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Longitudinal Associations of Job Demand-Control Characteristics With Objective and Subjective Cognitive Outcomes in Older Workers: The Health and Retirement Study

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Keywords: cognition | job demand-control | older workers | psychosocial work | subjective memory

ABSTRACT

Background: The job demand-control (JDC) psychosocial work model has demonstrated effects on objective cognitive performance, but its association with subjective memory is still poorly understood. We examined longitudinal associations of JDC characteristics with objective (general cognitive function/episodic memory) and subjective (perceived memory) cognition.

Methods: Using the Health and Retirement Study (HRS) data, 3497 workers aged 50+ were followed from 2006–2008 to 2018. Self-reported job demand and job control were dichotomized and later combined into quadrants reflecting high/low job strain and active/passive jobs. Analyses used covariate-adjusted generalized estimating equations.

Results: High job control was significantly positively associated with general cognitive function (regression coefficient: 0.409, $p < 0.001$), episodic memory (0.373, $p < 0.001$), and subjective memory (0.057, $p = 0.034$). "Low demand and high control" (low strain work) exhibited significant, positive associations with all cognitive outcomes. "High demand and high control" (active work) was significantly positively associated with objective cognitive outcomes.

Conclusions: Opportunities for enhancing job control may promote objective cognition and subjective memory health in the US aging workforce.

Institution at which the work was performed: University of California, Los Angeles.

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1 | Introduction

By 2033, the proportion of the United States (US) workers aged 55 and older is expected to represent almost one-quarter of the US labor force [1]. Therefore, understanding potential influences of work on cognitive performance and perceptions of memory abilities may contribute to optimized workplaces and cognitive health for this aging population. "Older workers," defined as individuals aged 50 years and older [2, 3], may have more occupational risks than younger workers [2]. Simultaneously, in older age, different aspects of cognition may decline, improve, or stabilize [4]. US older adults have expressed worry about abnormal cognitive decline and the risk of dementia diagnosis, with its symptoms often reducing independence and the overall quality of life [5]. Perceived cognitive decline, which in 2015–2020 has been reported by about 10% of US adults of age 45 and older [6], has been associated with elevated risks of mild cognitive impairment and dementia [7, 8]. Subjective memory complaints in particular have been related to Alzheimer's disease biomarkers [9] and objective memory decline [10].

Alzheimer's disease, the predominant cause of dementia, has been ranked among the leading causes of death in the United States [11, 12]. The most current report on dementia risk factors acknowledges that higher occupational cognitive stimulation has been associated with lower dementia risk [13, 14]. Yet, in this report, the identified modifiable risk factors for dementia in midlife and older age do not include work-related factors [13], prompting further inquiry into the relationship of work and cognitive outcomes.

Cognitive stimulation at work may be operationalized through the job demand-control (JDC) psychosocial work model, which defines the work environment through two components—job demand and job control [14, 15]. Job demand involves workload, work conflicts, and work task-related stressors, and job control includes decision authority and skill discretion [15]. Combining both elements depicts workers' experiences across "low demand and low control" as "passive" work, "high demand and low control" as "high strain," "low demand and high control" as "low strain," and "high demand and high control" as "active" work [15].

Many studies have explored the association between JDC psychosocial work factors and objective cognition, but fewer with subjective cognition. For perceived cognition, findings from one cross-sectional study of US workers suggest that high job control may be related to better subjective memory, although this result was based on the study's conceptual relation of decision-making occupational complexity with job control [16]. Among European workers, independent high job demand has been associated with worse subjective memory and perceived cognition [17, 18]. Objective cognition research suggests that high job control independently and in combination with high job demand (active work) has been associated with positive cognitive outcomes, including slowed cognitive decline [19–23], while work conditions with low job control—high strain and passive work—have been associated with poor cognitive performance [24, 25] and accelerated cognitive decline [20]. However, both independent and joint combinations, as theoretically outlined in the JDC model [15], have not been further evaluated against subjective memory among US worker populations.

Aligning with a life-course approach [13] that takes into consideration a wide spectrum of factors including demographic, socioeconomic, lifestyle, health, and work variables, this study aimed to evaluate longitudinal associations of self-reported independent and joint JDC categorizations with changes in objective general cognitive function and episodic memory and in subjective memory among US older workers. We hypothesized positive associations of high levels of job demand and job control, along with their combinations, with changes in cognitive outcomes.

2 | Methods

2.1 | Study Sample

The Health and Retirement Study (HRS) is a national, population-based longitudinal study of community-dwelling US adults aged 51 and older and their spouses or partners (regardless of age) within a household, conducted since 1992 every 2 years [26]. We used publicly available HRS data from the University of Michigan Institute for Social Research, including data sets that were prepared by the RAND Center for the Study of Aging.

The HRS is sponsored by the National Institute on Aging (Grant Numbers NIA U01AG009740 and NIA R01AG073289) and is coordinated by the Institute for Social Research at the University of Michigan [27, 28]. The University of California, Los Angeles Institutional Review Board determined this analytic research as exempt from review. This study was conducted in accordance with the Declaration of Helsinki and followed the STROBE cohort guidelines [29].

Data for JDC were available in limited waves of the Psychosocial and Lifestyle Self-Administered or "Leave-Behind" Questionnaire (LBQ), which in 2006 was assigned to a random half of the main sample, and then in 2008, to the remaining sample half [30]. This study combined the two sample halves in 2006 and 2008 to form the baseline sample for complete psychosocial data [31].

Objective cognition measures of general cognitive function and episodic memory, along with subjective memory, were measured in the main HRS survey that was administered to all participants every 2 years [32]. In this study, cognitive outcome data were organized to correspond to the timing of when participants provided baseline JDC data (baseline: 2006–2008, follow-up 1: 2008–2010, follow-up 2: 2010–2012, follow-up 3: 2012–2014, follow-up 4: 2014–2016, follow-up 5: 2016–2018, follow-up 6: 2018). Therefore, this study relied on up to six waves and up to 12 years of follow-up. Previous studies have similarly accounted for combined sample halves based on the psychosocial questionnaire and subsequent follow-up data from the biennial main HRS survey waves [33, 34].

