HHS Public Access
Author manuscript
J Occup Environ Med. Author manuscript; available in PMC 2017 June 01.

Published in final edited form as:
J Occup Environ Med. 2016 June ; 58(6): 535–541. doi:10.1097/JOM.0000000000000727.

Workplace Exposures and Cognitive Function during Adulthood: Evidence from National Survey of Midlife Development and the O*NET

Joseph G. Grzywacz[1], **Dikla Segel-Karpas**[2], and **Margie E. Lachman**[3]

[1]Department of Family and Child Sciences, Florida State University, Tallahassee, FL

[2]Department of Gerontology, The University of Haifa

[3]Department of Psychology, Brandeis University, Boston MA

Abstract

Objective—Expand understanding of the role of selected workplace exposures (i.e., occupational complexity, conflict in the workplace, pace of work, and physical hazards) in adults' cognitive function.

Methods—Cross-sectional data (n=1,991) from the second wave of the Midlife in the United States (MIDUS) study; restricted to participants who completed telephone-based cognitive assessments of episodic memory, executive functioning, and self-perceived memory. Occupational exposure data were harvested from the O*NET Release 6.0.

Results—Greater complexity was associated with better self-perceived memory among women and men, and better episodic memory and executive functioning among women. Greater physical hazards was independently associated with poorer episodic memory and executive functioning.

Conclusions—Objective assessments of physical and psychosocial exposures in the workplace are independently associated with cognitive outcomes in adulthood, with psychosocial exposures being particularly pronounced among women.

Keywords

Cognition; O*NET; Cognitive Reserve; Occupational Exposure; Complexity

Occupation is widely believed to shape adults' cognition and trajectories of cognitive change across the lifespan. Substantial occupational epidemiological research highlights the threats posed by physical agents in the workplace. There is compelling evidence that chronic occupational exposure to lead is associated with poorer cognitive function later in life.[1] Likewise, there is a substantial body of research implicating organophosphates,[2] various solvents,[3,4] and particular types of noise[5,6] result in poorer cognitive outcomes including

Address all correspondence to: Joseph G. Grzywacz, Ph.D., Department of Family and Child Science, Florida State University, 120 Convocation Drive, Tallahassee, FL 32306. jgrzywacz@fsu.edu. Telephone: 850-644-2484.

The authors have no conflicts of interest to declare.

cognitive disorders. An increasing body of research questions whether chronic exposure to intellectual, social, and interpersonal agents in the workplace shape adult trajectories of cognitive change. Occupational complexity or the extent to which workers must make decisions with ambiguous or competing contingencies[7] has been associated with better cognitive outcomes in both clinical[8,9] and general population samples.[10–15] These associations are frequently interpreted in terms of "cognitive reserve," or the idea that jobs requiring frequent problem solving provide regular opportunities to enhance brain structures and connections that are protective against aging-related or environmental insults to the brain.[16]

The Job Demands-Control (JDC) model[17] offers two additional perspectives on the often-cited protective effects of occupational complexity. The first perspective provided by the JDC model draws attention to the health implications of "demands" or the patterned and spontaneous stressors that occur through or arise from performing the job. Specifically, the JDC model would argue that psychological demands imposed on workers, such as inappropriate production goals or pace of work and interpersonal conflict in the workplace, likely have direct effects on any health outcome. Second, if the decision making component of "occupational complexity" is conceived of as a form of "control" or the amount of freedom workers have over tasks and how they are performed, the JDC model would argue that the putative benefit of occupational complexity depends on the relative level of psychological demands. This argument receives some empirical support. In contrast to the evidence linking complexity to cognitive outcomes, some researchers find null or inverse associations between complexity and cognitive outcomes.[18,19] Such an inconsistency is suggestive of modifying effects, and there is evidence that individuals in jobs characterized by high demands and low control (so called 'high strain jobs") have poorer cognitive outcomes.[20]

Research on the putative role of occupational experiences in shaping cognition across adulthood is developing, but several meaningful gaps remain in the literature. First, the evidence base is carved into clear silos, such that physical agents in the workplace is largely done by industrial hygienists and occupational epidemiologists, whereas research focused on the social and psychological agents in the workplace is largely performed by social epidemiologists, organizational psychologists, or organizational behavior researchers. Cross-fertilization of ideas is rare, and there are few cases where both physical and psychosocial agents in the workplace are considered simultaneously in the same analysis. Likewise, there is substantial variability in the methods employed in this domain of research. Several population studies of aging rely on self-reported measures of cognitive function[10,13,16] or occupational characteristics.[15,20] Others use more sophisticated measures of both, including composite measures of job exposures from the Dictionary of Occupational Titles[11,21,22] or the Occupational Information Network (O*NET).[13,23,24] Few studies have used robust indicators of cognitive function and occupational characteristics[13,22,25] and we could locate no studies that consider possible modifying effects of objectively assessed psychological demands on the occupational complexity - cognitive function association. Further, despite some evidence that the putative benefit of occupational complexity on subsequent cognitive capacity differs by gender,[19] few studies examine possible variation in protective effects of mental demand on cognition by age, gender, or educational attainment despite the fact that these are major bases of occupational stratification.

