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# An examination of dedifferentiation in cognition among African-American older adults

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## Abstract

The structure and organization of cognitive abilities has been examined across the life span. The current analysis had three specific aims: (1) test the factor structure of a broad cognitive ability battery across three age groups; (2) examine differences in the pattern of factor covariation across age groups; and (3) examine the pattern of factor mean differences across age groups. A sample of 512 older African Americans (mean age = 66.6 years, 25.4% male) from the Baltimore Study of Black Aging was administered a battery of cognitive tests assessing the domains of perceptual speed, verbal memory, inductive reasoning, vocabulary, and working memory. Factor models were estimated separately in middle-age adults (50-59 years, n = 107), young-old adults (60-69 years, n = 198), and old-old adults (70-79 years, n = 207). There was loading invariance across the three age groups that suggests that the selected tests measured cognition similarly across age. There was no evidence of dedifferentiation across increasingly older age groups. Factor mean differences were observed with the middle-age group having significantly higher factor means than the young-old and old-old groups; however, there was only one factor mean difference between the young-old and the old-old groups. The results suggest that a pattern of dedifferentiation of cognitive abilities does not exist within this sample of older African Americans and that the 60-69 year age range may be a critical period for cognitive decline in this population.

### Keywords

Cognition; Dedifferentiation; African Americans; Cognitive abilities; Cognitive aging

## An examination of dedifferentiation in cognition among African-American older adults

While there is growing interest in the impact of culture on cognition, it is not clear if the patterns of decline and even stability vary across different cultural and ethnic groups (Kitayama, 2000; Park, Nisbett & Hedden, 1999). Numerous studies have attempted to address whether there is change in the structure and organization of cognition across the lifespan by examining childhood, adolescent, and adult patterns of cognitive abilities. The predominant hypothesis posed to address this question is the “age-differentiation hypothesis of psychometric

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intelligence." The age-differentiation hypothesis of psychometric intelligence suggests that the structures involved in cognitive ability integrate in early childhood, become differentiated during late childhood and adolescence, and remain so throughout most of adulthood (Burt, 1954; Garrett, 1946). Later, the Burt-Garrett age-differentiation hypothesis was extended to later adulthood and yielded evidence suggesting that cognitive ability structures begin to reintegrate or "dedifferentiate" in old age (Baltes et al., 1980).

Cattell's and Horn's theory of fluid/crystallized (Gf/Gc) intelligence has been used as theoretical grounding for examinations of dedifferentiation (Cattell, 1971; Horn, 1970). As the mechanics of cognition change with age, it is thought that fluid and crystallized intelligence diverge with increasing age, with poorer performance emerging for fluid abilities, and stability or increases emerging for crystallized abilities (Horn, 1982; Schaie, 1989). Within a dedifferentiation framework, as the factor structure of cognitive abilities reduces in late adulthood, it is expected that tests of both fluid and crystallized intelligence will generalize. Recent investigations suggest that cognitive abilities indeed cluster according to this division (Ghisletta & Lindenberger, 2003; Lindenberger & Baltes, 1997).

There are at least two compelling reasons for the continued interest in examining differentiation versus dedifferentiation in old age. First are unresolved issues about the construct validity of cognitive measures for different age groups. Researchers have sought to determine whether cognitive instruments developed for younger populations are valid for testing cognitive abilities in older age (Baltes et al., 1980). Time limits on cognitive tests have been a particular concern. Slowing of performance is a natural occurrence in old age and often translates to poor outcomes on measures that are speed-based; therefore, a test designed to measure performance in the young may translate to a test of speed for the old (Hertzog, 1989; Salthouse, 1991; Salthouse et al., 1996). Taking into account the problem of comparable construct validity for cognitive measures across age groups should reduce the interpretational difficulties met when measuring cognitive ability in late life. Second, newer and more sophisticated factor analytic strategies now exist that allow researchers to more accurately test the factor structure of cognitive abilities between age groups, and could shed new light on how dedifferentiation might occur (Baltes et al., 1980). Techniques such as confirmatory factor analysis are used to successfully address questions of differentiation and dedifferentiation and to test measurement invariance across groups with differing characteristics (Horn & McArdle, 1992; Zelinsky & Lewis, 2003).

Evidence for and definitions of dedifferentiation in old age are complex and varied. Dedifferentiation is traditionally interpreted as an age-associated increase in the correlations between individual cognitive abilities. A number of life span aging studies have shown evidence of dedifferentiation of cognitive abilities in late adulthood (Baltes et al., 1980; Cornelius et al., 1983; de Frias et al., 2007; Green & Berkowitz, 1964; McHugh & Owens, 1954). The number of cognitive factors that emerge and the rate of dedifferentiation in these studies vary. For example, Baltes et al. (1980) evaluated the fit of data from a sample of 109 elderly adults (age range = 60-89) to structural models with varying numbers of factors using confirmatory factor analysis They found that their data supported models with fewer factors to fit the ability performance of participants, supporting the notion of dedifferentiation. On the contrary, Zelinski and Lewis (2003) examined the size and configuration of factor loadings longitudinally and found no differences in factor structure with increasing age, contradicting support for dedifferentiation with age. Other studies have not shown support for dedifferentiation (Anstey, Hofer, & Luszcz, 2003; Cunningham, Clayton, & Overton, 1975; Foulds & Raven, 1948). Possible explanations for the inconsistencies in these previous findings is due to differences in the sample age ranges, differences in the measures included in the analyses, and/or differences in the types of analyses used to examine dedifferentiation across age groups or with increasing age.

A number of plausible hypotheses have been put forward to explain the increase in correlations among cognitive abilities associated with dedifferentiation. Deary et al. (1996) suggested that higher correlations at greater ages can be attributed to low efficiency of a general cognitive process. In other words, the relationships among cognitive variables may appear to be highly related because there is one underlying cognitive factor that accounts for cognitive performance. Studies that evaluate the size of correlations among cognitive ability variables have mixed findings because the testing of manifest variables includes error. Cunningham and Birren (1980) considered the practice of comparing the magnitude of correlations among cognitive ability variables as weak evidence for dedifferentiation. They suggested that examining latent factors is more sound because latent factors represent cognitive performance on a number of observed variables shown to reliably represent a particular cognitive ability.

