# THE EFFECTS OF OCCUPATIONAL COMPLEXITY ON LATE LIFE COGNITION IN ACTIVE: EXAMINING THE MEDIATING AND MODERATING EFFECTS OF RACE

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
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To my mother, Mary Owens, who made being a single mom look easy

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## Objective

Cognitively demanding occupations are associated with better late life cognition. Obstacles encountered by African American workers mean that racial disparities in occupational complexity may explain late life race cognitive differences. Three models were evaluated: 1) the relationship between occupational complexity and cognition; 2) whether African American status moderated these relationships; 3) whether the apparent Black-White cognitive differences are mediated by occupations.

## Methods

Participants were 2,371 ACTIVE study volunteers who provided occupational information. Occupations were coded and grouped into six factors of occupational complexity: substantive complexity, fine motor skills, physical demand, visual attention, color vision, and handling/reaching. Cognitive outcomes included composite scores representing reasoning, speed of processing, memory, digit symbol, and vocabulary. Covariates of age, sex, and education were included.

## Results

White participants evinced higher cognitive performance in all five cognitive domains. African Americans reported having occupations that were higher in physical demands, visual attention, and handling/reaching and lower in substantive complexity and fine motor skills.

Model 1: substantive complexity was positively associated with reasoning, memory, digit symbol, and vocabulary; fine motor skills was positively associated with reasoning and vocabulary. Physical demands was negatively associated with reasoning and digit symbol; and color vision was negatively associated with reasoning, speed, memory, digit symbol, and vocabulary.

Model 2: In general, race did not moderate relationships, except for vocabulary, where fine motor skills and handling/ reaching showed weaker relationships for Black participants.

Model 3: There were significant indirect effects of race through one of substantive complexity, physical demands, and fine motor skills for all cognitive domains except speed.

## Conclusion

Multiple dimensions of occupational complexity are related to cognition, with few race differences in these associations. Race differences in several dimensions of occupational complexity appear to explain some of the disparities in older adults' cognition. Thus, policy and social justice initiatives aimed at achieving higher levels of racial equity in occupational attainment may help to reduce some of the race disparities in late life cognition.

# CHAPTER 1
# INTRODUCTION

This study investigates the relationship between occupational complexity and late-life individual differences in cognitive functioning. Occupational complexity refers to the day-to-day demands that are required by one's job. Occupational complexity is most commonly categorized into domains that capture the extent to which an occupation requires intellectual, interpersonal, and physical effort, although other aspects like visual attention (G. G. Potter et al., 2006) and undesirable working conditions (Y. Stern et al., 1995) have also been examined.

The cognitive targets investigated as correlates of occupational complexity, researchers have been varied, include global mental status (G. G. Potter et al., 2006), IQ (Smart et al., 2014), multiple facets of memory (Carolina et al., 2016; Fritsch et al., 2007; Jonaitis et al., 2013; Jorm et al., 1998), attention, processing speed and executive functioning (Sörman et al., 2019). Across domains, investigators have generally reported that jobs with higher intellectual and interpersonal demands (a concept often referred to as substantive complexity); (Kohn & Schooler, 1973) are associated with higher levels of late life cognition, while jobs with more physical and motor demands are associated with poorer late life cognition.

Occupational complexity has complex meaning. On the one hand, jobs can constitute a key locus of intellectual, interpersonal and physical stimulation, training and enrichment after formal schooling, becoming a kind of post-formal education. On the other hands, one's occupational trajectory does not emerge independent of other influences. Educational history, family socioeconomic status, and social factors that restrict occupational mobility can all play a role, beyond individual aptitudes and interests, on lifetime careers. In that vein, it is important to consider how social factors may both contribute to, and moderate, the association of occupational complexity with cognition in later life. Indeed, differences in occupational opportunity have been identified (Braveman et al., 2011) as one aspect of the social determinants of health that may help to explain race- and ethnicity-related disparities in physical, mental and cognitive health outcomes across the life span.

In the current study, we focused on race (specifically differences between Black and White Americans) as a factor that might explain individual differences in occupational complexity, and also as a factor that might influence the strength of the association between occupational complexity and cognition. There is strong evidence of a lack of equality in occupational careers, and thus occupational complexity, across races in America. Relative to White adults, Black American adults in recent cohorts experienced higher unemployment rates (Fairlie & Sundstrom, 1999), higher levels of downward mobility (McBrier & Wilson, 2004), and tended to be employed in jobs of lower prestige and complexity (Browne et al., 2001). These racial differences are likely due to the obstacles African Americans have faced when pursuing high occupational attainment. For example, ethnic minorities are more likely to be overqualified for their occupational positions than whites (Vaisey, 2006), are less likely to have an effective network when applying to jobs (Pedulla & Pager, 2019), are more likely to work jobs with unstable or unpredictable work schedules (Storer et al., 2020), and weighed against other equally qualified applicants, African Americans are less likely to be chosen for a job due to the incorrect assumption that they lack “soft skills” required by the position (Streib et al., 2019). If a Black individual does reach high occupational attainment, they are more likely to be isolated and face greater stress, resulting in poorer health outcomes (Hudson et al., 2020).