The overall goal of this study was to expand understanding of the role of workplace exposures in both of the physical and psychosocial domains in adults' cognitive function. To accomplish this goal we use objective assessments of occupational exposure from the O*NET integrated with the Midlife Development in the United States to accomplish two primary aims. Specifically, this study sought to: 1) delineate variation in selected indicators of adult cognitive function by objective indicators of occupational exposure to occupational complexity, as well as objective indicators of psychological demands; 2) determine whether associations of occupational complexity with cognitive function are modified by psychological demands; and 3) determine if associations of occupational complexity and psychological demands persist after further adjustment for exposure to physical hazards in the workplace. We also explore age, gender, and educational variation in associations of occupational characteristics with cognitive function.

Method

Participants

Data for this study was derived from the second wave of the Midlife in the United States (MIDUS) study, collected between 2004 and 2006. The initial wave two survey included 4963 non-institutionalized adults aged 32–84 (M=55, SD=12.4), from the 48 contiguous states. The sample was obtained using a random digit dialing (RDD), for a response rate of 71%. The cognitive measurements were obtained in a second telephone interview (n=4,186), with a completion rate of 86%. Forty seven percent of the participants were male, and their mean education level was 14.24 years (SD = 2.60). We limited our analysis to data collected at the second wave, as the first wave (1995–1996) was not matched with the O*NET occupational scoring.

The initial sample included MIDUS participants who were employed at the time of data collection (N=2,273). Final analyses were performed on a subsample of respondents who provided all necessary data (n=1,991). To test for non-random attrition, we compared participants with and without complete data. Participants who did not provide all the necessary data were approximately two years older, more likely to be female, had greater educational attainment, and had more functional limitations. The mean age of participants in our sample was 51.4 (SD=9. 7) and ranged between the ages of 32 and 81. Just under half the sample (49.7%) was male (n=989). The sample was well educated with 43.9%having earned an undergraduate college degree (BS/BA) or more, 52.3% completing high school and some college or technical training, and 3.8% with less than a high school degree.

Measures

Dependent variables—Cognitive function was assessed using the Brief Test of Adult Cognition by Telephone (BTACT).[26,27] The BTACT was designed especially to enable assessment of cognitive functioning in large community based samples. Unlike other cognitive batteries (such as the Mini Mental State Examination,[28] the BTACT aims to identify non-pathological variation in cognitive function. Participants were asked to complete a series of tests after a brief hearing test.

The BTACT includes seven cognitive dimensions: immediate recall and delayed recall of a list of 15 words; working memory span, where participants are asked to repeat a series of digits in reversed order; verbal fluency – examines the number of animals participant can recall in 60 seconds; inductive reasoning – where participants are requested to complete the next number in a series of 5 numbers; processing speed – the number of digits completed in 30 seconds by counting backwards from 100; attention switching task – in this task participants' reaction times are recorded in two conditions: a normal condition in which they are asked to respond with "go" to the stimulus "green" and "stop" to the stimulus red", and a reverse condition were they are asked to respond with "stop" to the stimulus "greed" and "go" to "red".

The 5 later tests reflect the construct of *executive functioning*, and the first two tests (immediate and delayed recall) reflect respondents' *episodic memory*. This structure was confirmed using exploratory and confirmatory factor analysis.[29] In this study, we will only use the two constructs and will not present the results for the separate tasks. The scores were standardized. *Self-perceived memory* was assessed with a single item asking respondents to compare their memory to their age counterparts. Responses ranged from 1 "poor" to 5 "excellent".

Independent variables—The independent variables in our models were based on the Occupational Information Network (O*NET). The O*NET collects information regarding occupational characteristics by surveying occupation analysts and workers from each occupation, under the sponsorship of the US Department of Labor/Employment and Training Administration. The collection of data from workers is aimed at identifying the typical workers' characteristics in each occupation, the requirements from workers, occupational requirements and the characteristics of the workforce typical of the occupation. The current O*NET taxonomy covers 974 occupations, and provides scaling on 227 variables. A subset of the O*NET variables, largely those reflecting the Occupational Requirements section of the O*NET content model[30] were harvested from the O*NET Release 6.0, which was released July 2004. Release 6.0 data were harvested as they were most temporally proximal to the collection of occupational information from MIDUS respondents.

Occupational complexity was measured with a single item determining the degree to which the job requires workers to identify complex problems, review related information to develop and evaluate options, and implement solutions. Two indicators of psychological demand were obtained. *Pace of work* refers to the role that time constraints play in the way job tasks are performed and was assessed with four items relating to the frequency in which worker has to meet strict deadlines; the level to which the pace of the job is set by speed of machinery or equipment; the regularity of the work schedule; and the number of hours worked in a typical work week. Finally, the amount of conflict workers are likely to encounter at their work (*conflict at work*) was assessed with three items assessing the frequency workers: face conflict situations in the job; deal with unpleasant, angry or discourteous individuals as part of the job requirements; and deal with physical aggression of violent individuals.