Participants were included in this study if they: (1) were working and working for part-time or full-time pay in HRS 2006–2008, (2) were aged 50 and older, (3) had complete data at baseline for JDC, covariates, and objective and subjective cognitive outcomes, and (4) had at least one follow-up of objective

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and subjective cognitive data. Participants were excluded if they: (1) were not working at baseline, (2) were younger than 50 years of age, (3) had missing data at baseline for the variables of interest, (4) self-reported physician diagnosis of memory-related disorder or were identified as cognitively impaired-no dementia or dementia according to Langa-Weir classifications of baseline cognitive function scores [35] at baseline, or (5) did not have any follow-up cognitive data after baseline.

In HRS 2006–2008 overall, 19,193 individuals provided core survey interviews [36]. A total of 7480 participants were working for pay, including business ownership and second job paid work. Of the 7480, 4395 had complete data on JDC at baseline, as the LBQ was assigned to alternating halves of the 2006 and 2008 samples. Of these, 3934 participants were part-time or full-time workers aged 50 and older with complete baseline covariate data. Regarding cognitive data at baseline, 3606 had complete objective and subjective data and denied having memory-related disease or were classified as cognitively normal. An additional 109 had no cognitive follow-up data. Therefore, the final analytic sample was 3497 workers that had complete baseline data and at least one follow-up of objective and subjective cognitive variables (Figure 1).

2.2 | Measures

2.2.1 | Job Demand-Control

The psychosocial JDC exposure was derived from a validated version [37] of the original Job Content Questionnaire [38]. Three items on time pressure, fast work pace, and conflicting demands represented psychological job demand, while three items on decision-making freedom, skill development, and situational control represented job control [31, 37]. These items had four response options based on statement agreement, ranging from 1 as *strongly disagree* to 4 as *strongly agree*. Items were reverse-coded as needed and summed so that higher scores indicated higher job demand and job control for their respective scales. Job demand and job control scales were then dichotomized according to the median (job demand = 7; job control = 9) to form high and low conditions for job demand and job control, referred to as “independent” JDC groups. “Joint” JDC groups were formed as the following combinations: (1) “high demand and high control” or active work; (2) “low demand and high control” or low strain; (3) “high demand and low control” or high strain; and (4) “low demand and low

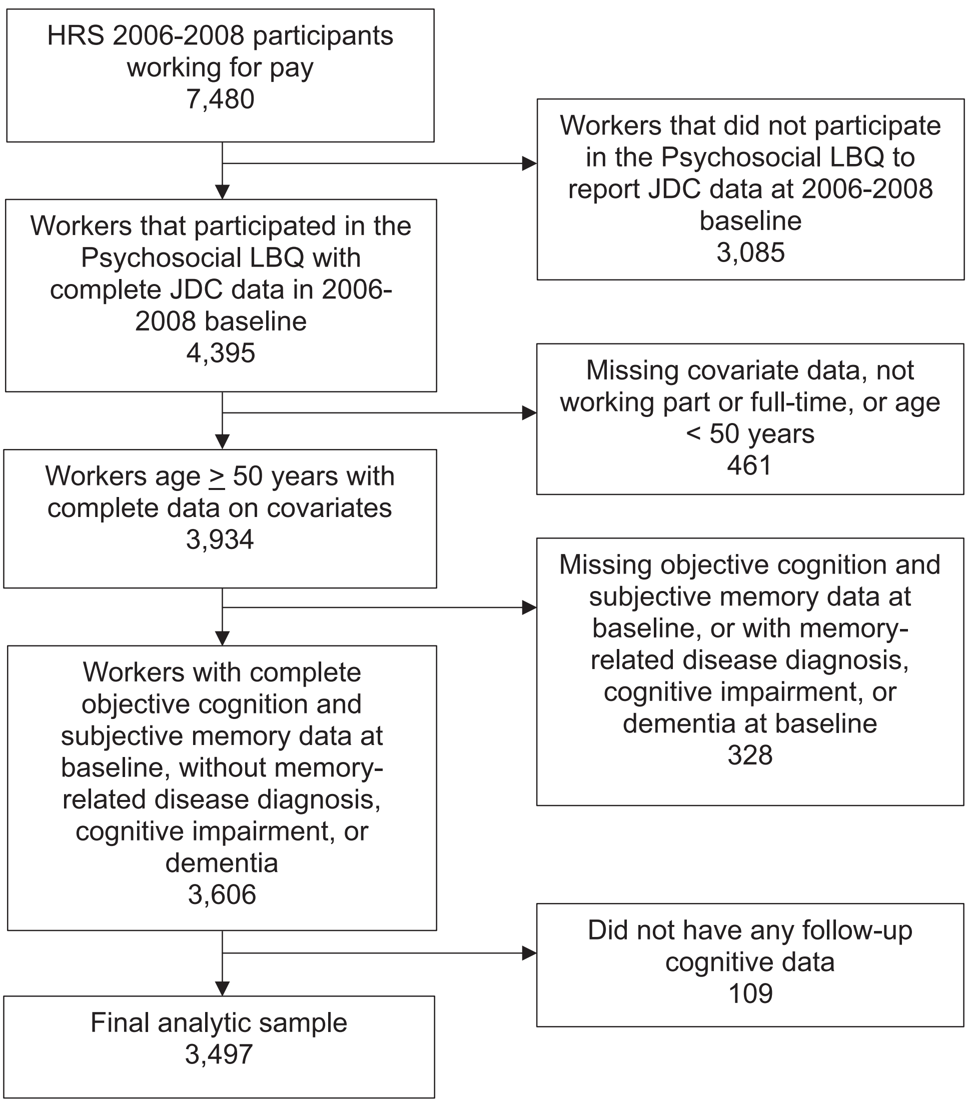

FIGURE 1 | Sample flowchart of HRS 2006–2008.

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control" or passive work. Cronbach's α values were 0.59 for job demand and 0.62 for job control.

