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Keywords
Centenarians, normative, cognition, oldest old, Georgia Centenarian Study, Memory

Disciplines
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Norms from the Georgia Centenarian Study: Measures of verbal abstract reasoning, fluency, memory, and motor function

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Abstract

We previously presented normative data from a relatively large, population-based sample (n = 244) of centenarians and a reference group of octogenarians (n = 80) for several brief, global neurocognitive tasks adapted for use for older adults with physical and sensory limitations (Miller et al., 2010). Here, we present additional normative data on several domain-specific tasks from these samples from Phase III of the Georgia Centenarian Study, including measures of verbal abstract reasoning, fluency, memory, and motor function. Expected age differences were demonstrated across all cognitive measures, and, consistent with our previous findings, centenarians showed a stronger association between age and performance. Normative tables are presented unweighted as well as population-weighted, and stratified by age and education level. These findings offer a unique contribution to the literature on cognitive aging, as normative performance in this age group is understudied and largely unavailable to clinicians and researchers.

Introduction

Centenarians represent an increasingly large segment of the United States (US) population, with the most recent census estimating over 53,000 living in the US in 2010 (US Census,

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The contents of this study do not represent the views of the U.S. government or the Department of Veterans Affairs.

2010), and a relative increase in the proportion of the population reaching age 100 has been reported in many industrialized nations, including the US, England and Wales, Japan, and Sweden (Hagberg, Bauer Alfredson, Poon, & Homma, 2001). Available normative data on cognitive test performance of commonly administered neuropsychological tests is lacking in this age group. For example, the most recent version of the Wechsler Adult Intelligence Scale (WAIS-IV) provides normative comparisons for adults up to age 90 (Wechsler, 2008) and even clinical research programs specifically aimed at providing normative data for older adults face challenges with having adequate sample sizes for this exceptionally old age group (Ivnik et al., 1992). In addition to the paucity of normative data on standardized tests for centenarians, standardized tests themselves pose practical issues for assessing centenarians, as there are increasing levels of sensory and motor impairments that may attenuate performance on cognitive measures designed for younger examinees and may thus put centenarians at an unfair disadvantage (Poon et al., 2012).

Several studies have followed centenarians and near-centenarians longitudinally, but there is considerable variability in the sampling methods used (Poon et al., 2007; Silver, Jilinskaia, & Perls, 2001). Recruiting participants from this cohort presents unique challenges, as the population of centenarians in any given geographic area is relatively small, and physical limitations may limit a potential participant's likelihood of volunteering for a study. The use of convenience samples is understandably more common when recruiting centenarians for research studies, which in turn limits the generalizability of findings from these studies. In light of these methodological considerations, Phase III of the Georgia Centenarian Study sought to recruit centenarians using a population-based recruitment strategy, and additionally includes post-construction analyses that were designed to enable census-based statistical weighting in order to accurately represent the full population of centenarians residing in 44 counties of Northeast Georgia (Poon, et al., 2012). These sampling and statistical methods enable us to provide more accurate data regarding the normative performance of centenarians. In addition, the Georgia Centenarian Study includes global and domain-specific measures of cognitive function, each of which was chosen to be sensitive to variability in this population (i.e., tests that were prone to floor effects in impaired populations were not used) and tests were modified to minimize effects of sensory and motor limitations.

We previously presented both raw and population-weighted normative data on several measures of global cognitive functioning (Miller, et al., 2010) from Phase III of the Georgia Centenarian Study including the Mini-Mental Status Exam (Folstein, Folstein, & McHugh, 1975), the Severe Impairment Battery (Saxton, McGonigle-Gibson, Swihart, Miller, & Boller, 1990), and the Behavioral Dyscontrol Scale (Grigsby, Kaye, & Robbins, 1992; Grigsby & Kaye, 1996). Here, we present additional data on the normative performance of this sample on several domain-specific cognitive measures, including measures of verbal abstract reasoning, memory, and motor function. These measures were based on tests that were developed using standardized testing procedures, but were modified to reduce floor effects and maximize likelihood that centenarians could complete the tasks. As with our previous work, we present corresponding data from a smaller cohort of octogenarians as a reference for comparison.