Physical hazards in the workplace reflects the combination of two sets of items. The first set of items assessed the frequency of exposure to hazardous conditions, the likelihood of injury as well as the degree of injury resulting from the exposure, if an injury occurred. The list of hazardous conditions includes exposure to: radiation; disease or infections; high places, hazardous conditions in general; hazardous equipment; and minor cuts, burns, bites or stings. The second set of items assessed exposure to environmental conditions. The list of environmental conditions included exposure to uncomfortable or distracting levels of sounds or noises; very hot or cold temperatures; extremely bright or inadequate lighting; exposure to contaminants; cramped workspace; and exposure to whole body vibrations. The correlation between the “hazards” and “environmental conditions” was high (r=.84, p<.001); consequently, the two scores could not be used separately. Factor analysis with Varimax rotation revealed that all but two items loaded on a single factor (eigenvalue of 6.7). Consequently, all the items except for the two that did not load (i.e., exposure to radiation and exposure to diseases and contaminations) were combined to create a single *physical hazards* variable

Control variables—*Age* (continuous) and *gender* (male=1) were assessed as likely confounds of posited associations of occupational exposures and cognitive function. Likewise, *educational attainment* was assessed using a single item asking participants to report the highest level of education completed. Response options were: (1) no school/some grade school; (2) eighth grade/junior high school; (3) some high school (9–12 years) no diploma/no GED; (4) graduated from high school; (5) 1 to 2 years of college, no degree yet; (6) 3 or more years of college, no degree yet; (7) graduated from 2-year college, vocational school, or associated degree; (8) graduated from a 4 or 5 year college, or bachelor's degree; (9) some graduate school; (10) master's degree; PhD, EdD, MD, DDS, LLB, LLD, JD, or other professional degree. Finally, *functional limitations* were assessed by asking participants to report level of limitation in performing a list of 8 daily activities including: lifting/carrying groceries; bathing/dressing; climbing several flight stair; climbing one flight of stairs; bending/kneeling/stooping; walking more than one mile; walking several blocks and walking one block. Each item was rated on a scale ranging from 1 “not at all” to 4 “a lot”. The score was created by averaging the items (M=1.56, SD=.76).

Analysis

Multilevel models were fit to account for dependence among observations resulting from the clustering of individuals in the same occupational groups. Prior to conducting final analyses, an unconditional model was fit to calculate the intraclass correlation (ICC) coefficient to determine the proportion of the variance explained by the different occupational groups. ICC scores were significant (above 5% of variation) and vary as follows: episodic memory (ICC=.07); executive functioning (ICC=.15); self-perceived memory (ICC=.05).

A stepwise model building strategy was used for each indicator of cognitive function. In the first step the outcome was regressed on occupational complexity and the indicators of psychological demand (i.e., pace of work, conflict at work) and relevant control variables to determine if occupational complexity and the indicators of psychological demand were independently associated with the outcome. In the second step, two-way interactions of complexity with pace of work and complexity with conflict were added to the model to delineate possible moderation effects. Only significant interactions were carried forward to the third and final step where physical hazards were added to the model.

Results

Means, Standard deviations and correlations between study variables are presented in Table 1. The independent variables occupational complexity, pace of work, conflict at work, and physical hazards were associated with nearly every indicator of cognitive function. The only exception was a null association of conflict at work with self-perceived memory. Occupational complexity and conflict at work were positively correlated with both episodic memory ($r = 0.10$, $p < 0.001$; $r = 0.08$, $p < 0.001$ respectively) and executive functioning ($r = 0.23$, $p < 0.001$; $r = 0.05$, $p < 0.05$ respectively). Occupational complexity was positively associated with self-perceived memory ($r = 0.11$, $p < 0.001$), the association of conflict at work with self-perceived memory approached significance ($r = 0.04$, $p < 0.10$). Pace of work and physical hazards were negatively correlated with episodic memory ($r = -0.12$, $p < 0.001$; $r = -0.17$, $p < 0.001$, respectively), executive functioning ($r = -0.14$, $p < 0.001$; $r = -0.21$, $p < 0.001$, respectively), and self-perceived memory ($r = -0.05$, $p < 0.05$ $r = -0.08$, $p < 0.001$, respectively).

The first outcome considered was episodic memory (Table 2). Consistent with the cognitive reserve hypothesis, greater occupational complexity was associated with better episodic memory ($b = 0.003$, $p < 0.05$). Neither of the psychological demand variables was associated with episodic memory, nor was there any evidence suggesting that psychological demand modifies the association of occupational complexity with episodic memory. Greater exposure to physical hazards was associated with poorer episodic memory ($b = -0.005$, $p < 0.01$). Further, once exposure to physical hazards was added to the model, the previously significant association of occupational complexity with episodic memory was attenuated ($p < 0.10$).

Greater occupational complexity was associated with better executive function (b = 0.005, p < 0.001). Pace of work, one indicator of psychological demand, was inversely associated with executive function suggesting that individuals exposed to elevated pace of work had poorer executive function (b = −0.005, p < 0.05). Conflict at work was not associated with executive function. There was no evidence that psychological demand modifies the association of occupational complexity with executive function. Greater exposure to physical hazards was associated with poorer executive function (b = −0.01, p < 0.001). Once exposure to physical hazards was controlled, association of pace at work with executive function was attenuated to the null. The magnitude of the association of occupational complexity with executive function was also attenuated, but it retained statistical significance.

The final outcome was self-perceived memory (Table 4). Greater occupational complexity was associated with better self-perceived memory ($b = 0.003$, $p < 0.05$). Neither of the psychological demand variables was associated with self-perceived memory. However, there was evidence that conflict at work modified the association of occupational complexity with self-perceived memory such that the association is stronger for higher levels of conflict, and weaker when conflict at the workplace is at mean or low (see Figure 1). There was no evidence that exposure to physical hazards was associated with self-perceived memory.