Beyond race differences in occupational careers, the effects of occupational complexity may function differently by race. For example, in Black men, greater substantive complexity was associated with better cognition in those with lower levels of education, but not in those with higher levels of education. In contrast, in white men, greater substantive complexity was associated with better cognition at all levels of education (Fujishiro et al., 2019). These racial differences may be partly explained by the higher likelihood of over-qualification for black individuals. When an individual is over-qualified for their occupation, they are not maximizing their cognitive effort, and thereby not receiving the same level of intellectual challenge.

Thus, drawing on previous research, the current paper addressed three specific aims: 1) to determine if multiple dimensions of occupational complexity were associated with individual differences in cognition at the baseline assessment of a large, community-based study of diverse elders, 2) to examine whether the association of occupational complexity with late life cognition was moderated by Black/White race, and 3) to examine whether occupational complexity mediated some or all of the race/ethnicity related variance in late life cognition.

# CHAPTER 2
# METHODS

## Participants

Initial cognitive assessment data from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) was included for 2,371 participants who also provided occupational information (which, for reasons of study logistics, was not collected until one year later). Not included from the original ACTIVE parent sample of 2,802 individuals were: (a) 3 individuals who provided occupational data but did not identify as Black or White,  and were excluded, (b) 46 individuals who were asked about occupations, but did not report an occupation for themselves, (c) 32 individuals who provided occupational data that was not codable (e.g military, army, US Steel), and (d) 350 individuals that did not return to the first or third annual assessments in which occupational information was asked. Detailed information regarding inclusion criteria for ACTIVE has been described elsewhere (Jobe et al., 2001). Participants were recruited from six sites throughout the United States and all procedures were approved by the Institutional Review Boards, in compliance with the Helsinki Declaration, and informed consent was obtained prior to participation. At baseline, participants were at least 65 years of age, had a Mini Mental Status Exam (MMSE) (Folstein et al., 1975) score >23, had intact basic activities of daily living, and were free of severe sensory impairments and medical conditions likely to impact functioning or significantly increase mortality risk. Descriptive information regarding participants is provided in the results section below.

## Cognitive Measures

This study utilizes multiple measures of cognition as described below; further administration and psychometric details about these instruments are given elsewhere

(Karlene Ball et al., 2002; Jobe et al., 2001). Cognitive outcomes were Blom normalized (Blom, 1958), which also resulted in all measures being standardized (mean=0, standard deviation=1).

### Reasoning

A unit-weighted reasoning composite was comprised of three measures, all of which required identification of patterns in collections of letters and words, and included Letter Series (Thurstone & Thurstone, 1949) Letter Sets (Ekstrom et al., 1976) and Word Series (Gonda, 1985).

### Memory

A unit-weighted memory composite was comprised of the sum of the learning trials for three measures including, Hopkins Verbal Learning Test (Brandt, 1991), Rey Auditory Verbal Learning Test (Rey, 1941), and the Rivermead Behavioral Memory Test- Paragraph Recall (Wilson et al., 1985).

### Speed of Processing

Speed of processing was measured using the Useful Field of View (UFOV) test (K. Ball et al., 1993). The composite was comprised of four subtests of incremental complexity, each requiring participants to perform a computer-administered speeded visual attention task including: Speed (identify whether a centrally presented object is a car or a truck), Divided attention (object identification coupled with peripheral object localization), Selective attention (addition of visual clutter to the divided attention task) and Same-different (comparison of two centrally presented tasks, and concurrent peripheral target localization, in clutter). Using an adaptive double-staircase procedure, score was the presentation time needed for the participant to achieve 75% accuracy on each task.

### Digit Symbol Substitution (Wechsler, 1981)

Participants were required to match as many symbols and numbers as they could in 90 seconds; this measure was not combined into a composite, as it represented unique perceptual speed variance not included in other domains.

### Vocabulary (Ekstrom et al., 1976)

Also not included in a composite, this was a multiple-choice measure in which participants had to find the best match of a target word to one of four possible synonyms.