The measurement of dedifferentiation in old age has been complicated by several methodological challenges. Many studies have relied on visual inspection of correlation matrices followed by participative judgments about the relative strength of the relationships between factors across groups, rather than using statistical tests to detect significant differences in the magnitude of correlations. This practice is not ideal, particularly for analyses that utilize small sample sizes and are unlikely to yield robust factor correlations (Zelinski & Lewis, 2003). Moreover, other studies have failed to discuss or define what constitutes a meaningful increase in the association between cognitive factors from one age group to the next. The absence of a difference cut-off or reference creates dedifferentiation findings that are not easily generalizable. Another challenge is encountered within studies that do not consider confounding variables such as health and education, or consider age-related variance, that may affect the strength of the relationships between cognitive factors. Studies that evaluate latent variables are more accurate in hypothesis testing because correlational changes can be more directly examined (for a review of methodological challenges, see Zelinski & Lewis, 2003).

An assumption is made within cross-sectional analyses of the dedifferentiation hypothesis that between-person differences will be reflective of intraindividual changes in the structure of cognitive abilities across time. In other words, it is assumed that the cognitive abilities of individuals in the older age groups are representative of the abilities of younger individuals when they reach later ages, and that examining group differences is similar to examining individual trajectories. This assumption is an accepted one, but begs the addition of follow-up longitudinal analyses.

Few studies investigating the structure of intellectual abilities have examined the issue within special populations. Between-group differences in patterns of differentiation have been explored across different socioeconomic conditions and cultural groups (McGaw & Joreskog, 1971; Vernon, 1969). However, there are no studies that examine the question of structural differences in cognitive abilities across age among African Americans. Given that cognitive measures may not assess ability similarly across ethnic groups (e.g. House, Landis, & Umberson, 1988; Whitfield et al., 2000; Whitfield & Baker, 1999; Whitfield & Willis, 1998), an assumption of the generalizability of dedifferentiation findings may not be appropriate. Whitfield and Willis (1998) suggest that indices of health like chronic conditions and physical functioning, and social factors like education are the primary sources of differences in variability across ethnic groups.

Previous research suggests that the cognitive abilities of older adults are impacted by factors such as physical health (Barrett & Watkins, 1986; Elias, Elias, & Elias, 1990; Perlmutter et al., 1988; Perlmutter & Nyquist, 1990; Rosano et al., 2005; Schaie, 1994; Whitfield et al., 1997; Ylikoski et al., 2000) and educational attainment (Birren & Morrison, 1961; Blum & Jarvik, 1974; Denny & Palmer, 1981; Green, 1969; Kesler, Denny, & Whitney, 1976; Ripple & Jaquish, 1981; Selzer & Denny, 1980). In general, older African Americans experience poorer health outcomes and have attained fewer years of education as compared to their Caucasian counterparts (Harper & Alexander, 1990). In fact, the cumulative advantage and disadvantage theory (Dannefer, 1988; Dannefer, 2003) suggests that the societal inequalities experienced by African Americans can generate an accumulation of disadvantages, such as low educational attainment and poor health conditions, which negatively impact cognitive functioning throughout the life course (Whitfield et al., 2000). Social factors such as social support (Cohen & Syme, 1985), religious practices (Livingston, Levine, & Moore, 1991), and socioeconomic status (SES) (Arbuckle, Gold, & Andres, 1986; Gribbon, Schaie, & Parham, 1980; Owens, 1966; Schaie, 1983) that are related to health, may also impact cognition. It follows, therefore, that the cognitive abilities of African-American elders may be distinctly different from other groups. It is unknown how these differences may translate to unique changes in the structure of cognitive abilities across the life span. Moreover, the degree of influence these factors have on African-American elders varies within the racial group (see Whitfield & Aiken-Morgan, 2008), suggesting a need to explore both between- and within-group patterns of dedifferentiation.

Certain cultural influences on cognitive abilities may also distinguish the dedifferentiation findings of older African Americans from other racial groups. Findings from desegregation research suggest that some cognitive variables are influenced by qualitative differences in educational experiences. Factors such as attitudes toward school, relationships with teachers, performance in school, and attendance may have created distinct differences in educational attainment among African Americans (Whitfield & Wiggins, 2003). The fluid and crystallized abilities distinction is one that is impacted by cultural influences. Crystallized abilities are influenced by educational and cultural factors, while fluid abilities are not limited to processes involved in acculturation (Horn & Hofer, 1992). In light of the educational and cultural differences that exist between African Americans and Caucasian Americans, crystallized abilities may be distinct between groups, potentially resulting in different dedifferentiation patterns between groups.

The purpose of this analysis was to explore the patterns of dedifferentiation of cognitive abilities across middle-age, young-old, and old-old African Americans. First, we examined the fit of a structural model for cognitive assessment by testing the factor structure of a broad cognitive ability battery across three age groups. Next, we examined differences in the pattern of factor covariation across age groups to determine whether cognitive ability factors were more highly related as age increased. Our last objective was to examine the pattern of factor mean differences across age groups to determine differences in cognitive performance that may lend insight into African-American patterns of cognitive decline.

We implemented several design characteristics to attempt to overcome some of the measurement challenges that have been critiqued in previous studies on differentiation (e.g., Baltes & Lindenberger, 1997; Park et al., 2002; Zelinski & Stewart, 1998). We selected only one cognitive ability (perceptual speed) that required participants to work at a rapid pace, reducing the likelihood that results would be skewed due to slower processing speeds at older ages. The remaining four factors were comprised of non-speed based tests, deemphasizing speed of completion as a factor in performance differences between age groups. We also established invariance of model fit across age groups prior to assessing the structure of cognitive abilities (see Horn & McArdle, 1992). Lastly, we went beyond comparing correlations among factors, as is typical in most other studies, and tested the pattern of factor mean differences across age groups.

# Method

## Participants

The sample consisted of 512 community-dwelling African-American adults (25.4% male) who participated in the first wave of Patterns of Cognitive Aging (PCA) study, part of a larger group of aging studies known as the Baltimore Study of Black Aging (BSBA). Participants were recruited from 29 senior apartment complexes in the city of Baltimore, Maryland. PCA consists of 602 participants ranging in age from 50 to 95 years of age. While the sample was ascertained using a snowball technique which makes it a sample of convenience, our data are comparable in some ways to what would be expected from the demographics of the area. In the sample, education, a key demographic indicator for the study, looks very much like Census data (ascertained: 13.5% 0-8 years; 55.7% 9-12 years; 30.8% 12+years compared to the population estimates of 13% 0-8 years; 53% 9 and 12 years; 34% 12+ years). Demographic characteristics of the sample are provided in Table 1.