Method

Participants

Participants were from a population-based sample of 244 community-dwelling and institutionalized centenarians and near centenarians (age 98 or older; hereafter referred to as the centenarian group) and 80 octogenarians from the Georgia Centenarian Study (GCS). These sample sizes represent our final samples after contacting a total of 174 octogenarians and 378 centenarians asked to participate. Of these, 94 octogenarians and 129 centenarians declined to participate, and an additional 5 centenarians died prior to study completion. All participants included in the normative data presented below were administered a cognitive test battery that included the Wechsler Adult Intelligence Scale-III (WAIS-III) Similarities subtest, a measure of verbal abstract reasoning (Wechsler, 1997), an abbreviated Controlled Oral Word Association Test (COWAT), a measure of verbal fluency, the Fuld Object Memory Evaluation (FOME), a measure of verbal episodic memory (Fuld, Masur, Blau, Crystal, & Aronson, 1990), and measures of motor functioning, which were modified measures of motor speed (hand tapping) and gross motor strength (grip strength).

We sought to present normative data divided into as many age ranges as possible while still maintaining a sufficient number of participants within each age range. Octogenarians were divided into two 5-year cohorts (80–84; 85–89) and centenarians (defined as age range 98 – 107) were divided into two 2-year age range cohorts (98–99 and 100–101) and a final 5-year age range cohort (102–107). The average age of the centenarian sample was 100.6 years (*SD* = 2.04) and average education was 10.6 years (*SD* = 3.78). The centenarian sample was predominantly female (n = 207, 85 %), Caucasian (n = 192, 79 %), and 37 percent were living independently (n = 91). The average age of the octogenarian sample was 84.3 years (*SD* = 2.78), and average education was 12.9 years (*SD* = 3.52). The octogenarian sample was predominantly female (n = 53, 66 %), Caucasian (n =66, 83 %), and 84 percent were living independently (n = 67).

Recruitment and Sampling Strategies

For complete details on the sampling methods used in the GCS, please to refer to earlier work from GCS investigators (Poon, et al., 2007). Briefly, the GCS recruited centenarian and octogenarian samples from 44 counties in northeast Georgia and used two sampling strategies. First, a census of all skilled nursing facilities (SNFs) and personal care homes (PCHs) located in the 44-county area was compiled and counts of all beds at each facility were made. SNFs and PCHs were selected and contacted by interviewers, who explained the study and requested lists of all residents age 98 or older, who were then contacted by study staff. Second, registered voter lists were obtained for the entire 44-county area and date of birth was used to identify adults age 98 or older, who were then contacted by study interviewers via telephone. Using these two recruitment techniques, there was some overlap in potential participants identified (i.e., SNF or PCH residents were in some cases also identified on voter registration lists).

In order to ensure that our sample represented the 44 counties and reflected the number of centenarians estimated to reside in each based on estimates from the 2000 United States

census, the 44 counties were divided into four strata, defined to be largely contiguous and with approximately the same number of centenarians. We then identified a target number of centenarians in each stratum by defining the census estimate of individuals in each stratum who were age 98 or older at the beginning of the field period for that stratum. Our sample represented 19.6% of all centenarians residing in our defined geographic area, and demographic comparisons with special tabulations from the 2000 census data and Centers for Medicare and Medicaid Services suggested a broadly representative sample.

In order to adjust for remaining known differences between our sample and the population, sampling weights (estimated to reflect the observed sample size) were developed and described in full detail in a supplement to Arnold et al. (2010). An iterative (or raking) procedure was used to create population-adjusted weights with the goal of bringing the weighted sample distribution in close agreement with the population estimates from the 2000 Census on five demographic characteristics (county, age, gender, race, and type of residence). Each of the five characteristics was used to create an adjusted weighting, and then additional characteristics were added successively in pairs to create readjusted estimates using cross-tabulation. This procedure was done in an iterative fashion until the weighted values stabilized across iterations, yielding a stable set of weights. Results from both weighted and unweighted analyses are reported below.