## Occupational Complexity

Occupational information in ACTIVE was collected at the first and third annual follow-up. Participants were asked “Have you ever worked?” If the answer to this question was “yes”, the participants were further asked “what type of work did you do, or occupation did you hold for the longest period of time”. If this response was not clear participants were then asked, “What occupation do you consider yourself?” Two raters then assigned an occupational classification code based on the Dictionary of Occupational Titles (DOT) revised fourth edition (USDo, 1991). Unique DOT codes were assigned to each participant independently by each rater, based on the participants longest held occupation reported at the first annual follow up. If the participant’s report was unclear at the first annual follow up, the participant’s response at the third annual follow up was used. Interrater reliability of coding, and the integration of the two raters’ codes, is discussed in the next section.

The DOT was originally published in 1939 and has been a major source of occupational information in the United States over the ensuing decades. The revised fourth edition, published in 1991, contains descriptions of 12,762 occupations (U.S.

Department of Labor, 1991). Each occupation was systematically analyzed by a job rater and contains a unique nine-digit code and trailer values with embedded occupational complexity characteristics that included: 1) complexity of work with data, people, and things, 2) general educational development, 3) specific vocational preparation, 4) aptitudes, 5) temperaments, 6) physical demands and 7) environmental conditions. From this corpus of ratings and trailer values, we used 63 items with ordinal or dichotomous scales (Owens, 2020).

The trailer values extracted from DOT were used to conduct an exploratory factor analysis on the corpus of 12,672 occupations in the DOT database (Owens, 2020). The exploratory factor analysis was performed with principal axis extraction and promax rotation. Three guidelines were used to aid in the determination of the number of factors to extract: (a) inspection of the scree plot, (b) eigenvalues > 1 (Costello & Osborne, 2005), and (c) mention in prior research (Smyth et al., 2004; Y. Stern et al., 1995), resulting in six factors. The six factors are listed here, with jobs in parentheses representing the three occupations in the ACTIVE sample that received the highest ratings on each factor: 1) Substantive Complexity, capturing the intellectual demands of jobs (clinical psychologist, clinical therapist, and editor), 2) Fine Motor Skills, capturing jobs that require precise movement with your hands (physicist, orthodontist, and machinist), 3) Physical demands, capturing jobs that are highly taxing to the body (house builder, bricklayer, and combat rifle crewman), 4)Visual Attention, capturing jobs that require high visual acuity (airplane pilot, driver of military equipment, and bus driver), 5) Color Vision, capturing jobs that require high color perception (chemist, decorator, and painter), and 6) Reaching and Handling, (packager, central office operator, and fast food worker) capturing jobs that require repetitive movements with your hands.

## Statistical Analysis

Initial descriptive analyses examined Black/White differences in demographic, cognitive and occupational variables. Subsequent models were tested according to study aims. For aim one, linear regression models including demographic variables Black/White race, education, sex, and age and the six occupational factors were used to predict each of five cognitive outcomes (memory, reasoning and speed composites, as well as measures of vocabulary and digit symbol substitution). For aim two, to examine whether race moderated occupation-cognition relationships, six Black/White race by occupational complexity interaction terms were added to the aim one model. To reduce interaction term multicollinearity, following Aiken and West (Aiken et al., 1991), product terms were computed using centered predictors. For aim three, to examine whether occupational variables mediated race effects on cognition, six mediation models (one per cognitive outcome) were run, in which the effects of black/white race on cognition were mediated by the six occupational complexity factors, with age, sex and education included as covariates. Tests of indirect effects were conducted in R (R Core Team, 2019; Rossee, 2012; RStudio Team, 2019) using the lavaan package (Rossee, 2012) and standard errors and confidence intervals generated over 1,000 bootstrapped resamplings.

# CHAPTER 3
# RESULTS

## Baseline Race Differences and Association of Demographic Variables with Occupational Complexity

T-test results comparing Black and White participants on age, years of education, occupational complexity, and baseline cognition are shown in Table 3-1. Black participants were younger, less educated, and more female ($\chi^2$=30.2, p<.001) than White participants. Furthermore, Black participants were significantly lower on substantive complexity and fine motor skills and significantly higher on physical demands and reaching and handling. Lastly, Black participants were significantly lower in all baseline cognitive measures. Table 3-2 shows the relationships between years of education, Black/ White race, and gender with all occupational complexity factors. Table 3-1 shows that there was a moderate to high association between substantive complexity and years of education (*r*=.63, p<.01). There were weak negative relationships with years of education and physical demands (*r*=-.32, *p*<.01) and handling and reaching (*r*=-.43, *p*<.01). Gender had a weak negative association with physical demands (*r*=-.21, *p*<.01) and a weak positive association with handling and reaching (*r*=.22, *p*<.01). All other relationships were very weak.

## Aim One and Two: Determine the Relationship between Occupational Complexity and Cognition and Examine the Moderating Effects of Black/White Race

Table 3-3 shows the main effect of the six occupational complexity factors, as well as their product term interactions with race, in predicting the five cognitive outcomes at baseline.