The age was restricted to 79 for this analysis due to the small numbers of participants in older age groups (80-89 and 90-99) Mean age of the subsample analyzed here was 66.6 years (SD = 7.98). The mean educational level was 11.80 years (SD = 2.86). There was a significant age difference in education between the 50-59 and 70-79 age groups only ($t = 3.25$, $p = .001$). Demographic characteristics of the sample can be found in Table 1.

## Measures

Psychometric measures of five abilities were included in the battery: Perceptual Speed, Verbal Memory, Inductive Reasoning, Vocabulary, and Working Memory. These abilities were selected for a number of reasons, including: (1) each of the abilities has been studied in several major investigations of psychometric intellectual aging, including the Seattle Longitudinal Study (e.g., Schaie, 2004), the Adult Development and Enrichment Project (e.g., Baltes & Willis, 1982), the Berlin Aging Study (e.g., Baltes & Mayer, 1999), the Victoria Longitudinal Study (Hultsch, Hertzog, Small, & Dixon, 1998), and the Einstein Aging Studies (Sliwinski & Buschke, 1999); (2) the chosen abilities are particularly sensitive to the negative effects of the aging process (Lövdén, Ghisletta, Lindenberger, 2004); and (3) previous longitudinal investigations of Caucasians have found a strong association between these abilities and markers of health (Elias & Elias, 1993; Saxby et al., 2003; Verhaeghen, Borchelt, & Smith, 2003; Waldstein, 2000).

**Inductive Reasoning—**This is a measure of the participant's ability to produce novel concepts or relationships in over-learned material.

**Shipley Institute of Living Scale Abstraction Test (Shipley, 1986):** The participant is shown a series of numbers, letters, or words (e.g. Caucasian black; short long; down ___) and then asked to identify the most logical item that would follow in the series (e.g., up). This test is composed of 20 items, and the total number of correct responses is summed to provide an overall score on the measure.

**Verbal Memory—**This is the ability to encode, store, and recall meaningful language units.

**Immediate Recall test:** The participant studies a list of 20 words for 3.5 minutes. The participant is then given an equal period of time to recall the words in any order.

**Hopkins Verbal Learning Task (HLVT; Brandt, 1991):** This task is also included as a measure of memory, and is similar to the AVLT. However, in this measure, the to-be remembered words can be placed into one of three semantic categories. As with the AVLT, the number of correctly recalled words is used as the total score for this measure.

**Rey Auditory Verbal Learning Task (AVLT; Rey, 1941):** This task is included as a measure of Memory, and requires participants to study a list of 15 semantically unrelated words for one minute, followed by a one-minute free recall trial. The number of correctly recalled words is used as the total score for this measure, with no penalties for intrusion or perseveration errors.

**Verbal Ability—**This is language knowledge and comprehension that is measured by assessing the scope of a person's recognition vocabulary.

**Shipley Institute of Living Verbal Meaning Test (Zachary, 1986):** This is a 40 item, four-choice synonym test. Each correct response is scored as “1” and correct responses are summed to generate a total score.

**ETS Vocabulary II and IV-(V2) Tests (Ekstrom, French, Harman, & Derman, 1976):** This measure contains two five-choice synonym subtests, with each test consisting of 18 items. A total of eight minutes, four minutes per test, is provided for the completion of both halves, and summing the number of correct responses from both subtests generates the total score.

**Working Memory—**This is the ability to encode, store, and recall as well as manipulate numbers and words.

**Computation Span Task (Salthouse & Meinz, 1995):** The Computation Span task involves four blocks of two trials, with different numbers of items in each block. Trials involve the auditory presentation of two to five addition or subtraction problems (e.g., 7 + 6), each followed by three alternative answers printed in the test booklet. The participant is instructed to place a check mark next to the correct answer for each arithmetic problem, while also remembering the second number from the addition (e.g., 6). After selecting the answer to all of the arithmetic problems, participants are instructed to turn the page and recall all the target (second) digits by writing them in the spaces provided. The number of arithmetic problems increases from two to five as participants' progress from Block 1 to Block 4.

**Backward Digit Span Test (Wechsler, 1981):** This measures short-term or primary memory. Participants are instructed to recall the previously presented digits backwards. The maximum score is eight.

**Alpha Span (Craik, 1990):** This is a task that measures short-term memory. Participants are read a list of words (from two to eight words). After each list is read, participants are asked to repeat the list in alphabetical order. Responses are recorded as pass or fail. If a participant fails two consecutive attempts, the test is ended.

**Perceptual Speed—**This is the ability to find figures, make comparisons, and do other simple tasks involving visual perception with speed and accuracy.

**Number Comparison (Ekstrom et al., 1976):** In this 48-item test, each item presents a pair of side-by-side number strings ranging from 3 to 13 digits in length. The participant is asked to compare each pair of strings and to mark an “×” between each pair of strings that is mismatched by at least one number (e.g., 54732 × 54742). The number of items correctly classified is summed to represent the overall score on this measure.

**Digit Symbol Test (Weschler, 1981):** This measure requires participants to reproduce, within 120 seconds (60 seconds per trial), as many coded symbols as possible in blank boxes beneath randomly generated digits, according to a coding scheme for pairing digits with symbols. The number correct and incorrect are recorded and used as variables.

**Identical Pictures Test (Ekstrom et al., 1976):** This test requires that a picture presented in the left margin be correctly matched to an identical picture embedded in a row of five similar depictions. Ninety seconds are provided to complete as many items as possible in this 48-item test. Correct identification of an identical object is scored as “1” and scores are summed to generate a total score.

### Procedures

The recruitment began with the project staff contacting staff and management of senior apartment facilities, directors of senior citizen centers, or representatives from social service agencies. The project staff presented the research project then asked permission to advertise the project through flyers and provide a short presentation at building meetings or during planned activities. The participants were given a telephone number to call to participate in the study. The potential participants were informed that this is a longitudinal study that will require a commitment of at least 30 months. If they accepted, they were scheduled a time and place to be tested that was convenient for them.

On the day of the interview, the participant was read a consent form. After signing the informed consent, the participants were given the interview battery. The testing session lasted approximately 2 ½ hours. At the conclusion of testing, the participants were compensated $30 for their time.