We explored whether the associations of occupational complexity, psychological demand (i.e., pace of work and conflict at work), and physical hazards with cognitive functioning differed across age groups, gender, and educational attainment. There was little consistent evidence suggesting that associations reported in Tables 2–4 differed by age or educational attainment. However, the association of conflict at work with executive functioning was found to differ by age ($b = 0.0004$, $se = 0.001$, $p < 0.05$). We evaluated the nature of the interaction by conducting a test of simple slopes by splitting the file into younger and older adults based on a simple median split of the age variable. The test of simple slopes indicated that conflict at work was not significantly associated with executive function in either age group.

The association of occupational complexity with two indicators of cognitive function differed by gender. The occupational complexity-by-gender interaction term for episodic memory was significant ($b = -0.006$, $se = 0.004$, $p < 0.05$), as was the occupational complexity-by-gender interaction term for executive functioning ($b = -0.007$, $se = 0.002$, $p < 0.05$). Gender-stratified simple slopes analyses indicated that associations of occupational complexity with each outcome were significant for women ($b = 0.006$, $se = 0.002$, $p < 0.01$ for episodic memory; $b = 0.008$, $se = 0.002$, $p < 0.001$ for executive functioning), but not for men. These differential slopes are illustrated in Figure 2.

Discussion

The goal of this study was to expand understanding of the role of workplace exposures in adults' cognitive function. Specifically, this study was designed to address the bifurcation in the cognitive aging literature that tends to separate physical and psychosocial exposures in the workplace, and the relative paucity of cognitive aging research with robust measures of both cognitive function and occupational characteristics. Additionally, this study considered interactive effects of discrete workplace exposures on adult cognition, and the possibility that the putative effects of workplace exposures on cognition may vary by age, gender and educational attainment (cf. Stenfors and colleagues[19]).

This analysis of objective indicators of occupational exposure found consistent associations between occupational complexity and each indicator of cognitive function. Consistent with the cognitive reserve hypothesis[16] and a recent literature review[31] we found that exposure to higher levels of occupational complexity was associated with better researcher-assessed episodic memory and executive function, as well as better self-perceived memory. These results are consistent with previous studies[11,21,23] that used objective indicators of job exposure and self-reported cognitive ability, as well as the few other studies that have used rigorous measures on each side of the equation.[13,22,25] Our findings contribute to the literature by replicating previous results in another national data set using different instruments to assess episodic memory and executive function. This replication provides compelling evidence of a robust association between exposure to occupational complexity and adults' cognitive functioning that is consistent with notions of "cognitive reserve".[16]

A second and equally meaningful contribution to the literature is our joint attention to both the physical and psychosocial environments in the workplace. Independent of occupational complexity, greater exposure to physical hazards in the workplace was associated with poorer episodic memory and executive function. These results are consistent with evidence from industrial hygiene research suggesting that greater exposure to chemicals like lead,[1] organophosphates[2] and solvents[3,4] are associated with poorer cognitive outcomes. They are also consistent with studies documenting that exposure to other physical hazards, like particular types of noise,[5,6] may undermine cognitive function.

That both occupational complexity and physical hazards are independently associated with episodic memory and executive function is compelling. First, it highlights the reality that cognition in adulthood has a complex etiology, and signals the importance of looking across disciplines and fields for plausible predictors. More research combining physical and psychosocial workplace exposures is needed. Second, the independent associations of occupational complexity and physical hazards with objectively assessed cognitive outcomes may offer insight into well-described socioeconomic inequalities in cognitive outcomes.[32–34] Indeed, although not the focus of this study, it is noteworthy that associations of educational attainment with episodic memory and executive function were attenuated after exposure to physical hazards were added to the model containing occupational complexity. This finding is consistent with Marengoni's and colleagues'[32] finding that high physical demand on the job attenuated but did not completely explain educational differences in incident cognitive impairment without dementia. Together the evidence is suggestive that additive or incremental workplace exposures in both the physical and psychosocial domains of work may be useful for explaining inequalities in cognitive aging. More research in this area is needed

Finally, three other findings of this study are noteworthy. First, it is noteworthy that the association of occupational complexity with self-perceived memory was modified by conflict at work. This association is consistent with the Job Demand-Control model arguing that control and decision making in the workplace is a meaningful buffer of job stressors.[17] However, the meaningfulness of this finding must be tempered by the fact that it emerged only for the self-reported cognitive outcome. Second, it is interesting that the association of pace of work, essentially an indicator of time constraints in the workplace, with executive function was attenuated to non-significance after adjustment for exposure to physical hazards. This is an important area for additional research because it highlights the potential significance of physical and psychosocial workplace exposures in understanding occupational health outcomes. Finally, we found that associations of occupational complexity with objective indicators of cognitive function differed by gender such that the associations only held for women. A pair of manuscripts by Rieiro and Lourenco[21,35] using data from Brazilian adults suggests that occupational complexity is equally relevant to both women and men. However, in their study that focused solely on women,[35] these authors did suggest that the putative benefit of occupational complexity for cognitive functioning appears to be linear for men, but non-linear for women. That is, there was no difference in cognitive function between non-working women and those with low occupational complexity; whereas for men, there were notable differences in cognitive functioning between non-working men and those with low occupational complexity. Our results are completely opposite of these previous findings because they suggest that only women benefit from occupational complexity. Perhaps the survey items completed by O*Net occupational analysts and selected workers in work sites perform differently in male versus female dominated positions. Our findings coupled with the absence of parallel previous research and clear stratification in types of jobs held by women and men indicate that more research in the area is needed.