In addition, 80 octogenarians (age 80 to 89) were recruited as a control group, and they were administered the same measures that were given to the centenarians. Based on the proportion of institutionalized octogenarians according to the 2000 census, we recruited approximately 85% of the sample of octogenarians from the voter registration rolls and 15% from the SNF and PCH sites in those same counties.

Procedure

In order to provide normative data for our population-based sample of centenarians, participants were not excluded for physical or cognitive impairments. All participants completed study measures across multiple home-based study sessions, which included measures of physical and mental health, cognition, functional capacity, genetics, nutrition, resources and adaptations, and personality as part of the larger GCS study. All participants or their legal proxy provided informed written consent prior to participating. All test administration was conducted by trained GCS research assistants. Depending on the number of sessions completed, participants were paid up to $600 for their participation in the larger study. This study was approved by the University of Georgia Institutional Review Board.

Measures

WAIS-III Similarities (Wechsler, 1997)—The WAIS-III Similarities test was administered according to standardized procedures specified in the WAIS-III manual. A measure of verbal abstract reasoning, the examinee is presented with two words and asked to say how they are alike. Items are scored on an ordinal scale with 0 representing an incorrect or non-response, 1 representing a concrete response, and 2 representing an abstract response.

Controlled Oral Word Association Test (COWAT; (Benton & Hamsher, 1978)— The COWAT is a measure of verbal fluency, typically administered by averaging responses across three 60-second trials with three phonemic cues (typically the letters F, A, S or C, F, L). The GCS version was modified for use in centenarians to reduce undue burden of task difficulty. Specifically, participants were given 30 seconds to name as many different words as they could think of beginning with the letter "C." Participants were instructed to not give responses that were proper names, such as the names of people or places (e.g., "Bob" or "Boston" for the letter "B") and they were not to use the same word with different endings (such as "eat," and "eating"). Raw scores presented below are based on the total number of correct responses generated in 30 seconds.

Fuld Object Memory Evaluation (FOME, (Fuld, 1980)—The FOME was developed for assessing memory in individuals with significant cognitive, physical, and/or sensory impairment and was designed to provide useful information regarding cognitive functioning at lower levels of performance (Fuld, Masur, Blau, & Crystal, 1990). The FOME has numerous advantages for use in a frail population such as centenarians, as items are quite simple and designed to minimize floor effects. Participants engage in controlled learning of 10 common objects that are presented via multiple sensory modalities in order to maximize the likelihood of encoding. Specifically, participants are first instructed to feel each unseen object by handling the object in a bag (tactile naming). After tactile naming of each object, each object is visually presented and named if not already correctly identified via tactile naming (visual naming). Next, five recall trials are administered, with selective reminding of objects not recalled at the end of each trial. Each recall trial is followed by an interference task (60 sec. trials of semantic fluency after the first learning trial and 30 sec trials of semantic fluency following each of the next four learning trials). The sum of correctly recalled items across all learning trials represents the FOME Retrieval Trials 1–5 score (range = 0–50). Following the five recall trials, participants are tested for their memory of the 10 items after a 5-minute delay (FOME Delayed Recall, range = 0–10). Items not freely recalled during delayed recall are subsequently tested (following a 60 sec. delay) by asking the participant to identify the correct word in a three-choice multiple choice format. The sum of all freely recalled words and correctly recognized words represents an estimate of all items retained (FOME Retention Estimate, range = 0–10).

Motor Testing (Reitan, 1985)—Given the prevalence of fine motor impairment and arthritis in centenarians, GCS investigators modified a commonly used neuropsychological measure of motor speed, the Finger Tapping Test (Reitan, 1985), for use in this study. Specifically, participants performed a hand tapping test, in which they were asked to tap their dominant hand on a table as quickly as possible. Performance (recorded as number of hand taps) was based on the number of hand taps completed in ten seconds. Gross motor strength was assessed with a modified version of the Grip Strength test (Reitan, 1985), and raw scores represent grip strength on a single trial using the dominant hand. While both motor tests were originally designed to compare performance across dominant and non-dominant hands and to detect lateralized motor impairments, the GCS-modified versions of these tests were modified in order to get a global assessment of overall motor function, with

the expectation that increased motor impairments in centenarians would limit the utility of the traditionally-administered tests.