## Results

The purpose of the current investigation was to determine whether cognitive abilities dedifferentiate at older ages within a sample of African Americans. First, the factor structure of a cognitive test battery was tested within the entire sample. Second, measurement invariance of the factor structure was tested within the middle-age, young-old, and old-old age groups. Next, the patterns of covariance among factors in each age group were compared to test for dedifferentiation. Finally, differences in the factor means between the groups were tested.

All models were estimated using AMOS 16.0 structural equation modeling software (SPSS, 2008). Model fit for the models was assessed with the root mean square error of approximation (RMSEA), comparative fit index (CFI), and the non-normed fit index (NFI). The chi-square goodness-of-fit index is reported for each factor model.

### Factor Structure in the Total Sample

A hypothesized five-factor model was estimated in the total sample of African-American elders. This model consisted of intercorrelated factors underlying five cognitive abilities measured by the cognitive battery. These abilities included Working Memory, Verbal Ability, Inductive Reasoning, Verbal Memory, and Perceptual Speed. The Working Memory factor consisted of Operation Span, Backward Digit Span, and Alpha Span. Verbal ability consisted of ETS Vocabulary and Shipley Vocabulary. The third factor, Inductive Reasoning, was made up of the Shipley Reasoning test. Verbal memory was composed of Immediate Recall, the HVLT, and the AVLT. The last factor, Perceptual Speed, was comprised of the Digit Symbol Test and the Number Comparison and Identical Pictures tests. The fit of this five-factor unconstrained model was good [$\chi^2$ (223, $N$ = 512) = 436.69, $p < .001$ (*RMSEA* = .04, *NFI* = .86, *CFI* = .92. There was sufficient power with a sample size of 512 to detect significant differences between age groups (Byrne, 2001). Statistics for the unconstrained model and subsequent models can be found in Table 2.

## Measurement Invariance: Loadings

The next analysis examined the extent to which the factor structure found in the full sample was invariant across subgroups defined by age. The total sample was divided into three age groups: middle-age, young-old, and old-old. The middle-age group consisted of 107 participants age 50-59 (M = 54.64 years, SD = 4.14). The young-old group consisted of 198 participants age 60-69 (M = 64.98, SD = 2.80) and the old-old group was comprised of 207 participants age 70-79 (M = 74.32, SD = 2.83). We tested the equality of factor loadings, or loading invariance, between the three age groups by setting all factor loadings to equality. By constraining loadings to equal, we determined that there was no significant change in $\chi^{2\cdot}$ fit across the three age groups. The fit of this model was adequate [$\chi^2$ (247, $N$ = 512) = 465.85, $p < .05$], and did not significantly differ from the unconstrained model [$\Delta\chi^2$ (24, $N$ = 512) = 29.16, $p > .05$] indicating that the loadings for each factor were similar across age groups. Factor loadings across age groups are shown in Table 3.

## Testing Dedifferentiation

In order to test for dedifferentiation of cognitive abilities across age groups, it was necessary to test the invariance of the factor covariances. Factor covariances were analyzed, but factor correlations, which are standardized covariances, are presented for greater ease of interpretation. If dedifferentiation was indeed present, it was expected that the relationships among the factor covariances for the old-old group would be stronger than those for both the middle-age and young-old groups, and likewise the relationships would be stronger for the young-old group than for the middle-age group. The factor covariances for all age groups were set to equality to test invariance of covariances across age groups. The fit of this model was also adequate was also adequate [$\chi^2$ (263 $N$ = 512) = 483.37, $p < .05$]. There was no significant change in $\chi^2$ fit as compared to the unconstrained model [$\Delta\chi^2$ (16, $N$ = 512) = 17.52, $p > .05$], indicating that the factor covariances were equivalent across age groups. Factor correlations, representing these covariance relationships across age groups, are found in Table 4.

## Factor Mean Differences

The final set of analyses examined whether the factor means for the five cognitive factors significantly differed across age groups using the approach outlined by Byrne (2001). In this approach, each factor is scaled by fixing one of the indicator variables for each factor to “1.” To ease interpretability across factors, each of the indicator variables were standardized to a mean of 50 and standard deviation of 10 resulting in factors with the same metric. Next, the 50-59 age group served as an initial reference group with all factor means within this group fixed to zero while freely estimating the factor means of the 60-69 and 70-79 age groups. Based on this specification to the model, mean deviation values were determined that reflected the direction and magnitude of the differences in factor means between the three age groups. Standardized factor mean values and significant differences are shown in Table 5. There were significant differences in factor means between the 50-59 and 60-69 age groups. Specifically, inductive reasoning, perceptual speed and working memory performance were significantly lower within the 60-69 age group. There were no significant differences in verbal ability or verbal memory factor means. The findings for the 50-59 and 70-79 age group comparisons were similar. Inductive reasoning, perceptual speed, and working memory performance were significantly lower for the 70-79 age group while no significant mean differences emerged for the remaining two factors. Next, the factor means for the 60-69 age group served as a reference to detect significant differences between the 60-69 and 70-79 age groups for each of the five cognitive factors. The only observed factor mean difference between these groups was for perceptual speed.

## Discussion

As the structure of cognitive abilities remains of interest to cognitive aging researchers, there continues to be a need to examine the structural relationships that exist within the cognitive abilities, particularly in the study of underrepresented ethnic/minority groups. In this paper, we addressed a critical question: do the cognitive abilities of African Americans follow structural patterns across the lifespan in the same way they do in studies of Caucasian Americans? Our measures were found to be valid and replicated the factor structure for five cognitive abilities that has been established in studies of cognition and aging with predominately Caucasian samples (e.g. Horn & McArdle, 1992; Taub, McGrew, & Witta, 2004). The findings presented here suggest that these measures also have utility for studying older African Americans. Furthermore, we established loading invariance for cognitive abilities across age groups, a requirement necessary to analyze patterns of differentiation between groups when utilizing confirmatory factor analysis as a detection tool (Horn & McArdle, 1992). Not only was the cognitive battery a valid assessment of cognitive abilities, but it was reliable across groups, suggesting that these were appropriate measures for older African Americans of varying ages.

Due to the paucity of literature on cognitive aging in African Americans, this and other questions remain unanswered. The cognitive performance of minority elders, particularly African Americans, may vary from the performance of Caucasian-American elders due to differences in health, social support, religious practices, and SES (cf. Whitfield & Baker, 1999). Furthermore, cultural differences in educational experiences and cultural effects on crystallized abilities may impact the structure of cognitive abilities (Whitfield & Wiggins, 2003; Horn & Hofer, 1992).