With regard to Aim 1, examining the association between occupational complexity and cognition, two complexity dimensions were positively related with one or more cognitive outcomes (substantive complexity was positively associated with reasoning, memory, digit symbol substitution, and vocabulary; more engagement in jobs requiring fine motor skill was positively associated with reasoning and vocabulary). Two other complexity dimensions were negatively associated with cognitive outcomes (more engagement in jobs with greater physical demand was associated with lower reasoning and digit symbol substitution performance; more engagement in jobs requiring color vision was associated with poorer reasoning, speed of processing, memory, digit symbol substitution, and vocabulary).

With regard to Aim Two, which addressed whether Black/White race moderated the association between occupational complexity and cognition, there was little evidence that race moderated this relationship, with one exception. Black-White race and occupational complexity interacted only for the cognitive outcome of vocabulary, where the race by fine motor skill interaction ($b=-0.11$, $\beta= -0.05$, $se=.05$, $p <.05$) and the race by handling/reaching interaction ($b=-0.12$, $\beta= -0.04$, $se=.06$, $p<.05$) reached significance ($p < .05$). In both cases, the association between the occupational complexity dimension and cognition was more negative in Black participants than in Whites.

### Aim Three: Examine Whether Occupational Complexity Mediates Some or All of the Race/ Ethnicity Related Variance in Late Life Cognition.

Table 3-4 displays the indirect effects of race on each of the cognitive outcomes, mediated through the six occupational complexity dimensions. There were significant indirect effects of race through substantive complexity via reasoning, memory, digit symbol and vocabulary. Further significant indirect effects of race via physical demand were found for reasoning and digit symbol. Finally, there were indirect effects of race via fine motor skills on reasoning and vocabulary. No significant indirect effects of race through any occupational complexity dimension were found for speed of processing, nor were the occupational complexity dimensions of visual attention, color vision, or handling/reaching involved in any conditional indirect effects. In regard to magnitude, the total percent of the direct effect that was accounted for by the combined indirect effect was 6.32, 4.04, 2.50, 6.18, 6.15 for reasoning, speed of processing, memory, digit symbol, and vocabulary respectively.

Table 3-1. Analytical sample characteristics:

| | Black | | White | | T test | | |
|---|---|---|---|---|---|---|---|
| | Mean | SD (Range) | Mean | SD (Range) | t(DF) | Cohen’s D | P Value |
| Demographic | | | | | | | |
| Age | 72.21 | 5.23 (65-91) | 73.94 | 5.93 (65-93) | 6.69 (1113.7) | 0.30 | p <.001 |
| Years of Education | 13.07 | 2.67 (5-20) | 13.75 | 2.66 (4-20) | 5.36 (2367) | 0.26 | p <.001 |
| Occupational | | | | | | | |
| Substantive Complexity | 0.79 | .93 (-1.09-2.27) | 1.01 | .84 (-1.09-2.68) | 5.24 (912.35) | 0.26 | p <.001 |
| Fine Motor Skill | -0.41 | .90 (-2.32-2.61) | -0.15 | 1.05 (-2.32-271) | 5.65 (1137.6) | 0.25 | p <.001 |
| Physical Demands | -0.20 | .81 (-1.18-3.51) | -0.38 | .79 (-1.25-4.94) | -4.67 (972.27) | 0.23 | p <.001 |
| Visual Attention | 0.06 | .81 (-1.25-460) | -0.06 | .81(-1.30-5.20) | -3.08 (2369) | 0.15 | .002 |
| Color Vision | 0.12 | .75 (-.90-2.41) | 0.12 | .81 (-1.12-3.56) | .15 (2369) | 0.01 | .883 |
| Handling/Reaching | -0.05 | .73 (-3.90-2.54) | -0.14 | .88 (-3.96-3.08) | -2.38 (1182.6) | 0.10 | .030 |
| Cognitive | | | | | | | |
| Reasoning | -.42 | .82 (-2.39-2.39) | .20 | .85 (-2.55-3.51) | 15.84 (1022.4) | 0.74 | p <.001 |
| Speed of Processing | -.12 | .77 (-1.35-2.16) | .08 | .82 (-1.44-2.54) | 4.94 (2354) | 0.24 | p <.001 |
| Memory | -.31 | .77 (-2.77-2.06) | .14 | .84 (-2.93-3.02) | 12.22 (1080.8) | 0.56 | p <.001 |
| Digit Symbol | -.38 | .99 (-3.44-4.73) | .19 | .95 (-2.54-3.47) | 12.51 (2364) | 0.60 | p <.001 |
| Vocabulary | -.65 | 1.07 (-3.14-1.43) | .25 | .86, (-3.14-1.43) | 18.34(850.02) | 0.97 | p <.001 |