2.2.2 | Objective Cognition: General Cognitive Function and Episodic Memory

Two measures of objective cognition, general cognitive function and episodic memory summary scores, were taken from the HRS version of the 27-point modified Telephone Interview for Cognitive Status (TICSm) [39–41]. This HRS TICSm battery of cognitive tests was administered in the main HRS survey every 2 years to all participants regardless of age [32]. The cognitive tests were (1) immediate and (2) delayed word recall lists to measure objective memory function and memory delay; (3) serial 7's test to assess working memory, and (4) backwards count to evaluate processing speed and attention [32, 42]. General cognitive function was operationalized as the total score of these cognitive tests (range: 0–27), while episodic memory performance was isolated from the word recall list scores (range: 0–20), with higher scores indicating better cognitive performance [32]. Previous studies have used these cognitive function [43] and episodic memory [44] measures across HRS 2006–2018 survey waves. The HRS TICSm has previously demonstrated validity [41, 45] and reliability [46].

2.2.3 | Subjective Memory

For subjective memory, participants were evaluated on their self-rating of current memory with the inquiry, "How would you rate your memory at the present time?", "Would you say it is excellent, very good, good, fair, or poor?", which had response options on a scale of 1–5 [32]. The response was reverse-scored so that higher scores indicate better subjective memory at "present-time" [47]. This single item was used to measure subjective memory in studies using the HRS and international population-based data sets of older adults [47–49]. Additional supplementary analyses were conducted on two alternate measures for subjective memory. The first assessed self-report of changes in memory in comparison to the previous 2 years, with the prompt, "Compared to 2 years ago, would you say your memory is better now, about the same, or worse now than it was then?" [32]. The other supplementary measure was a subjective memory summary score, which consisted of the primary "present-time" subjective memory outcome, and the supplementary "2-year comparison" subjective memory outcome. To create the subjective memory summary score, first, these two items were reverse scored [47] and the "2-year comparison" variable was rescaled via linear transformation before summing these items for an overall subjective memory summary score [50].

2.2.4 | Covariates

Covariates, which were demographic, socioeconomic, lifestyle, health, and psychosocial work at baseline, as well as time-varying employment status, were chosen for their relation to cognitive outcomes [13, 51–59]. Demographic data were age in years, sex (male, female), marital status as (1) "married," (2) "never married," and (3) "other" for separate or divorced, widowed, or unknown; and race as (1) "White or Caucasian," (2) "Black or African American," and (3) "Other." Socioeconomic factors were educational attainment, categorized as (1) "university or more" for participants with 4-year college, Master's, or professional degrees; (2) "some college" for 2-year college or some college; and (3) "high school or less" for high school diploma or equivalent, or none. In US dollars (USD), household income brackets were (1) over US $99,999; (2) 45,000–99,999; and (3) < 45,000.

Lifestyle factors included smoking status, which was based on current status (yes/no) [60] and alcohol consumption was dichotomized as "heavy" or "none or moderate" based on sex and daily frequency [61]. To represent leisure-time physical activity or physical exercise, items evaluated the frequency of moderate or vigorous physical activity and were divided into (1) "high"—more than once a week, (2) "moderate"—once a week or one to three times per month, and (3) "low"—hardly ever or never. A continuous composite variable of nonwork-related perceived social support from spouse or partner, living children, other immediate family members, and friends was derived from four corresponding scales composed of three response items each [30]. All scales were reverse scored so that higher scores represented higher social support, and within each scale, items were averaged. Then the composite social support score was calculated by averaging the available scales [62].

For health conditions, cardiovascular disease (yes/no) was obtained from self-reported myocardial infarction, stroke, or heart condition [63]. Symptoms indicative of depression were measured using scores from the eight-item short version of the Center for Epidemiologic Studies Depression Scale (CESD) [64, 65] and then dichotomized according to a cutoff score of 4 to indicate participants with clinically significant depression symptoms [65, 66].

The psychosocial work factor of reward, a component from another established and validated psychosocial work model, effort–reward imbalance (ERI) [67] was included in this study for its relation to positive cognitive outcomes [68, 69]. ERI is based on the concepts of social exchange and reciprocity between effort and reward at work [67]. In this study, responses to five items on salary adequacy, work recognition, job promotion, job security, and job support [70, 71] were summed for the variable of reward. Previous HRS publications have used these ERI measures [70, 71].

The time-varying covariate of categorical employment status accounted for information changes during the course of follow-ups, if available. Employment status was determined biennially using accumulated self-report data on items including current job status, working for pay, working time, and job searching. In this analysis, employment status categories were (1) "full-time employment" for participants working full-time; (2) "part-time employment" for those working part-time and those partly retired; and (3) "leaving full-time employment" for those that were unemployed, retired, disabled, or not in the labor force [72].

2.3 | Statistical Analysis

Descriptive statistics for frequencies, means, and standard deviations represented the corresponding categorical and continuous baseline characteristics of the study sample. To assess

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for selection bias, comparative analyses of the baseline characteristics between the study sample ($n = 3497$) and those that had no cognitive follow-up data ($n = 109$) utilized χ^2 and Fisher's exact tests for categorical variables and t-tests for continuous variables. Additional supplemental analyses compared the study sample ($n = 3497$) with the subgroup of participants that did not provide baseline nor follow-up cognitive data, or had memory-related disease, cognitive impairment, or dementia at baseline ($n = 437$).