The contributions of this study need to be considered in light of its limitations. Most notably, the cross-sectional design undermines the ability to make causal inferences. Next, our occupational complexity measure consisted of a single item with unknown reliability. Furthermore, previous research suggests that complexity with data (relative to complexity with people or things)[11] or that complexity with people (relative to complexity with data or things)[12] may be most instrumental for cognitive function in later life. Although both the single item and the lack of differentiation in the type of complexity are weaknesses, the threat of these weaknesses is somewhat lessened by the convergence of the current results with the critical mass of previous research. Another limitation of this study is difficulty interpreting the observed gender differences in the effects of workplace exposures on cognitive function. Because of gender stratification in the workplace, we cannot discern whether the differential effects of workplace exposure are different for women, or if they are different because women occupy different types of jobs where variation in these exposures is more salient. Each of these limitations necessitates further research.

Limitations notwithstanding, this manuscript makes several contributions to the literature. We replicate previous research demonstrating potential enhancements to adults' cognitive reserve from occupational complexity, although the benefits of complexity to episodic memory and executive functioning were limited to women. Newer to the literature is clear and consistent evidence that exposure to physical hazards in the workplace undermines cognitive function for both women and men, independent of the effects of complexity. Collectively these results highlight the importance of ongoing attention directed toward occupational exposures, both physical and psychosocial, in understanding cognition among adults and potentially cognitive trajectories across adulthood.

Acknowledgments

This research was supported by a grant from the National Institute on Aging (2P01AG020166-07).

References

1. Shih RA, Hu H, Weisskopf MG, Schwartz BS. Cumulative Lead Dose and Cognitive Function in Adults: A Review of Studies That Measured Both Blood Lead and Bone Lead. Environ. Health Perspect. 2007; 115:483–492. [PubMed: 17431502]

2. Blanc-Lapierre A, et al. Cognitive Disorders and Occupational Exposure to Organophosphates: Results From the PHYTONER Study. Am. J. Epidemiol. 2013; 177:1086–1096. [PubMed: 23535900]
3. Berr C, et al. Occupational Exposure to Solvents and Cognitive Performance in the GAZEL Cohort: Preliminary Results. Dement. Geriatr. Cogn. Disord. 2010; 30:12–19. [PubMed: 20606440]
4. Sabbath EL, et al. Occupational solvent exposure and cognition Does the association vary by level of education? Neurology. 2012; 78:1754–1760. [PubMed: 22641403]
5. Gomes LM, Martinho Pimenta AJ, Castelo Branco NA. Effects of occupational exposure to low frequency noise on cognition. Aviat. Space Environ. Med. 1999; 70:A115–118. [PubMed: 10189166]
6. Szalma JL, Hancock PA. Noise effects on human performance: A meta-analytic synthesis. Psychol. Bull. 2011; 137:682–707. [PubMed: 21707130]
7. Schooler, C. Measuring environment across the life span: Emerging methods and concepts. Friedman, SL.; Wachs, TD., editors. American Psychological Association; 1999. p. 229-246.
8. Andel R, Vigen C, Mack WJ, Clark LJ, Gatz M. The effect of education and occupational complexity on rate of cognitive decline in Alzheimer's patients. J. Int. Neuropsychol. Soc. 2006; 12:147–152. [PubMed: 16433954]
9. Jonaitis E, et al. Cognitive activities and cognitive performance in middle-aged adults at risk for Alzheimer's disease. Psychol. Aging. 2013; 28:1004–1014. [PubMed: 24364404]
10. Andel R, Silverstein M, Kåreholt I. The Role of Midlife Occupational Complexity and Leisure Activity in Late-Life Cognition. J. Gerontol. B. Psychol. Sci. Soc. Sci. 2015; 70:314–321. [PubMed: 25190210]
11. Andel R, Kåreholt I, Parker MG, Thorslund M, Gatz M. Complexity of Primary Lifetime Occupation and Cognition in Advanced Old Age. J. Aging Health. 2007; 19:397–415. [PubMed: 17496241]
12. Finkel D, Andel R, Gatz M, Pedersen NL. The role of occupational complexity in trajectories of cognitive aging before and after retirement. Psychol. Aging. 2009; 24:563–573. [PubMed: 19739912]
13. Fisher GG, et al. Mental work demands, retirement, and longitudinal trajectories of cognitive functioning. J. Occup. Health Psychol. 2014; 19:231–242. [PubMed: 24635733]
14. Marioni RE, et al. Cognitive lifestyle jointly predicts longitudinal cognitive decline and mortality risk. Eur. J. Epidemiol. 2014; 29:211–219. [PubMed: 24577561]
15. Valenzuela M, Brayne C, Sachdev P, Wilcock G, Study FM. on B. of the M. R. C. C. F. and A. Cognitive Lifestyle and Long-Term Risk of Dementia and Survival After Diagnosis in a Multicenter Population-based Cohort. Am. J. Epidemiol. 2011; 173:1004–1012. [PubMed: 21378129]
16. Stern Y. The Concept of Cognitive Reserve: A Catalyst for Research. J. Clin. Exp. Neuropsychol. 2003; 25:589–593. [PubMed: 12815497]
17. Karasek, R.; Theorell, T. Healthy Work: Stress, Productivity, and the Reconstruction of Working Life. Basic Books; 1992.
18. Avolio BJ, Waldman DA. An examination of age and cognitive test performance across job complexity and occupational types. J. Appl. Psychol. 1990; 75:43–50. [PubMed: 2307633]
19. Stenfors CUD, Magnusson Hanson L, Oxenstierna G, Theorell T, Nilsson L-G. Psychosocial Working Conditions and Cognitive Complaints among Swedish Employees. PLoS ONE. 2013; 8:e60637. [PubMed: 23560101]
20. Elovainio M, et al. Physical and cognitive function in midlife: reciprocal effects? A 5-year follow-up of the Whitehall II study. J. Epidemiol. Community Health. 2009; 63:468–473. [PubMed: 19439578]
21. Ribeiro PCC, Lopes CS, Lourenço RA. Complexity of lifetime occupation and cognitive performance in old age. Occup. Med. 2013; 63:556–562.
22. Kröger E, et al. Is Complexity of Work Associated with Risk of Dementia? The Canadian Study of Health and Aging. Am. J. Epidemiol. 2008; 167:820–830. [PubMed: 18263600]