Table 3-2. Pearson correlations between demographic and occupational complexity variables: Only education showed moderate (r > .3) relationships with several complexity factors.

| | Substantive Complexity | Fine Motor Skills | Physical Demands | Visual complexity | Color Vision | Handling/ Reaching |
|---|---|---|---|---|---|---|
| Age | -.02 | .04* | -.01 | -.04 | -.03 | -.04* |
| Years of education | .63** | -.11** | -.32** | .05* | .04* | -.43** |
| Race | -.11** | -.11** | .10** | .06** | .00 | .04* |
| Gender | -.12** | -.12** | -.21** | -.14** | -.04 | .22** |

Correlation is significant at the 0.01 level (2-tailed).** Correlation is significant at the 0.05 level (2-tailed).

Table 3-3. Five cognitive outcomes regressed on race, demographic, and occupational complexity variables, and race-by-occupation interactions.

| | R Model1 | R Model2 | S Model1 | S Model2 | M Model1 | M Model2 | DS Model1 | DS Model2 | V Model1 | V Model2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Race | -0.59 | -0.59 | -0.26 | -0.26 | -0.51 | -0.52 | -0.61 | -0.58 | -0.73 | -0.74 |
| | (-0.29) *** | (-0.30) *** | (-0.14) *** | (-0.14)*** | (-0.26) *** | (-0.27) *** | (-0.26) *** | (-0.25) *** | (-0.32) *** | (-0.32) *** |
| Gender | 0.07 | 0.07 | 0.01 | -0.00 | 0.35 | 0.35 | 0.31 | 0.30 | 0.12 | 0.11 |
| | (0.03) | (0.03) | (0.00) | (-0.00) | (0.17) *** | (0.17) *** | (0.13) *** | (0.13) *** | (0.05) ** | (0.05) ** |
| Age | -0.05 | -0.05 | -0.07 | -0.07 | -0.05 | -0.05 | -0.06 | -0.06 | 0.01 | 0.01 |
| | (-0.33) *** | (-0.33) *** | (-0.46) *** | (-0.46) *** | (-0.33) *** | (-0.33) *** | (-0.34) *** | (-0.33) *** | (0.04) * | (0.04) * |
| Years of Education | 0.11 | 0.11 | 0.04 | 0.04 | 0.08 | 0.08 | 0.07 | 0.07 | 0.15 | 0.15 |
| | (0.32) *** | (0.32) *** | (0.12) *** | (0.12) *** | (0.24) *** | (0.24) *** | (0.18) *** | (0.18) *** | (0.39) *** | (0.39) *** |
| Substantive complexity | 0.09 | 0.09 | 0.03 | 0.04 | 0.08 | 0.08 | 0.10 | 0.09 | 0.13 | 0.13 |
| | (0.09) *** | (0.09) *** | (0.04) | (0.04) | (0.08) *** | (0.08) *** | (0.08) *** | (0.08) ** | (0.11) *** | (0.11) *** |
| Fine Motor Skill | 0.08 | 0.09 | 0.02 | 0.02 | 0.01 | 0.01 | 0.04 | 0.04 | 0.09 | 0.09 |
| | (0.09) *** | (0.10) *** | (0.03) | (0.03) | (0.02) | (0.02) | (0.04) | (0.05) * | (0.09) *** | (0.09) *** |
| Physical demands | -0.06 | -0.06 | -0.01 | -0.01 | 0.01 | 0.01 | -0.11 | -0.11 | -0.05 | -0.06 |
| | (-0.06) * | (-0.06) * | (-0.01) | (-0.01) | (0.01) | (0.01) | (-0.09) *** | (-0.09) ** | (-0.04) | (-0.05) |
| Visual Attention | -0.02 | 0.02 | -0.01 | -0.00 | -0.02 | -0.02 | -0.03 | -0.03 | -0.04 | -0.03 |
| | (-0.02) | (0.02) | (-0.01) | (-0.00) | (-0.02) | (-0.02) | (-0.03) | (-0.02) | (-0.03) | (-0.03) |
| Color Vision | -0.08 | -0.09 | -0.05 | -0.05 | -0.09 | -0.09 | -0.08 | -0.08 | -0.10 | -0.10 |
| | (-0.07) *** | (-0.08) *** | (-0.05) * | (-0.05) * | (-0.09) *** | (-0.09) *** | (-0.06) ** | (-0.07) ** | (-0.08) *** | (-0.08) *** |
| Handling/Reaching | -0.02 | -0.01 | 0.01 | 0.01 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 |
| | (-0.02) | (-0.01) | (0.01) | (0.01) | (0.03) | (0.03) | (0.01) | (0.01) | (0.03) | (0.02) |
| Substantive complexity* Race | | -0.02 | | -0.04 | | -0.02 | | 0.12 | | 0.00 |
| | | (-0.01) | | (-0.02) | | (-0.01) | | (0.05) | | (0.00) |
| Fine Motor Skill* Race | | 0.04 | | -0.03 | | -0.03 | | 0.03 | | -0.11 |
| | | (0.02) | | (-0.01) | | (-0.02) | | (0.01) | | (-0.05) * |
| Physical demands* Race | | -0.07 | | -0.07 | | -0.04 | | -0.04 | | 0.07 |
| | | (-0.03) | | (-0.03) | | (-0.02) | | (-0.01) | | (0.03) |
| Visual Attention* Race | | -0.01 | | -0.08 | | -0.05 | | -0.09 | | -0.12 |
| | | (-0.01) | | (-0.04) | | (-0.02) | | (-0.03) | | (-0.04) |
| Color Vision* Race | | -0.07 | | 0.05 | | 0.05 | | -0.11 | | 0.02 |
| | | (-0.03) | | (0.02) | | (0.02) | | (-0.04) | | (0.01) |
| Handling/Reaching* Race | | 0.04 | | 0.00 | | 0.02 | | 0.00 | | -0.12 |
| | | (0.1) | | (0.00) | | (0.01) | | (0.00) | | (-0.04)* |
| $R^2$ Values | .38 | .38 | .25 | .25 | .27 | .27 | .27 | .28 | .37 | .37 |