Generalized estimating equations (GEE) [73] were used to analyze the longitudinal associations of JDC at baseline with changes in objective cognition and subjective memory outcomes across baseline and follow-up(s). GEE particularly accommodates the within-person repeated measures of objective cognition and subjective memory taken at baseline and follow-ups via an exchangeable working correlation structure, as well as accounting for missing survey wave data and providing population estimates [73, 74]. In GEE, the correlations of the repeated objective and subjective cognitive outcome measures were adjusted using sandwich estimators. GEE analysis evaluated independent and joint JDC with objective general cognitive function, objective episodic memory, and subjective memory. The analysis produced regression coefficients, 95% confidence intervals, and p values. Positive regression coefficients represented positive change, while negative regression coefficients indicated negative change. Reference groups were "low demand" and "low control" for independent JDC, and "low demand and low control" for joint JDC. Covariates were systematically added in multistep multivariable models. Model 0 had mutual adjustment of job demand and control at baseline in the analyses of independent JDC. Models I through VI additionally adjusted for the following covariates at baseline: Model I additionally adjusted for age. Model II additionally adjusted for sex, marital status, and race. Model III additionally adjusted for education and income. Model IV additionally adjusted for smoking, alcohol consumption, physical exercise, and social support. Model V additionally adjusted for cardiovascular disease and depression. Model VI additionally adjusted for reward. Lastly, Model VII additionally adjusted for time-varying employment status variable. All analyses were conducted using SAS Analytics Software Version 9.4 (SAS Institute, Cary, NC, USA).

3 | Results

Table 1 summarizes characteristics of the study sample of 3497 workers, with comparison to participants that lacked cognitive data follow-up ($n = 109$). There were no significant differences in characteristics between these two groups. At 2006–2008 baseline, 3497 participants were predominantly aged 50–64 years (70.80%), with a mean age of 61.03 years (SD = 6.88). Over half of the sample (54.70%) were female participants, 72.75% were married, 84.70% were White, 59.85% had up to a high school level of education, and 38.80% earned 45,000–99,999 USD. For lifestyle characteristics, 86.13% did not currently smoke, 96.54% abstained from alcohol or had up to moderate alcohol consumption, 57.33% were highly physically active, and had a mean social support score of 3.15 (SD = 0.51, range: 1–4). Most did not have cardiovascular disease (84.56%) or depression (91.42%). At baseline, 67.29% worked full-time employment. Baseline scores averaged at 17.64 (SD = 3.04, range: 12–27) for general cognitive function, 11.55 (SD = 2.63, range: 5–20) for episodic memory, and 3.28 (SD = 0.87, range: 1–5) for subjective memory at the present time. Table SI shows the comparison of the main sample with participants lost to follow-up due to cognitive data missingness or cognitive impairment ($n = 437$). These two groups significantly differed in baseline characteristics, except for alcohol consumption, cardiovascular disease, employment status, social support, reward, and job control. Otherwise, those lost to follow-up had higher proportions of participants that were older, male, not currently married, and Black or other race. Also, more participants had high school or less educational attainment, income < 45,000 USD, were currently smoking, had lower exercise levels, and had depressive symptoms, but had lower mean job demand compared to the main sample.

In Table SII, alternate subjective memory means were 2.70 (SD = 0.83, range: 1–5) for perceived 2-year comparison, and 5.98 (SD = 1.39, range: 2–10) for the summary score. For all cognitive outcomes across all survey waves, sample sizes (which ranged from 1383 to 3497), means, standard deviations, and ranges are contained in Tables SIII–SVII. Across survey waves, objective and subjective cognitive scores were significantly correlated (all: $p < 0.001$; Tables SVIII–SXII; Pearson's correlation coefficient ranges: 0.43–0.61 for general cognitive function, 0.38–0.54 for episodic memory, 0.51–0.66 for present subjective memory; alternate subjective memory measures: 0.23–0.40 for 2-year comparison, 0.40–0.58 for summary). Over one-third of the sample participated in all survey waves ($n = 1319$; Table SXIII).

Table 2 details the JDC psychosocial work characteristics at baseline. High and low groups of job demand and job control were roughly halved, with the majority of participants categorized as high job demand (54.90%) and low job control (58.59%). For joint JDC combinations, more participants had "high demand and low control" or high strain work (38.63%), followed by one-quarter of participants with "low demand and high control" or low-strain work (25.14%).

Tables 3–5 contain the results from the GEE analysis of JDC with cognitive outcomes. Table 3 displays findings for the associations of independent and joint JDC with changes in general cognitive function scores. In fully adjusted results, compared to low job control, high job control was associated with positive change in general cognitive function (Model VII: regression coefficient: 0.409 [95% CI 0.216, 0.603], $p < 0.001$). Compared to the combination of "low demand and low control" (passive), both "low demand and high control" (low strain; Model VII: 0.324 [0.065, 0.583], $p = 0.014$) and "high demand and high control" (active; Model VII: 0.504 [0.225, 0.782] $p = < 0.001$) were associated with increased general cognitive function.

Results for independent and joint JDC associations with objective episodic memory are contained in Table 4. Like the general cognitive function findings, high job control (Model VII: 0.373 [0.214, 0.532], $p < 0.001$), "low demand and high control" (low strain; Model VII: 0.323 [0.109, 0.537], $p = 0.003$) and "high demand and high control" (active; Model VII: 0.504

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TABLE 1 | Characteristics of study sample ($n = 3497$), and comparison with participants lost to follow-up ($n = 109$) at 2006–2008 baseline.

Covariate variables	Study sample ($n = 3497$)		Participants lost to follow-up ($n = 109$)		
	n	%	n	%	p
Age group					0.979
50–64	2476	70.80	78	71.56	
65–74	864	24.71	26	23.85	
75 and up	157	4.49	5	4.59	
Sex					0.944
Male	1584	45.30	49	44.95	
Female	1913	54.70	60	55.05	
Marital status					0.638
Married	2544	72.75	78	71.56	
Never married	105	3.00	5	4.59	
Other	848	24.25	26	23.85	
Race					0.837
White	2962	84.70	93	85.32	
Black	339	9.69	9	8.26	
Other	196	5.60	7	6.42	
Education					0.751
High school or less	2093	59.85	68	62.29	
Some college	260	7.43	9	8.26	
University or more	1144	32.71	32	29.36	
Income (USD)					0.560
> 99,999	1089	31.14	38	34.86	
45,000–99,999	1357	38.80	37	33.94	
< 45,000	1051	30.05	34	31.19	
Smoking					0.185
Yes current	485	13.87	20	18.35	
No	3012	86.13	89	81.65	
Alcohol					0.790[a]
None/moderate	3376	96.54	105	96.33	
Heavy	121	3.46	4	3.67	
Exercise					0.947
High	2005	57.33	62	56.88	
Moderate	412	11.78	12	11.01	
Low	1080	30.88	35	32.11	
Cardiovascular disease					0.965
No	2957	84.56	92	84.40	
Yes	540	15.44	17	15.60	
Depression					0.649
No	3197	91.42	101	92.66	
Yes	300	8.58	8	7.34	