Typical studies of dedifferentiation have yielded mixed results, with some supporting this phenomenon (Baltes et al., 1980; Cornelius et al., 1983; de Frias et al., 2007; Green & Berkowitz, 1964; McHugh & Owens, 1954) and others failing to find significant differences across the lifespan (Anstey, Hofer, & Luszcz, 2003; Cunningham, Clayton, & Overton, 1975; Foulds & Raven, 1948). With the methodological challenges associated with examining dedifferentiation, it was important not only to measure dedifferentiation accurately, but to ensure that the assessments utilized to detect cognitive abilities were valid for our African-American sample. Based on previous findings, the issue of the generalizability of cognitive measures to ethnic minority groups was a concern (House, Landis, & Umberson, 1988; Whitfield et al., 2000; Whitfield & Baker, 1999; Whitfield & Willis, 1998).

A pattern of dedifferentiation was not supported in this sample of African Americans. These results were consistent with other studies of dedifferentiation that failed to illustrate stronger relationships among cognitive factors for older participants (Anstey, Hofer, & Luszcz, 2003; Cunningham, Clayton, & Overton, 1975; Foulds & Raven, 1948; Zelinsky & Lewis, 2003). Our findings contribute to this body of literature by suggesting that dedifferentiation is not a certain, automatic process, but rather a dynamic process that may or may not occur among older adults, the specifics of which are unknown. Our analyses were exploratory, in that we did not expect a particular outcome in support of dedifferentiation or not. It was important, however, to begin building dedifferentiation findings for African-American elders, a group with unique cultural experiences that has previously been excluded from studies of dedifferentiation. It follows that additional explorations of the structure of cognitive abilities within this population should be conducted that also attempt to control for significant covariates such as health, education, social support, religious practices, SES, and other unique cultural factors that may affect cognitive performance.

A significant difference in test performance was detected between the middle-age and young-old groups, but there was little difference in factor means from the young-old to the old-old. This finding suggests that the 60-69 age range may be of particular interest for examining cognitive variability with age within older African Americans. Large longitudinal studies of aging suggest that there is considerable cognitive decline in the 70s (Horn & Noll, 1997; Park, 2000). The finding for the 60-69 age group within this study suggests that African-American elders manifest a substantial cognitive decline a decade earlier than is reported for their Caucasian counterparts. Longitudinal changes in intellectual abilities for Caucasians were observable and more pronounced in the old-old (M = 83.84, range = 78-100) than in the old (M = 73.77, range = 70-77) in the Berlin Aging Study (Singer et al., 2003). This potential difference is important as researchers attempt to identify critical periods for prevention of and intervention for cognitive decline within African-American elders as well as examinations of disparities in cognitive function across ethnic groups.

One of the theories central to the discussion of dedifferentiation is the Fluid/Crystallized distinction. The results from these analyses show that the general pattern for fluid and crystallized abilities is present. We found that there were trends for declines in inductive reasoning, working memory, and perceptual speed at greater ages. In contrast, we found virtually no difference in performance at greater ages for the crystallized measures of vocabulary and verbal memory. The results also show there was no statistically significant decline in cognitive performance between the 60-69 and 70-79 age groups across any of the factors, except for perceptual speed performance. This finding was expected. Speed has been shown to play a central role in accounting for age-related differences in performance on cognitive tests (Salthouse & Babcock, 1991; Salthouse, 1994).

We hypothesize that our findings about age differences suggest a “leveling off” of cognitive decline that represents survivorship within the old-old group. The recent estimates suggest that life expectancy for African Americans is 73.1 years (National Vital Statistics Report, 2007), suggesting that most African Americans don't live into the seventh decade of life. We postulate that African Americans who survive into their 70s possess protective attributes, such as quality educational experiences, stress coping strategies, and optimal health profiles that postpone cognitive decline in this potentially vulnerable population (Whitfield, 2004; Whitfield & Aiken-Morgan, 2008). To this end, examination of very-old (80-year-olds, 90-year-olds, and beyond) African Americans may yield valuable insights about characteristics of those likely to successfully cognitively age, particularly as longevity increases.

In summary, our findings suggest that although there was no evident pattern of dedifferentiation found within the sample, there were interesting patterns of differences across the age cohorts. How cognitive function remains constant and how it changes across age provides insight about issues such as early cognitive decline and cognitive resilience. This information may help to inform future investigations of the structure of cognitive abilities which are particularly salient in the study of older African Americans. Additional research is needed to examine within-and between-group differences in cognitive performance, taking into account health, social, and cultural factors. The findings presented in this analysis offer an important contribution to the growing body of literature surrounding African-American cognitive aging, with an emphasis on the endorsement of certain cognitive measures for use with African-American elders and the unique pattern of cognitive decline associated with this minority group.

### Limitations

One limitation of the analysis was its cross-sectional nature. Dedifferentiation is ideally analyzed when intraindividual and interindividual differences in the structure of cognitive abilities can be assessed across time. The analysis of group differences, however, is a good start for detecting trends in changes in cognitive structures. Forthcoming longitudinal data will help to overcome this caveat in a later analysis of individual trajectories of changes in cognitive structures over time. Another limitation was that there was only one test in the inductive reasoning factor in the analysis. Due to missing data, the other two additional tests of inductive reasoning (Number Series and Letter Series) included in the BSBA were excluded from the analyses. Participants discontinued these tests due to the level of difficulty they presented.

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## References

Anstey KJ, Hofer SM, Luszcz MA. Cross-sectional and longitudinal patterns of dedifferentiation in late-life cognitive and sensory function: The effects of age, ability, attrition, and occasion of measurement. Journal of Experimental Psychology: General 2003;132:470–487. [PubMed: 13678379]

Arbuckle TY, Gold D, Andres D. Cognitive functioning of older people in relation to social and personality variables. Psychology and Aging 1986;1:55–62. [PubMed: 3267380]

Baltes PB, Cornelius SW, Spiro A, Nesselroade JR, Willis SL. Integration versus differentiation of fluid/crystallized intelligence in old age. Developmental Psychology 1980;16:625–635.

Baltes PB, Lindenberger U. Emergence of a powerful connection between memory and cognitive functions across the adult life span. A new window to the study of cognitive aging? Psychology and Aging 1997;12:12–21. [PubMed: 9100264]

Baltes, PB.; Mayer, KU. The Berlin Aging Study: Aging from 70 to 100. New York: Cambridge University Press; 1999.