23. Forstmeier S, Maercker A. Motivational reserve: Lifetime motivational abilities contribute to cognitive and emotional health in old age. Psychol. Aging. 2008; 23:886–899. [PubMed: 19140658]
24. Then FS, et al. Differential effects of enriched environment at work on cognitive decline in old age. Neurology. 2015; 84:2169–2176. [PubMed: 25925981]
25. Forstmeier S, et al. Motivational reserve: Motivation-related occupational abilities and risk of mild cognitive impairment and Alzheimer disease. Psychol. Aging. 2012; 27:353–363. [PubMed: 21875213]
26. Lachman ME, Agrigoroaei S, Tun PA, Weaver SL. Monitoring Cognitive Functioning Psychometric Properties of the Brief Test of Adult Cognition by Telephone. Assessment. 2014; 21:404–417. [PubMed: 24322011]
27. Tun PA, Lachman ME. Telephone assessment of cognitive function in adulthood: the Brief Test of Adult Cognition by Telephone. Age Ageing. 2006; 35:629–632. [PubMed: 16943264]
28. Folstein MF, Folstein SE, McHugh PR. 'Mini-mental state': A practical method for grading the cognitive state of patients for the clinician. J. Psychiatr. Res. 1975; 12:189–198. [PubMed: 1202204]
29. Lachman ME, Agrigoroaei S, Murphy C, Tun PA. Frequent Cognitive Activity Compensates for Education Differences in Episodic Memory. Am. J. Geriatr. Psychiatry. 2010; 18:4–10. [PubMed: 20094014]
30. Boese R, Lewis P, Frugoli P, Litwin K. Summary of O*NET 4.0 Content Model and Database. 2001
31. Then FS, et al. Systematic review of the effect of the psychosocial working environment on cognition and dementia. Occup. Environ. Med. 2014; 71:358–365. [PubMed: 24259677]
32. Marengoni A, Fratiglioni L, Bandinelli S, Ferrucci L. Socioeconomic Status During Lifetime and Cognitive Impairment No-Dementia in Late Life: The Population-Based Aging in the Chianti Area (InCHIANTI) Study. J. Alzheimers Dis. 2011; 24:559–568. [PubMed: 21297261]
33. Singh-Manoux A, Richards M, Marmot M. Socioeconomic Position across the Lifecourse: How Does it Relate to Cognitive Function in Mid-life? Ann. Epidemiol. 2005; 15:572–578. [PubMed: 16118001]
34. Horvat P, et al. Life Course Socioeconomic Position and Mid-Late Life Cognitive Function in Eastern Europe. J. Gerontol. B. Psychol. Sci. Soc. Sci. 2014; 69:470–481. [PubMed: 24598045]
35. Ribeiro PCC, Lourenço RA. Lifetime Occupation and Late-Life Cognitive Performance Among Women. Health Care Women Int. 2015; 0:1–11.