(Continues)

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TABLE 1 | (Continued)

Covariate variables	Study sample ($n = 3497$) n	%	Participants lost to follow-up ($n = 109$) n	%	p
Employment status					0.462
Full-time	2353	67.29	77	70.64	
Part-time (part-time/partly retired)	1144	32.71	32	29.36	

Covariate variables	Range (main sample)	Mean	SD	Mean	SD	p
Age	50–87	61.03	6.88	61.49	7.12	0.497
Social support	1–4	3.15	0.51	3.11	0.53	0.487
Reward	5–20	14.32	2.76	14.67	2.75	0.196
Psychosocial work variables						
Job demand	3–12	6.83	1.89	6.48	2.10	0.053
Job control	3–12	9.25	1.70	9.51	1.77	0.113
Cognitive variables						
Total general cognitive function score	12–27	17.64	3.04	17.21	2.75	0.150
Total episodic memory score	5–20	11.55	2.63	11.09	2.47	0.073
Subjective memory—present-time	1–5	3.28	0.87	3.28	0.94	0.911

Note: χ^2 test for categorical variables, *t*-test with assumed equal variances for continuous variables.
[a]Fisher's exact test.

TABLE 2 | Psychosocial work characteristics at HRS 2006–2008, $n = 3497$.

	n	%
Independent demand and control		
Job demand		
Low	1577	45.10
High	1920	54.90
Job control		
Low	2049	58.59
High	1448	41.41
Joint demand and control		
Low demand + low control (passive)	698	19.96
High demand + low control (high strain)	1351	38.63
Low demand + high control (low strain)	879	25.14
High demand + high control (active)	569	16.27

[0.275, 0.733] $p < 0.001$) were each associated with increased episodic memory after all covariate adjustments.

For subjective memory (Table 5), high job control was associated with increased present-time subjective memory scores in the fully adjusted model (Model VII: 0.057 [0.004, 0.109], $p = 0.034$). The joint JDC category of "low demand and high control" (low strain) was also significantly associated with improved present-time subjective memory perceptions (Model VII: 0.096 [0.026, 0.167], $p = 0.008$). Results with the alternate subjective memory outcomes were not significant after all covariate adjustments (Tables SXIV and SXV).

4 | Discussion

In this study of a US older adult worker cohort spanning up to 12 years of follow-up psychosocial work characteristics from the JDC model measured at baseline were longitudinally associated with positive changes in both objective cognition and subjective memory outcomes even after accounting for demographic, socioeconomic, lifestyle, health, and work factors. Particularly, high job control was associated with increased objectively measured general cognitive function and episodic memory, and subjective memory, underscoring the potentially crucial role of facilitating decision-making opportunities and skill development at the workplace whenever possible to help promote cognitive functioning in the aging US workforce.

This study emphasizes job control as a particularly pertinent component of work, especially with new knowledge of impacts on subjective cognition, together with cognitive performance both concurrently and over time. These results parallel similar findings with perceived control and cognition in older adulthood. General control and objective episodic memory have been positively associated [75], lower degrees of perceived control in life predicted poorer self-perceptions of aging [76], and cognitive control, the perception of one's control over cognitive decline, was reciprocally and positively associated with cognitive function [77]. The sense of control may instigate adaptation among older adults, promoting positive cognitive outcomes [77, 78]. Individuals exercising high control through tasks, skills, and situations in the workplace may permit workers to better adapt to cognitive challenges as age progresses.

For objective cognition, high job control and both JDC combinations with high job control, low strain and active work, were positively associated with general cognitive function and episodic memory, which is consistent with findings from other

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TABLE 3 | Independent and joint associations of demand and control at baseline with changes in objective general cognitive function scores between baseline and follow-ups (beta coefficient and 95% CI), $n = 3497$.

	Objective general cognitive function scores (HRS TICSm 27-point)															
	Model 0		Model I		Model II		Model III		Model IV		Model V		Model VI		Model VII	
JDC group	**Coeff. (95% CIs)**	***p***	**Coeff. (95% CIs)**	***p***	**Coeff. (95% CIs)**	***p***	**Coeff. (95% CIs)**	***p***	**Coeff. (95% CIs)**	***p***	**Coeff. (95% CIs)**	***p***	**Coeff. (95% CIs)**	***p***	**Coeff. (95% CIs)**	***p***
Low demand	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
High demand	0.607 (0.413, 0.801)	< 0.001	0.221 (0.030, 0.411)	0.023	0.197 (0.014, 0.381)	0.035	0.057 (−0.116, 0.230)	0.518	0.064 (−0.109, 0.237)	0.467	0.082 (−0.091, 0.255)	0.353	0.071 (−0.104, 0.246)	0.426	0.084 (−0.092, 0.259)	0.350
Low control	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
High control	0.761 (0.566, 0.956)	< 0.001	0.785 (0.599, 0.971)	< 0.001	0.732 (0.553, 0.912)	< 0.001	0.399 (0.229, 0.570)	< 0.001	0.373 (0.200, 0.546)	< 0.001	0.366 (0.194, 0.538)	< 0.001	0.418 (0.224, 0.612)	< 0.001	0.409 (0.216, 0.603)	< 0.001
Low demand + low control	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
High demand + low control	0.437 (0.178, 0.697)	0.001	0.061 (−0.189, 0.311)	0.635	0.053 (−0.187 0.293)	0.666	−0.032 (−0.257, 0.193)	0.781	−0.022 (−0.247, 0.203)	0.849	0.007 (−0.218, 0.233)	0.949	−0.003 (−0.230, 0.225)	0.983	0.011 (−0.216, 0.239)	0.922
Low demand + high control	0.561 (0.282, 0.841)	< 0.001	0.595 (0.331, 0.859)	< 0.001	0.561 (0.305, 0.818)	< 0.001	0.295 (0.052, 0.537)	0.017	0.272 (0.028, 0.515)	0.029	0.278 (0.035, 0.522)	0.025	0.331 (0.071, 0.591)	0.013	0.324 (0.065, 0.583)	0.014
High demand + high control	1.393 (1.085, 1.702)	< 0.001	1.029 (0.732, 1.327)	< 0.001	0.951 (0.665, 1.236)	< 0.001	0.471 (0.200, 0.742)	0.001	0.451 (0.180, 0.722)	0.001	0.460 (0.189, 0.731)	0.001	0.500 (0.222, 0.778)	< 0.001	0.504 (0.225, 0.782)	< 0.001