Note: * p < .05, ** p < .01, *** p < .001; Values outside of parentheses are unstandardized regression weights; values in parentheses are standardized regression weights. R = Reasoning, M=Memory, S=Speed, DS= Digit Symbol, V= Vocabulary, Model1 = Race, demographic and occupational complexity predictors, Model2 = Addition of race-by-occupational complexity interactions to Model

Table 3-4. Examining the six occupational complexity factors as mediators of Black-White differences on cognition: Unique and combined effects

| | Reasoning | Speed of Processing | Memory | Digit Symbol Substitution | Vocabulary |
|---|---|---|---|---|---|
| | Unstandardized b (95% CI) | Unstandardized b (95% CI) | Unstandardized b (95% CI) | Unstandardized b (95% CI) | Unstandardized b (95% CI) |
| | Direct effect of race as mediated through each complexity dimensions | | | | |
| | -0.633 | -0.272 | -0.520 | -0.647 | -0.781 |
| | (-0.699, -0.563) * | (-0.34, -0.201) * | (-0.586, -0.451) * | (-0.724, -0.558) * | (-0.867, -0.696) * |
| | Indirect effects of race as Mediated through each | | | | |
| Substantive Complexity | -0.008 | -0.003 | -0.007 | -0.008 | -0.011 |
| | (-0.017, -0.001) * | (-0.011,0.001) | (-0.018,-0.001)* | (-0.022, -0.002) * | (-0.025, -0.002) * |
| Fine Motor Skills | -0.020 | -0.006 | -0.003 | -0.010 | -0.022 |
| | (-0.033, -0.011) * | (-0.016,0.003) | (-0.014,0.005) | (-0.02,0.001) | (-0.036, -0.011) * |
| Physical Demands | -0.010 | -0.001 | 0.002 | -0.017 | -0.009 |
| | (-0.021, -0.001) * | (-0.01,0.008) | (-0.006,0.011) | (-0.034, -0.006) * | (-0.023,.000) |
| Visual Complexity | -0.003 | -0.001 | -0.003 | -0.005 | -0.006 |
| | (-0.011, 0.005) | (-0.01,0.007) | (-0.012,0.004) | (-0.016,0.004) | (-0.018,0.003) |
| Color Vision | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (-0.006,0.006) | (-0.004,0.004) | (-0.008,0.007) | (-0.006,0.006) | (-0.008,0.007) |
| Handling/Reaching | 0.001 | 0.000 | -0.001 | -0.001 | -0.001 |
| | (-0.001,0.006) | (-0.005,0.001) | (-0.006,0.001) | (-0.006,0.001) | (-0.007,0.001) |
| | Total Indirect Effects | | | | |
| | -0.040 | -0.011 | -0.013 | -0.040 | -0.048 |
| | (-0.057, -0.024) * | (-0.024,0.002) | (-0.028, -.001) | (-0.063, -0.023) * | (-0.068, -0.031) * |
| | Percent of direct effect explained by combined indirect effects | | | | |
| | 6.32 | 4.04 | 2.50 | 6.18 | 6.15 |

Note: * p < .05; Values outside of parentheses (b) are unstandardized regression weights; values in parentheses (95% CI) are 95% confidence intervals