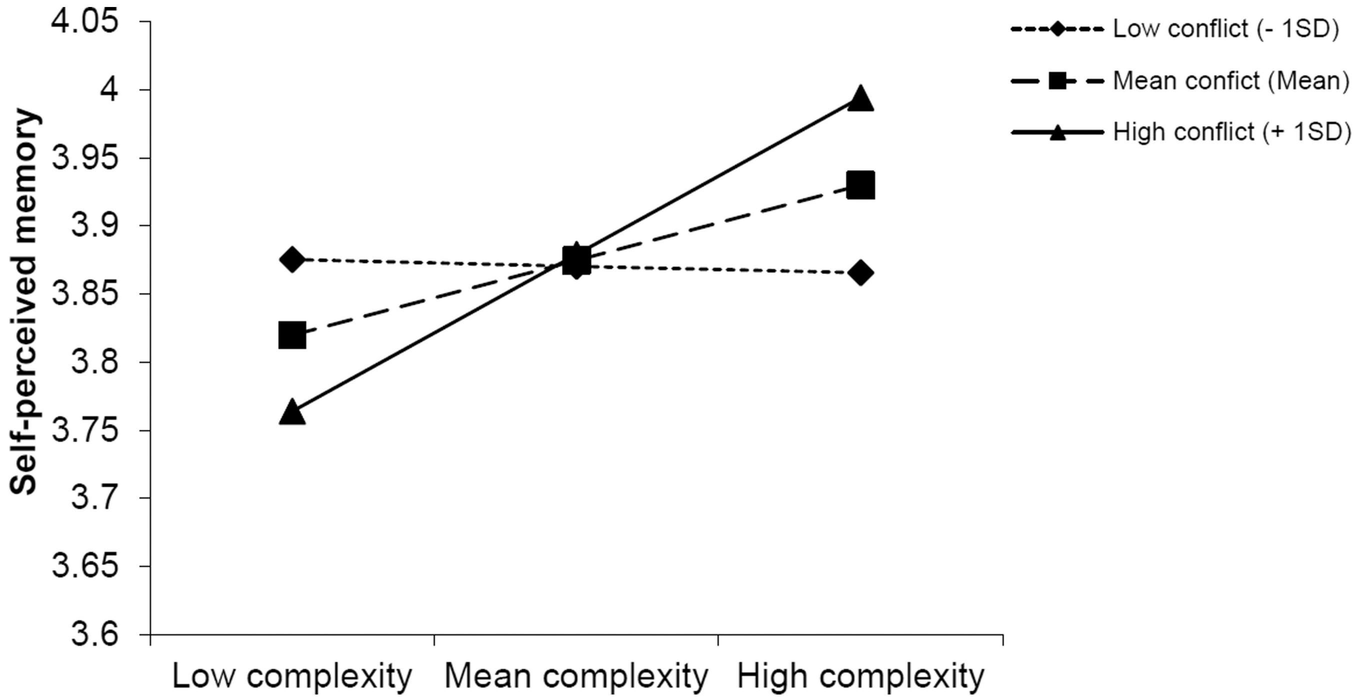

Figure 1.
Self-perceived memory – complexity and conflict

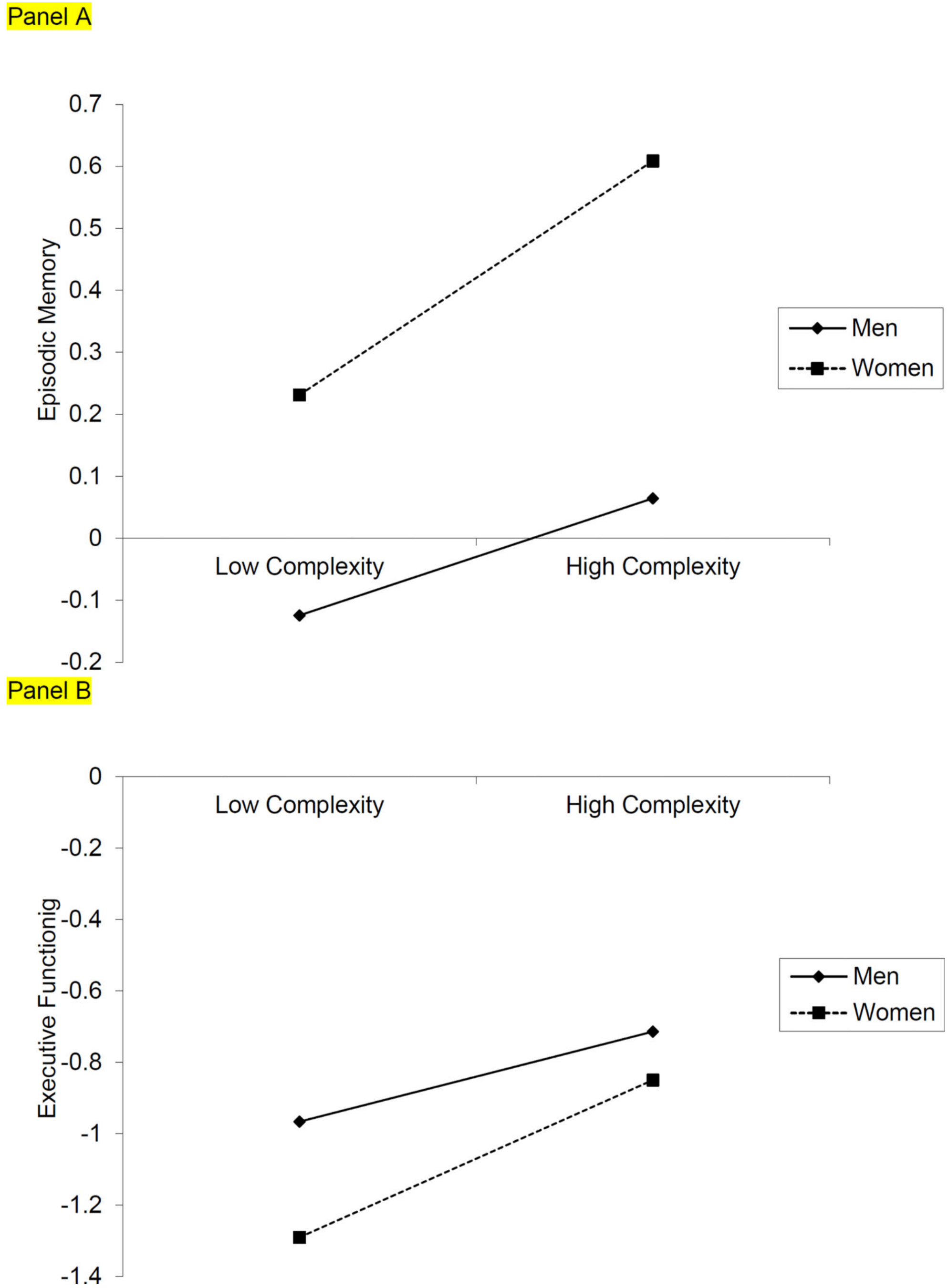

Figure 2.
Gender differences in the association of complexity with episodic memory (Panel A) and executive function (Panel B)