Note: Generalized estimating equations (GEE) linear regression with beta coefficients (coeff.) and 95% confidence intervals (CIs). "Low demand + low control" = passive; "high demand + low control" = high strain; "low demand + high control" = low strain; "high demand + high control" = active. Model 0: mutual adjustment for demand and control at baseline. Model I: Model 0 + additional adjustment for age (years) at baseline. Model II: Model I + additional adjustment for sex, marital status, and race at baseline. Model III: Model II + additional adjustment for educational attainment and annual household income at baseline. Model IV: Model III + additional adjustment for smoking, alcohol consumption, physical exercise, and social support at baseline. Model V: Model IV + additional adjustment for cardiovascular disease and depression at baseline. Model VI: Model V + additional adjustment for reward at baseline. Model VII: Model VI + additional adjustment for employment at baseline and across follow-ups.

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TABLE 4 | Independent and joint associations of demand and control at baseline with changes in objective episodic memory scores between baseline and follow-ups (beta coefficient and 95% CI), $n = 3497$.

	Objective episodic memory scores (word recall lists)															
	Model 0		Model I		Model II		Model III		Model IV		Model V		Model VI		Model VII	
JDC group	Coeff. (95% CIs)	*p*	Coeff. (95% CIs)	*p*	Coeff. (95% CIs)	*p*	Coeff. (95% CIs)	*p*	Coeff. (95% CIs)	*p*	Coeff. (95% CIs)	*p*	Coeff. (95% CIs)	*p*	Coeff. (95% CIs)	*p*
Low demand	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
High demand	0.534 (0.375, 0.693)	< 0.001	0.197 (0.042, 0.351)	0.013	0.208 (0.060, 0.357)	0.006	0.109 (−0.033, 0.251)	0.132	0.115 (−0.027, 0.257)	0.112	0.126 (−0.016, 0.268)	0.082	0.117 (−0.026, 0.260)	0.110	0.124 (−0.019, 0.268)	0.090
Low control	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
High control	0.593 (0.433, 0.753)	< 0.001	0.613 (0.461, 0.764)	< 0.001	0.602 (0.455, 0.748)	< 0.001	0.367 (0.223, 0.508)	< 0.001	0.341 (0.199, 0.484)	< 0.001	0.337 (0.195, 0.479)	< 0.001	0.381 (0.222, 0.540)	< 0.001	0.373 (0.214, 0.532)	< 0.001
Low demand + low control	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
High demand + low control	0.422 (0.210, 0.635)	< 0.001	0.094 (−0.109, 0.296)	0.365	0.115 (−0.078, 0.307)	0.244	0.055 (−0.128, 0.238)	0.558	0.062 (−0.122 0.245)	0.509	0.080 (−0.103, 0.264)	0.392	0.073 (−0.112, 0.258)	0.439	0.082 (−0.103, 0.267)	0.386
Low demand + high control	0.461 (0.231, 0.692)	< 0.001	0.491 (0.276 0.705)	< 0.001	0.491 (0.282, 0.699)	< 0.001	0.303 (0.104, 0.503)	0.003	0.279 (0.079, 0.480)	0.006	0.284 (0.084, 0.484)	0.006	0.329 (0.114, 0.543)	0.003	0.323 (0.109, 0.537)	0.003
High demand + high control	1.143 (0.889, 1.396)	< 0.001	0.825 (0.581, 1.068)	< 0.001	0.824 (0.590, 1.057)	< 0.001	0.484 (0.260, 0.708)	< 0.001	0.465 (0.241, 0.688)	< 0.001	0.470 (0.247, 0.694)	< 0.001	0.504 (0.275, 0.733)	< 0.001	0.504 (0.275, 0.733)	< 0.001

Note: Generalized estimating equations (GEE) linear regression with beta coefficients (coeff.) and 95% confidence intervals (CIs). "Low demand + low control" = passive; "high demand + low control" = high strain; "low demand + high control" = low strain; "high demand + high control" = active. Model 0: mutual adjustment for demand and control at baseline. Model I: Model 0 + additional adjustment for age (years) at baseline. Model II: Model I + additional adjustment for sex, marital status, and race at baseline. Model III: Model II + additional adjustment for educational attainment and annual household income at baseline. Model IV: Model III + additional adjustment for smoking, alcohol consumption, physical exercise, and social support at baseline. Model V: Model IV + additional adjustment for cardiovascular disease and depression at baseline. Model VI: Model V + additional adjustment for reward at baseline. Model VII: Model VI + additional adjustment for employment at baseline and across follow-ups.

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TABLE 5 | Independent and joint associations of demand and control at baseline with changes in subjective memory present-time scores between baseline and follow-ups (beta coefficient and 95% CI), $n = 3497$.