Baltes, PB.; Willis, SL. Plasticity and enhancement of intellectual functioning in old age: Penn State's Adult Development and Enrichment Project (ADEPT). In: FI, M.; Blanchard-Fields, F.; Chen, Y., editors. American Behavioral Scientist. Vol. 39. 1982. p. 231-248.(1996). Adaptive cognition and aging

Barrett TR, Watkins SK. Word familiarity and cardiovascular health as determinants of age-related recall differences. Journal of Gerontology 1986;41:222–224. [PubMed: 3950349]

Birren JE, Morrison DF. Analysis of the WAIS subtests in relation to age and education. Journal of Gerontology 1961;16:363–369. [PubMed: 13869450]

Blum JE, Jarvik LF. Intellectual performance of octogenarians as a function of education and initial ability. Human Development 1974;17:364–375. [PubMed: 4468927]

Brandt J. The Hopkins Verbal Learning Test: Development of a new memory test with six equivalent forms. The Clinical Neuropsychologist 1991;5:125–142.

Burt C. The differentiation of intellectual abilities. British Journal of Educational Psychology 1954;24:76–90.

Byrne, BM. Structural equation modeling with AMOS: Basic concepts, applications, and programming. Mahwah: New Jersey: 2001.

Cattell, RB. Abilities: Their structure, growth, and action. Boston: Houghton Mifflin; 1971.

Cohen, S.; Syme, SL. Social support and health. San Francisco: Academic Press; 1985.

Cornelius SW, Willis SL, Nesselroade JR, Baltes PB. Convergence between attention variables and factors of psychometric intelligence in older adults. Intelligence 1983;7:253–269.

Craik, FIM. Changes in memory with normal aging: A functional view. In: Wurtman, RJ.; Corkin, S.; Growdon, JH.; Ritter-Walker, E., editors. Advances in neurology: Alzheimer's disease. Vol. 51. New York: Raven Press; 1990.

Cunningham WR, Birren JE. Age changes in the factor structure of intellectual abilities in adulthood and old age. Educational and Psychological Measurement 1980;4:13–149.

Cunningham WR, Clayton V, Overton W. Fluid and crystallized intelligence in young and old adulthood. Journal of Gerontology 1975;30:53–55. [PubMed: 1109393]

Dannefer, D. Differential gerontology and the stratified life course. In: Maddox, GL.; Lawton, MP., editors. Annual review of gerontology and geriatrics 8: Varieties of aging. New York: Springer Publishing; 1988. p. 3-36.

Dannefer D. Cumulative advantage/disadvantage and the life course: Cross-fertilizing age and social science theory. Journal of Gerontology: Social Sciences 2003;S8B(6):S327–S337.

Deary IJ, Egan V, Gibson GJ, Austin EJ, Brand CR, Kellaghan T. Intelligence and the differentiation hypothesis. Intelligence 1996;23:105–132.

de Frias CM, Lovden M, Lindenberger U, Nilsson L. Revisiting the dedifferentiation hypothesis with longitudinal multi-cohort data. Intelligence 2007;35:381–392.

Denny NW, Palmer AM. Adult age differences on traditional and practical problem-solving measures. Journal of Gerontology 1981;36:323–328. [PubMed: 7229279]

Ekstrom, RB.; French, JW.; Harman, H.; Derman, D. Kit of factor-referenced cognitive tests. Vol. Rev. Princeton, N.J.: Educational Testing Service; 1976.

Elias MF, Elias PK. Hypertension affects neurobehavioral functioning: So what's new? Psychonomic Medicine 1993;55:51–54.

Elias, MF.; Elias, JW.; Elias, PK. Biological and health influences on behavior. In: Birren, JE.; Schaie, KW., editors. Handbook of the psychology of aging. New York: Academic Press; 1990. p. 70-102.

Foulds GA, Raven JC. Normal changes in mental abilities of adults as age advances. Journal of Mental Science 1948;94:133–142. [PubMed: 18866791]

Garrett HE. A developmental theory of intelligence. American Psychologist 1946;1:372–378.

Ghisletta P, Lindenberger U. Age-based structural dynamics between perceptual speed and knowledge in the Berlin Aging Study: direct evidence for ability dedifferentiation in old age. Psychology and Aging 2003;18:696–713. [PubMed: 14692858]

Green RF. Age-intelligence relationship between ages sixteen and sixty-four: A rising trend. Developmental Psychology 1969;34:404–414.

Green RF, Berkowitz B. Changes in intellect with age: II. Factorial analysis of Wechsler-Bellevue scores. The Journal of Genetic Psychology 1964;104:3–18. [PubMed: 14128963]

Gribbon K, Schaie KW, Parham I. Complexity of life style and maintenance of intellectual abilities. Journal of Social Issues 1980;36:47–67.

Harper, MS.; Alexander, CD. Profile of the Black elderly. In: Harper, MS., editor. Minority aging: Essential curricula content for selected health and allied health professions. Washington, DC: U.S. Department of Health and Human Services; 1990. p. 193-222.DHHS Publication No HRS-P-DV 90-4

Hertzog C. Influences of cognitive slowing on age differences in intelligence. Developmental Psychology 1989;25:636–651.

Horn, JL. Organization of data on life-span development of human abilities. In: Goulet, LR.; Baltes, PB., editors. Life-span developmental psychology: Research and theory. New York: Academic Press; 1970.

Horn, JL. The theory of fluid and crystallized intelligence in relation to concepts of cognitive psychology and aging in adulthood. In: Craik, FIM.; Trehub, S., editors. Aging and cognitive processes. New York: Plenum; 1982. p. 77-117.

Horn, JL.; Hofer, SM. Major abilities and development in the adult period. In: Sternberg, R.; Berg, C., editors. Intellectual development. New York: Cambridge University Press; 1992. p. 44-99.

Horn JL, McArdle JJ. A practical and theoretical guide to measurement invariance in aging research. Experimental Aging Research 1992;18:117–144. [PubMed: 1459160]

Horn, JL.; Noll, J. Human cognitive capabilities: Gf–Gc theory. In: Flanagan, DP.; Genshaft, J.; Harrison, PL., editors. Contemporary intellectual assessment: Theories, tests, and issues. New York: Guilford Press; 1997. p. 53-91.