# CHAPTER 4
# DISCUSSION

This study found that, after controlling for education, age, sex and race, substantive complexity and fine motor skills were uniquely positively associated, while physical complexity and color vision were uniquely negatively associated with performance in a number of cognitive domains. It is important to emphasize that these associations with occupational complexity were above and beyond education. We note that a future parameterization of these models could be to construe occupation as a mediator which also carries the effects of education on cognition; such models would not find a larger unique effect of occupation but would explicate the extent to which occupation reflects early life social determinants (Hintsa et al., 2006) that affect individuals' education attainment. Particularly in the ACTIVE cohorts of older adults, Jim Crow and other aspects of segregation (Carruthers & Wanamaker, 2017; Hswen et al., 2020), as well as destabilization of educational careers associated with urban migration (Izenberg & Fullilove, 2020) likely influenced occupational attainment.

This study agrees with past research that has shown a positive association between occupations high in substantive complexity (intellectually demanding jobs), and a negative association with jobs high in physical demands, with various aspects of cognition in older adulthood (Andel et al., 2014; Potter et al., 2008; Smart et al., 2014). The emergence of the finding that occupations high in color vision had a negative association with several domains of cognition at baseline was surprising. T-test results indicated that color vision did not differ between Black and White participants. In the ACTIVE sample, jobs high in color vision included visual and creative occupations (e.g., painters, photographers, and decorators). There is some evidence that shows painters, sculptors and architects differ in how they conceptualize space (Cialone et al., 2018), and more generally, creative occupations may be more likely to demand divergent production abilities rather than the kinds of convergent production abilities assessed in the ACTIVE study (Zhang et al., 2020). It is also important to note that the unique association of color vision demand with cognitive outcomes was small.

There was no evidence for Black-White race as a moderator of the relationship between occupational complexity and cognition with one exception: Black elders showed a more negative association than White elders between vocabulary and the extent to which their occupations demanded fine motor skills and handling/reaching. Vocabulary is a somewhat complicated measure to consider as a cognitive outcome. We included it within the context of a fluid/crystallized or mechanics/pragmatics model of cognition, with the goal of exploring occupational complexity effects on cognitive outcomes that varied in relationship to education/acculturation and to age. At the same time, vocabulary is close in concept to literacy, which has been argued to better serve as a proxy for educational quality than as a late life cognitive outcome in its own right (Arce Rentería et al., 2019; Manly et al., 2003; Morgan et al., 2008; Sisco et al., 2015).

There was a significant indirect effect of race through at least one of substantive complexity, fine motor skills, and physical demands for all cognitive domains except for speed of processing; the extent of the mediation was small. Across the board, occupational complexity explained less than 10% (and mostly less than 5%) of the race-related variance in cognitive outcomes. Furthermore, Black-White race had no significant indirect effects though the occupational complexity domains of visual complexity, color vision, and handling/reaching. Thus, the evidence in this study does not support the notion of strong Black-White differences in the association of occupational complexity with cognitive outcomes in late life.

Nonetheless, given the persistent association of occupational complexity with late life cognition in this study, and the current finding that Black participants held jobs that demanded lower substantive complexity, fine motor skills and greater physical demand than White participants, the study continues to support the idea that reduced occupational opportunities for Black elders may represent one social determinant that contributes to late-life cognitive disparities.

With regard to the Black/ White differences in this study, it is interesting to speculate wether in fact they are underestimated given the nature of the sample that was recruited. Participants were required to have an MMSE score >23, intact basic activities of daily living, and were free of severe sensory impairments and medical conditions likely to impact functioning or significantly increase mortality risk. It seems likely that these selection factors would have led to a positively selected cohort in general; given other known health disparities, the selection might have been even greater in Black participants. Thus, there is unknown and likely unequal representativity of the larger population of American elders in our sample. Despite these presumed selection pressures, a large magnitude of race difference persisted even after the inclusion of covariates like education and occupational complexity in our models. Why did these race differences persist?

As described in the introduction, race disparities in health and cognition are widely thought to be attributable to a number of social determinants of health (SDOH). Future research must consider occupational complexity in the context of this larger

SDOH model, to address whether (a) inclusion of other factors helps to explain persistent race differences in cognitive performance, and (b) whether occupational complexity adds anything above and beyond these SDOH. (Centers for Disease Control, 2019).