	Subjective memory—present-time															
	Model 0		Model I		Model II		Model III		Model IV		Model V		Model VI		Model VII	
JDC groups	Coeff. (95% CIs)	p	Coeff. (95% CIs)	p	Coeff. (95% CIs)	p	Coeff. (95% CIs)	p	Coeff. (95% CIs)	p	Coeff. (95% CIs)	p	Coeff. (95% CIs)	p	Coeff. (95% CIs)	p
Low demand	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
High demand	0.060 (0.012, 0.108)	0.015	0.027 (−0.021, 0.076)	0.274	0.022 (−0.026, 0.071)	0.364	−0.001 (−0.049, 0.046)	0.956	0.004 (−0.044, 0.051)	0.879	0.013 (−0.034, 0.060)	0.589	0.027 (−0.021, 0.074)	0.268	0.024 (−0.024, 0.071)	0.325
Low control	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
High control	0.193 (0.145, 0.242)	< 0.001	0.195 (0.147, 0.244)	< 0.001	0.189 (0.141, 0.237)	< 0.001	0.131 (0.083, 0.178)	< 0.001	0.113 (0.065, 0.161)	< 0.001	0.110 (0.063, 0.158)	< 0.001	0.059 (0.006, 0.111)	0.028	0.057 (0.004, 0.109)	0.034
Low demand + low control	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
High demand + low control	0.073 (0.010, 0.137)	0.024	0.041 (−0.023, 0.105)	0.206	0.038 (−0.026, 0.101)	0.246	0.024 (−0.039 0.087)	0.453	0.030 (−0.032, 0.092)	0.345	0.044 (−0.018, 0.106)	0.161	0.059 (−0.003, 0.121)	0.062	0.057 (−0.005, 0.119)	0.072
Low demand + high control	0.210 (0.140, 0.278)	< 0.001	0.212 (0.143, 0.281)	< 0.001	0.207 (0.139, 0.276)	< 0.001	0.160 (0.093, 0.228)	< 0.001	0.144 (0.077, 0.212)	< 0.001	0.147 (0.080, 0.214)	< 0.001	0.097 (0.027, 0.168)	0.007	0.096 (0.026, 0.167)	0.008
High demand + high control	0.251 (0.174, 0.328)	< 0.001	0.220 (0.143, 0.297)	< 0.001	0.209 (0.132, 0.286)	< 0.001	0.125 (0.048, 0.202)	0.001	0.113 (0.037, 0.189)	0.004	0.118 (0.043, 0.194)	0.002	0.081 (0.004, 0.158)	0.039	0.076 (−0.001, 0.152)	0.054

Note: Generalized estimating equations (GEE) linear regression with beta coefficients (coeff.) and 95% confidence intervals (CIs). "Low demand + low control" = passive; "high demand + low control" = high strain; "low demand + high control" = low strain; "high demand + high control" = active. Model 0: mutual adjustment for demand and control at baseline. Model I: Model 0 + additional adjustment for age (years) at baseline. Model II: Model I + additional adjustment for sex, marital status, and race at baseline. Model III: Model II + additional adjustment for educational attainment and annual household income at baseline. Model IV: Model III + additional adjustment for smoking, alcohol consumption, physical exercise, and social support at baseline. Model V: Model IV + additional adjustment for cardiovascular disease and depression at baseline. Model VI: Model V + additional adjustment for reward at baseline. Model VII: Model VI + additional adjustment for employment at baseline and across follow-ups.

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worker populations [79–85]. Outside of the United States, high job control has been associated with better cognitive performance [79, 80] and slower cognitive decline [81]. Likewise, active work has been associated with increased cognition [82–84], slower decline [81], and lower odds of cognitive impairment [82, 85]. Low strain has been associated with decreased memory [84] and more rapid cognitive decline [81], but longer duration of low-strain work has also been associated with increased cognition and slower memory decline [84]. Overall, this study's findings are consistent with global evidence, and suggest a positive cognitive benefit of high job control, active work, and low-strain work.

Two previous studies also used the HRS to examine JDC, operationalized through a job exposure matrix (JEM) approach, with general cognitive function among adults 65 and older [86] and episodic memory [23]. Low job control and high strain were associated with decreased episodic memory [23], and for cognitive function, high strain and passive work were associated with decreased performance, while low strain and active work were associated with better performance [86]. This current study's use of JDC based on individual assessment complements the previous research with JEM measures, and contributes additional evidence on high job control, active work, and low-strain work in relation to positive cognitive outcomes, including new insights into subjective memory.

This study provides longitudinal evidence linking validated self-reported JDC exposures—specifically high job control and low-strain work—with changes in currently perceived subjective memory. It also expands upon a prior cross-sectional study of US midlife adults, which reported on an association between greater occupational complexity, a measure that was framed as a version of job control, and better subjective memory [16]. However, a challenge in studying subjective memory involves the greater heterogeneity of measures than is common for objective measures of memory [87], as previous studies evaluating psychosocial work differed in their subjective memory and cognition measures [16–18]. For this study inquiry, we introduce the use of a present-time subjective memory single item, which has been previously applied in population-based US and European cohorts [47]. The null associations of the alternate subjective memory measures in the supplementary analyses may reflect the influence of differences in time perspectives, as the primary subjective memory variable focused on assessment at the current time, while the alternate measures involved evaluation of both past and present [88]. Future research may consider a more nuanced or detailed approach to measuring subjective memory, such as testing other dimensions and multi-item instruments, to improve understanding of subjective memory among worker samples.

Notably, job demand by itself did not have significant associations with any of the cognitive outcomes, but its joint involvement with job control in the combinations of active work and low-strain work demonstrated associations with better cognitive outcomes. The fact that active work includes high demands and low-strain work includes low demands further underscores the notion that job demand does not affect cognitive outcomes as much as job control does. Some previous US and European research into the link between job demand and objective cognitive function have likewise yielded null associations [16, 23, 82, 89, 90], but other studies in Europe and North America suggest that high job demand and cognition may be positively associated [81, 91, 92]. Divergent findings may be influenced by differences in contexts and worker populations. Study findings in this sample of US older workers support previous evidence of better cognition associated with active work in multiple studies [82–84, 86, 91], and with low-strain work in fewer studies [84, 86]. The original hypotheses of the job strain model were "better health" in the "low strain" group but more "active learning" in the "active" group [93]. The current study's results are consistent with both "active learning" and "better health" being beneficial for cognitive function.