House J, Landis K, Umberson D. Social relationships and health. Science 1988;241:540–565. [PubMed: 3399889]

Hultsch DF, Hertzog C, Small BJ, Dixon RA. Use it or lose it? Engaged life style as a buffer of cognitive decline in aging. Psychology and Aging 1999;14:245–263. [PubMed: 10403712]

Kesler MS, Denny NW, Whitney SE. Factors influencing problem solving in middle-aged and elderly adults. Human Development 1976;19:310–320.

Kitayama, S. Cultural variations in cognition: Implications for aging reasarch. In: Stern, P.; Carstensen, L., editors. The Aging Mind: Opportunities for aging research. National Academy of Sciences Press; Washington D.C.: 2000. p. 217-239.

Lindenberger U, Baltes P. Intellectual functioning in old and very old age: cross-sectional results from the Berlin Aging Study. Psychology and Aging 1997;12(3):410–432. [PubMed: 9308090]

Livingston IL, Levine DM, Moore RD. Social integration and Black intraracial variation in blood pressure. Ethnicity and Disease 1991;1:135–149. [PubMed: 1842530]

Lövdén M, Ghisletta P, Lindenberger U. Cognition in the Berlin Aging Study (BASE): The first 10 years. Aging, Neuropsychology, and Cognition 2004;11:104–133.

McGaw B, Joreskog KG. Factorial invariance of ability measures in groups differing in intelligence and socioeconomic status. British Journal of Mathematical and Statistical Psychology 1971;24:154–168.

McHugh RB, Owens WA. Age changes in mental organization—a longitudinal study. Journal of Gerontology 1954;9:296–302. [PubMed: 13184112]

National Vital Statistics Reports. United States Life tables. 2007 December 28;2004

Owens WA. Age and mental abilities: A second adult follow-up. Journal of Educational Psychology 1966;57:311–325. [PubMed: 5958121]

Park, DC. The basic mechanisms accounting for age-related decline in cognitive function. In: Park, D.; Schwarz, N., editors. Cognitive aging: A primer. Philadelphia: Taylor & Francis; 2000. p. 3-21.

Park DC, Lautenschlager G, Hedden T, Davidson NS, Smith AD, Smith PK. Models of visuospatial and verbal memory across the adult life span. Psychology and Aging 2002;17:299–320. [PubMed: 12061414]

Park DC, Nisbett RE, Hedden T. Aging, culture, and cognition. Journal of Gerontology: Psychological Sciences 2000;54B:75–84.

Perlmutter, M.; Adams, C.; Berry, J.; Kaplan, M.; Persons, D.; Verdonic, F. Memory and aging. In: Schaie, KW., editor. Annual review of gerontology and geriatrics. New York: Springer; 1988. p. 57-92.

Perlmutter M, Nyquist L. Relationships between self-reported physical and mental health and intelligence performance across adulthood. Journal of Gerontology 1990;45:145–155.

Rey A. L'examen psychologique dans les cas d'encephalopathie tramatique. Archives de Psychologie 1941;28:21.

Ripple RE, Jaquish GA. Fluency, flexibility, and originality in later adulthood. Educational Gerontology 1981;7:1–10.

Rosano C, Simonsick EM, Harris TB, Kritchevsky SB, Brach J, Visser M, et al. Association between physical and cognitive function in health elderly: The Health, Aging, and Body Composition Study. Neuroepidemiology 2005;24:8–14. [PubMed: 15459503]

Salthouse TA. Mediation of adult age differences in cognition by reductions in working memory and perceptual speed. Psychological Science 1991;2:179–183.

Salthouse TA. The nature of the influence of speed on adult age differences in cognition. Developmental Psychology 1994;30:240–259.

Salthouse TA, Babcock RL. Decomposing adult age differences in working memory. Developmental Psychology 1991;27:763–776.

Salthouse TA, Hambrick DZ, Lukas KE, Dell TC. Determinants of adult age differences on synthetic work performance. Journal of Experimental Psychology, Applied 1996;2:305–329.

Salthouse TA, Meinz EJ. Aging, inhibition, working memory and speed. Journal of Gerontology: Psychological Sciences and Social Sciences 1995;50(6):P297–P306.

Saxby BK, Harrington F, McKeith IG, Wesnes K, Ford GA. Effects of hypertension on attention, memory, and executive function in older adults. Health Psychology 2003;22:587–591. [PubMed: 14640855]

Schaie, KW. The Seattle Longitudinal Study: A twenty-one year exploration of psychometric intelligence in adulthood. In: Bengston, VL.; Schaie, KW., editors. The course of latter life: Research and reflections. New York: Springer; 1983. p. 68-83.

Schaie, KW. Individual differences in rate of cognitive change in adulthood. In: Bengston, VL.; Schaie, KW., editors. The course of latter life: Research and reflections. New York: Springer; 1989. p. 68-83.

Schaie KW. The course of adult intellectual development. American Psychologist 1994;49:304–313. [PubMed: 8203802]

Schaie, KW. Developmental influences on cognitive development: The Seattle Longitudinal Study. New York: Oxford University Press; 2004.

Selzer SC, Denny NW. Conservation abilities among middle-aged and elderly adults. International Journal of Aging and Human Development 1980;11:135–146. [PubMed: 7203657]

Sliwinski M, Buschke H. Cross-sectional and longitudinal relationships among age, cognition, and processing speed. Psychology and Aging 1999;14:18–33. [PubMed: 10224629]

Taub GE, McGrew KS, Witta EL. A confirmatory analysis of the factor structure and cross-age invariance of the Wechsler Adult Intelligence Scale-Third Edition. Psychological Assessment 2004;16:85–89. [PubMed: 15023096]

Verhaegen P, Borchelt M, Smith J. Relation between cardiovascular and metabolic disease and cognition in very old age: cross-sectional and longitudinal findings from the Berlin Aging Study. Health Psychology 2003;22(6):559–569. [PubMed: 14640852]

Vernon, PE. Intelligence and Cultural Environment. London: Methuen; 1969.

Waldstein, SR. Committee on Future Directions for Cognitive Research on Aging Commission on Behavioral and Social Sciences and Education. Health effects on cognitive aging. In: Stern, PC.; Carstensen, LL., editors. The Aging Mind: Opportunities in Cognitive Research. Washington, D.C.: National Academy Press; 2000. p. 189-217.