Another category of potential differential post-educational influences on cognition is that of complex leisure activities. Participation in more intellectual and physically demanding leisure activities, as with occupations, has been shown to be associated with higher levels of late life cognition (Anatürk et al., 2018; Lee et al., 2019; Sala et al., 2019). Leisure activity can also buffer the relationship between psychological stress and cognition (Ihle et al., 2018). However, leisure activities are another domain in which there are historical Black-White differences in access. For example, in ACTIVE, Black participants tended to be more urban while White participants tended to be more exurban. These differences have implications for the availability of green space (Williams et al., 2020), parks, recreation centers, community programs (McNamara et al., 2020; Yang et al., 2021) and other venues for facilitating leisure. The Jim Crow era, in which many ACTIVE elders lived, might further have contributed to unequal access to leisure (Jackson, 2019). Lower access to education has also been shown to predict lower subsequent participation in complex leisure, so these factors are also intertwined (Scholes & Bann, 2018). In addition, to the extent that Black elders were more likely to be coping with less occupational opportunity and income disparities, there may also not have been sufficient non-work time or economic resources to engage in leisure pursuits, particularly if they were equipment- or supply-intensive. The ACTIVE study did not include a leisure time questionnaire, and thus our model of post-educational influences on cognition is, by definition, under-specified.

Occupational complexity may also play a role in contextualizing cognitive performance in the clinical context of neuropsychological evaluations. While it is unlikely that we would ever be able to develop norms for different occupational levels, it does seem that we can do a better job of helping clinicians reflect and quantify occupational engagement. For example, employment status, length of employment, and complexity of employment for the early adulthood, middle adulthood, and late adulthood portions of their patient's career. Using this information and developing a standardized coding scheme for quick clinical implementation, might help clinicians better elicit and understand the role that occupations play in forming late life cognitive levels, and to probe occupational history in a more standardized and consistent way across all patients.

The current study has several limitations. With regard to representativity, the sample only included individuals who were eligible for, and enrolled in, a clinical trial of cognitive interventions. Beyond voluntarism biases (Van Heuvelen et al., 2005) the clinical trial excluded individuals with frank cognitive impairment, significant ADL impairments, or medical conditions that were likely to make them unavailable for a two-year study. All of these factors undoubtedly positively biased the sample, corroborated by the fact that virtually no participants – male or female – indicated that they had never held paid employment. Furthermore, the study was conducted across the United States at six geographical sites and as noted, it is not representative of the US population in the cohorts studied. In addition, the cognitive battery studied, while broad, was optimized for the measurement of outcomes in the ACTIVE trial. Thus, some common neuropsychological constructs (e.g., delayed recall, measures of working memory, attention, and working memory) were not included in the assessment battery.

Turning to the occupational measurement, as a result of how occupational information was collected, there was a large amount of subjectivity when assigning occupational complexity ratings. Using two raters mitigated this subjectivity, but without directly assigning DOT codes with the participant via interview probes, some level of subjectivity remained. In addition, by only querying participants on their longest held occupation, the study did not obtain a cumulative occupational history, so that job variety, periods of unemployment, or years in each job could be used to construct a better accumulated occupational complexity variable. Nonetheless, we believe the analytical sample was large (N=2371), diverse (White=1786, Black=585), and contained over 400 unique occupations. Furthermore, the current study benefited from having 63 occupational complexity variables and a broad mix of fluid and crystalized cognitive measures.

This study supports, using a broader cognitive battery than many other studies, that multiple dimensions of occupational complexity are related to cognition, but there are relatively few race differences in these associations (the sole exception is Vocabulary, which likely reflects this outcome as one that is more strongly related to education and the opportunity structures that contribute to occupation). There is widespread support, across all cognitive dimensions except useful field of view, that a history of having jobs lower in substantive complexity and fine motor skills, and higher in physical demand may explain at least some of the apparent race differences in elders' cognition, and that there were race related discrepancies in attaining jobs of higher substantive complexity. While the current research included participants who would have completed high school between about 1924 and 1952, the persistence of educational and occupational effects on cognition four to six decades later suggests that, even in present day, policy and social justice initiatives aimed at providing equal access to high quality education, creating inclusive hiring and recruitment processes and addressing biases that prevent black individuals from stable and cognitively demanding work may help to reduce some of the apparent race disparities in late life cognition that will emerge in the decades to come.

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# BIOGRAPHICAL SKETCH

Joshua Owens graduated from Virginia Polytechnic Institute and State University in 2018 with two bachelor’s degrees in psychology and biological sciences. Following graduation, Joshua took a gap year where he participated in research that sought to better understand post trauma psychopathology by utilizing Pavlovian Fear-Conditioning. He then moved to Germany to explore a diverse ray of cultural backgrounds. Joshua was accepted into the doctoral program in Clinical and Health Psychology at the University of Florida in 2019. He is currently working towards his doctorate in clinical psychology with a specialization in neuropsychology. His research interests involve disparities in cognitive aging, with specific emphasis on the neuronal consequences of health disparities and cognitive interventions.