This study's findings on JDC psychosocial work with objective and subjective cognition may contribute to clinical and occupational practices that support older worker populations. In clinical practice, the diagnosis of neurocognitive disorders involves decline from objective cognitive performance as well as subjective report or assessment [4]. However, individuals may be reluctant to disclose perceived difficulties with memory to healthcare providers, including workers who are concerned about job loss [94]. This study's findings on the psychosocial work environment with both cognitive performance and perceptions over time, along with increased awareness among clinicians, employees, and employers, may help to destigmatize cognitive health concerns in clinical settings, communities, and workplaces. The positive associations of job control and cognitive outcomes in this study also provide additional evidence on potential benefits of promoting job control among older worker populations. In relation to the skill discretion aspect of job control, higher digital skill proficiency involving technology and problem-solving was associated with reduced risk of job automation among US older workers [95]. Continued investigations evaluating evolving work environments, including JDC applications in current contexts of work digitalization, and their possible cognitive impacts may lead to occupational practices that integrate job control to sustain cognitive health and job security for aging workers.

Study limitations involve the associative rather than causative relationships between the JDC exposures and cognitive outcomes. This study only used JDC at baseline, which does not represent possible changes in psychosocial work throughout follow-ups. However, as this study focused on aging, this study design was implemented to sustain sample size and attempted to reduce selection bias toward those that stopped working across follow-ups. Yet, results may represent the "healthy worker survival effect," in which individuals with better health statuses remain in the workforce [2] and follow-up in research, considering that the final sample had low prevalence of health conditions and predominantly healthy lifestyle behaviors. Additionally, the original Job Content Questionnaire consists of a 5-item job demand scale and a 9-item job control scale (Cronbach's $\alpha > 0.70$ in the US sample) [38]. Due to space restriction, only three items in each scale were included in the HRS. Consequently, the explanatory power of brief job strain model might be limited in this study. Although the Cronbach's α of the JDC scales in this study suggest limited internal consistency, future HRS studies may further explore these scales and alternate reliability measures. Additionally, findings may

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not be generalizable to participants that did not have cognitive data or were cognitively impaired, who also significantly differed in demographic, socioeconomic, lifestyle, health, and psychosocial work characteristics (Table SI). This possibility of selection bias may be related to the psychosocial work exposures, but it is unclear if it is also related to the cognitive outcomes, as nonparticipants may have lower cognition overall. Thus, results may underestimate true effects. The administration of the LBQ to the half-samples in 2006 and 2008 also contributed to nonparticipation [96]. Furthermore, the time-varying covariate of employment status was incorporated to account for employment changes in older adulthood, and the results in Model VIIs remained essentially unchanged after this adjustment. The objective and subjective cognitive measures do not substitute the comprehensive clinical neurocognitive assessment. Cognitive measures are limited to the survey wave periods, and do not reflect changes that may have occurred in between survey waves. Self-reported psychosocial work exposures and subjective memory perceptions may be affected by reporting bias. Study findings may have limited generalizability to other worker populations. Future research utilizing more current data from 2020 and onward may differ, with additional historical and economic effects on psychosocial work and cognition.

Several strengths of this study include its use of a population-based US worker cohort and a cognitive follow-up of up to 12 years. The use of self-reported job demand and job control from validated items in the LBQ [31, 37] serves as a subjective complement to previous work that employed JEMs [23, 86], and may additionally reflect participants' experiences that may not be captured via matrices that are generalized to occupations [19, 97]. Additionally, this study varied its cognitive outcomes with both the general cognitive function and episodic memory scores, as research suggests that different cognitive domains progress and decline differently with age [4, 98]. Multiple demographic, socioeconomic, lifestyle, health, and work factors were accounted for in analyses, including time-varying employment status and time between cognitive assessments. Study findings on high job control and better subjective memory address the scarcity of literature investigating psychosocial work and subjective cognition.

In conclusion, high job control was associated with all cognitive outcomes in objective cognition and subjective memory in this longitudinal study of US older workers. Active work and low-strain work were associated with better objective general cognitive function and episodic memory. Findings suggest that the promotion of job control through decision-making freedom, skill development, and situational control at work may potentially support cognitive health among an aging US workforce.

Author Contributions

Conceptualization, Jian Li; methodology, Jian Li and Megan Guardiano; software, Jian Li and Megan Guardiano; validation, Megan Guardiano, Ross Andel, Xavier Trudel, and Jian Li; formal analysis, Megan Guardiano and Jian Li; investigation, Megan Guardiano and Jian Li; resources, Jian Li; data curation, Megan Guardiano; writing – original draft preparation, Megan Guardiano; writing – review and editing, Megan Guardiano, Ross Andel, Xavier Trudel, and Jian Li; visualization, Megan Guardiano; supervision, Jian Li; project administration, Jian Li; funding acquisition, Megan Guardiano and Jian Li.

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Disclosure

The authors have nothing to report.

Ethics Statement

The University of California, Los Angeles Institutional Review Board (IRB#24-001361) determined this study exempt from review on November 8, 2024. This study was conducted consistent with the Declaration of Helsinki.

Consent

All participants provided informed written consent for the original HRS study.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data sets analyzed during the current study are publicly available in the corresponding repositories. The RAND HRS Longitudinal File 2020 (V2) and the RAND HRS Fat Files 2006 (V4A) and 2008 (V3A) are available at: https://hrsdata.isr.umich.edu/data-products/rand. The HRS Cross-Wave Tracker File (Early 2022 V2.0) and the Langa-Weir Classification of Cognitive Function contributed data set (1995-2020 V2.0) are available at https://hrsdata.isr.umich.edu/data-products/public-survey-data. RAND HRS public use data sets are produced and distributed by the University of Michigan with funding from the National Institute on Aging (Grant Numbers NIA U01AG009740 and NIA R01AG073289) and produced by the RAND Center for the Study of Aging, with funding from the National Institute on Aging and the Social Security Administration. HRS public use data sets are produced and distributed by the University of Michigan with funding from the National Institute on Aging (Grant Number NIA U01AG009740). Program code and scripts for statistical packages are available from the corresponding author upon request.

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