Table 1

descriptive statistics and correlations between study variables

		M	SD	1	2	3	4	5	6	7	8	9	10
1.	Age	51.35	9.68										
2.	Gender (1=male)	0.50	0.50	0.04*									
3.	Education	7.68	2.47	−0.06*	0.09***								
4.	Functional limitations	1.34	0.56	0.19***	−0.12***	−0.16***							
5.	Conflict	42.18	10.97	−0.05*	−0.10***	0.13***	−0.01						
6.	Pace	44.75	11.91	0.002	0.23***	−0.28***	0.04	−0.01					
7.	Complexity	55.67	15.75	−0.08***	0.13***	0.39***	−0.12***	0.12***	−0.14***				
8.	Hazards	22.37	15.19	−0.04	0.25***	−0.32***	0.03	−0.08***	0.54***	−0.17***			
9.	Episodic memory	0.00	1.00	−0.20***	−0.23***	0.17***	−0.09***	0.08***	−0.12***	0.10***	−0.17***		
10.	Executive functioning	0.00	1.00	−0.29***	0.12***	0.39***	−0.17***	0.05*	−0.14***	0.23***	−0.21***	0.35***	
11.	Self-perceived memory	3.61	0.86	0.05*	0.05*	0.15***	−0.21***	0.04+	−0.05*	0.11***	−0.08***	0.10***	0.14***

+p<.10,

*p<.05,

**p<.01,

***p<.001

Author Manuscript
Author Manuscript
Author Manuscript

Table 2

Parameter estimates of multilevel analysis for episodic memory

	Model 1		Model 2		Model 3	
Parameter	**EST**	**SE**	**EST**	**SE**	**EST**	**SE**
Complexity	0.003*	0.002	0.003*	0.002	0.003+	0.001
Psychological Demands						
Pace	−0.001	0.002	−0.002	0.002	0.002	0.002
Conflict	0.002	0.002	0.01	0.002	0.001	0.002
Interaction terms						
Complexity*Pace			−0.001	0.001		
Complexity*Conflict			0.001	0.001		
Physical Hazards					−0.005**	0.002
Controls						
Age	−0.02***	0.002	−0.02***	0.002	−0.02***	0.002
Gender (male)	−0.48***	0.05	0.48***	0.05	−0.45***	0.05
Education	0.06***	0.01	0.06***	0.01	0.05***	0.01
Ill Health	−0.09*	0.04	−0.09*	0.04	−0.09*	0.04
Intercept	−0.57***	0.10	−0.56***	0.10	−0.52***	0.10

+ p<.10,

* p<.05,

** p<.01,

*** p<.001

Table 3

Parameter estimates of multilevel analysis for executive functioning

	Model 1		Model 2		Model 3	
Parameter	**EST**	**SE**	**EST**	**SE**	**EST**	**SE**
Complexity	0.005**	0.002	0.005**	0.002	0.004*	0.002
Psychological Demands						
Pace	−0.005*	0.002	−0.005*	0.002	0.001	0.002
Conflict	0.001	0.002	0.001	0.002	−0.001	0.002
Interaction terms						
Complexity*Pace			−0.001	0.001		
Complexity*Conflict			−0.001	0.001		
Physical Hazards					−0.01***	0.002
Controls						
Age	−0.03***	0.002	−0.03***	−0.002	−0.03***	0.002
Gender (male)	0.19***	0.04	0.18***	0.04	0.24***	0.04
Education	0.12***	0.01	0.12***	0.01	0.11***	0.01
Ill Health	−0.08*	0.03	−0.08*	0.03	−0.08*	0.04
Intercept	−0.73***	0.10	−0.73***	0.10	−0.64***	0.10

+ p<.10,

* p<.05,

** p<.01,

*** p<.001

Table 4

Parameter estimates of multilevel analysis for self-perceived memory

	Model 1		Model 2		Model 3	
Parameter	EST	SE	EST	SE	EST	SE
Complexity	0.003 *	−.001	0.004 *	0.001	0.004 *	0.001
Psychological Demands						
Pace	−0.001	0.001	−0.002	0.002	−0.001	0.002
Conflict	0.001	−0.002	0.001	0.002	0.001	0.002
Interaction terms						
Complexity*Pace			−0.001	0.001		
Complexity*Conflict			0.001 **	0.001	0.001 **	0.001
Physical Hazards					−0.002	0.002
Controls						
Age	0.01 ***	0.002	0.01 ***	0.002	0.01 ***	0.002
Gender (male)	0.01	0.04	0.02	0.04	0.02	0.04
Education	0.03 ***	0.01	0.03 **	0.01	0.023 **	0.01
Ill Health	−0.31 ***	0.03	−0.31 ***	0.03	−0.31 ***	0.03
Intercept	3.78 ***	0.09	3.80	0.09	3.81	0.09

+ p<.10,

* p<.05,

** p<.01,

*** p<.001