Wechsler, D. The Wechsler Adult Intelligence Scale-Revised. New York: Psychological Corporation; 1981.

Whitfield KE. Accelerated cognitive aging: a hypothesis to account for racial differences. African American Perspectives 2004;10(1):120–129.

Whitfield, KE.; Aiken-Morgan, A. Minority populations and cognitive aging. In: Hofer, S.; Alwin, D., editors. Handbook of Cognitive Aging. Sage Publications; 2008. p. 384-396.

Whitfield KE, Baker TA. Individual differences in aging among African-Americans. International Journal of Aging and Human Development 1999;48(1):73–79. [PubMed: 10363561]

Whitfield KE, Fillenbaum G, Peiper C, Seeman TE, Albert MS, Berkman LF, Blazer DG, Rowe JW. The effect of race and health related factors on naming and memory: The MacArthur Studies of Successful Aging. Journal of Aging and Health 2000;12(1):69–89. [PubMed: 10848126]

Whitfield KE, Seeman TE, Miles TP, Albert MS, Berkman LF, Blazer DG, et al. Health indices as predictors of cognition among older African Americans: MacArthur Studies of Successful Aging. Ethnicity and Disease 1997;7:127–136. [PubMed: 9386953]

Whitfield KE, Wiggins S. The impact of desegregation on cognition among older African Americans. Journal of Black Psychology 2003;29:275–291.

Whitfield KE, Willis S. Conceptual issues and analytic strategies for studying cognition in older African Americans. African-American Research Perspectives 1998;4(1):115–125.

Ylikoski R, Ylikoski A, Raininko R, Keskivaara P, Sulkava R, Tilvis R, et al. Cardiovascular diseases, health status, brain imaging findings and neuropsychological functioning in neurologically healthy elderly individuals. Archives of Gerontological Geriatrics 2000;30:115–130.

Zachary, RA. Shipley Institute of Living Scale, Revised manual. Los Angeles: Western Psychological Services; 1986.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Zelinski EM, Lewis KI. Adult age differences in multiple cognitive functions: differentiation, dedifferentiation, or process-specific change? Psychology and Aging 2003;18:727–745. [PubMed: 14692860]

Zelinski EM, Stewart S. Individual differences in 16-year memory changes. Psychology and Aging 1998;13:622–630. [PubMed: 9883462]

**Table 1**

**Participant demographic information**

| | 50-59 Age Group n = 107 Mean (Std.Dev) | 60-69 Age Group n = 198 Mean (Std.Dev) | 70-79 Age Group n = 207 Mean (Std.Dev) |
|---|---|---|---|
| Age | 54.64 (2.87) | 64.98 (2.80) | 74.32 (2.83) |
| Years of education | 12.49 (2.84) | 11.84 (2.86) | 11.40 (2.81) |
| Gender | % Men = 35% | % Men = 28% | % Men = 18% |

**Table 2**

**Model estimates, model fit, and chi-square change**

| | Current model | | | | | | Comparison to previous model |
|---|---|---|---|---|---|---|---|
| | $X^2$ | df | p | NFI | CFI | RMSEA | $\Delta X^2$ |
| Unconstrained | 436.69 | 223 | .000 | .86 | .92 | .04 | |
| Factor loadings set to equality | 465.85 | 247 | .000 | .85 | .92 | .04 | 29.16 |
| Covariances set to equality | 483.37 | 263 | .000 | .84 | .92 | .04 | 17.52 |

## Table 3

### Factor loadings across age subgroups

| | 50-59 | 60-69 | 70-79 |
|---|---|---|---|
| **Inductive Reasoning** | | | |
| Shipley Reasoning | 1.00 | 1.00 | 1.00 |
| **Verbal Memory** | | | |
| Immediate Recall | .72 | .73 | .72 |
| HVLT | .44 | .50 | .65 |
| AVLT | .62 | .68 | .063 |
| **Verbal Ability** | | | |
| ETS Vocabulary A | .87 | .88 | .87 |
| ETS Vocabulary B | .85 | .88 | .89 |
| Shipley Vocabulary | .87 | .90 | .88 |
| **Working Memory** | | | |
| Operation Span | .51 | .60 | .41 |
| Backward Digit Span | .64 | .65 | .66 |
| Alpha Span | .76 | .79 | .72 |
| **Perceptual Speed** | | | |
| Digit Symbol | .83 | .83 | .83 |
| Number Comparison | .74 | .74 | .74 |
| Identical Pictures | .78 | .78 | .76 |

## Table 4

**Factor correlations for age groups**

| **50-59** | **Inductive Reasoning** | **Verbal Memory** | **Verbal Ability** | **Working Memory** | **Perceptual Speed** |
|---|---|---|---|---|---|
| Inductive Reasoning | -- | -- | -- | -- | -- |
| Verbal Memory | .57 | -- | -- | -- | -- |
| Verbal Ability | .66 | .53 | -- | -- | -- |
| Working Memory | .63 | .71 | .57 | -- | -- |
| Perceptual Speed | .55 | .63 | .54 | .64 | -- |
| 60-69 | Inductive Reasoning | Verbal Memory | Verbal Ability | Working Memory | Perceptual Speed |
| Inductive Reasoning | -- | | | | |
| Verbal Memory | .57 | -- | | | |
| Verbal Ability | .59 | .56 | -- | | |
| Working Memory | .62 | .69 | .57 | -- | |
| Perceptual Speed | .52 | .58 | .47 | .68 | -- |
| 70-79 | Inductive Reasoning | Verbal Memory | Verbal Ability | Working Memory | Perceptual Speed |
| Inductive Reasoning | -- | | | | |
| Verbal Memory | .73 | -- | | | |
| Verbal Ability | .64 | .59 | -- | | |
| Working Memory | .79 | .72 | .73 | -- | |
| Perceptual Speed | .70 | .72 | .63 | .70 | -- |

**Table 5**

**Factor mean differences across age groups (t-scores)**

| | 50-59 | 60-69 | 70-79 |
|---|---|---|---|
| Inductive reasoning | 54.34*+ | 49.76 | 48.02 |
| Verbal ability | 51.15 | 49.84 | 49.96 |
| Verbal memory | 51.64 | 51.11 | 49.81 |
| Perceptual speed | 54.37*+ | 51.06+ | 48.97 |
| Working memory | 52.18*+ | 50.51 | 49.70 |

*significantly greater than 60-69 group

+significantly greater than 70-79 group