dementia risk (Andel et al., 2011, 2012).

As with Marquie and colleagues (2010), cognitive ability was analyzed as a general composite from multiple measures to reduce the effect of individual measurement error. This represents an advantage over some previous studies relying on single, broad screening tests of cognitive function (Andel et al., 2011). The current research question was purely focused on general cognitive ability and therefore did not examine potentially interesting domain-specific effects. Though worthy of follow-up, the sample often completed only a single measure for a given domain; a large battery with multiple markers of each cognitive domain would be beneficial.

The sample studied currently is a narrow-age, year-of-birth cohort and therefore the confounding effect of age and generation was reduced. As with other studies in this area, we were unable to account for the duration of the occupation assessed (Andel et al., 2012), though given the age of the cohort, the occupational histories are likely to have been more stable and constrained than alter generations. The key strength, however, lies in the ability to control for a measure of cognitive ability assessed 10 years before the occupational assessment. Though this assessment at age 50 reflected cognitive differences that predated the occupational assessment, they did not predate occupational choice or the potential effect that the resultant occupational factors will have had on cognitive function up to age 50. It would have been advantageous if cognitive ability data were available from earlier in the life span, before the effect of occupational or other lifestyle characteristics have made an impact, though as the question here was in the continuing effect of occupational characteristics into old age, this was less of an issue. Finally, though the sample comprised both men and women, the effects were examined in the whole sample and separately in the men. This was partly due to the historical nature of the cohort, whereby the women would have had fewer opportunities to pursue the range of careers open to later cohorts. Further examination of these effects in more recent groups of women is certainly warranted.
CONCLUSIONS

The long-term effects of occupational characteristics—intellectual challenge, physical hazards, and psychological demands—on cognitive ability were examined, and there was no evidence of differential preservation of cognitive skills due to levels of these demands. Although intellectually challenging occupations appeared to increase the level of cognitive ability, when an earlier measure of cognitive ability was considered, this effect was reversed. Studies addressing occupational characteristics need to account for this confounder, in order that the effect of the characteristics might be more fully understood.

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