Results

Overall performance of centenarians as a group and octogenarians as a group are provided in Table 1, as well as a statistical comparison of group differences. Figures 1–3 additionally portray average performance across age cohorts on the WAIS-III Similarities, abbreviated COWAT, and FOME summary scores. Across all measures, expected large group differences were found, with centenarians consistently having lower average performance. In our previous normative paper examining performance of octogenarians and centenarians on global cognitive measures, we found that as age increased, variability in test scores and dispersion of scores also increased. Interestingly, we did not find a consistent pattern of increase in the dispersion or overall variability in scores in the centenarians relative to the octogenarian group on the measures included in this paper.

Table 2 provides a correlation matrix of demographic and cognitive measures in both age groups for comparison and shows some interesting differences. Age was negatively correlated with all cognitive measures in both age groups, but correlation coefficients were larger in the centenarian group, with one exception (for the correlation between age and FOME Delayed Recall, $r = -.22$ in centenarians, $r = -.23$ in octogenarians, $z = -0.02$, $p = .98$). This pattern suggests that with advanced age, there is an increase in the strength of the relationship between cognitive performance and age. In both age groups, education was positively correlated with test performance, and these relationships were statistically significant with one exception in the octogenarian group (for the correlation between education and grip strength, $r = .18$, $p = .11$). As is shown in Table 2, education did not appear to have a differential influence on cognitive test scores in one age group versus the other.

Normative performance on all tasks is presented in several ways in Tables 3–5. First, Table 3 provides the raw descriptive scores, including *N*, mean, standard deviation, minimum, and maximum score for each age range, and so as to be used to calculate *z*-scores if an exact standardized score is desired. For ease of clinical use, we additionally present normative tables that list the percentile equivalent of raw test scores on each measure by age group. These scores are based on both the uncorrected, raw performances of our sample, alongside the population-weighted scores (provided parenthetically) for comparison in Table 4. Finally, Table 5 provides an additional level of normative specificity by providing percentiles by age cohort and dichotomized education level (less than high school versus high school or greater, or 0–11 versus 12+ years of education), and also includes population-weighted normative estimates parenthetically.

Discussion

This paper is provided to serve as a companion to our previous paper presenting normative performance on global test measures, and both papers in conjunction can be used to guide development of test batteries for centenarians or extremely old participants in clinical

research and applied settings. Relative to the extant normative data on centenarians, the GCS is exceptional in its design, in that it sought to obtain a population-based sample, and additionally used sophisticated but well validated statistical techniques to adjust scores to even more closely represent US Census-based demographic characteristics of our geographic region. While we view this sampling technique as a strength of our study, the representation of all levels of cognitive impairment in our normative samples (including dementia) should be considered when using our normative tables.

Perhaps the most interesting finding from this study was that there was not a consistent pattern of increased variability and dispersion of scores as age increased. This finding perhaps reflects variability in the sensitivity of the domain-specific measures used in this paper versus the global measures used in our previous work, as well as the basis for scoring global versus task-specific measures. Specifically, the global measures presented in our previous work (e.g., the Severe Impairment Battery, the Mini-Mental State Examination) are scored based on scoring criteria that scale responses based on a standardized scoring procedure, and the tests are designed to track cognitive impairments even at very low levels of cognitive functioning. In contrast, the majority of tests presented in this paper are scored purely based on the raw number of correct responses generated (e.g., COWAT, motor testing, FOME), are in one instance not designed with the level of impairment seen in centenarians in mind (WAIS-III Similarities), and/or have a timed component to performance (e.g., COWAT, motor testing), that may reduce or altar the range of scores on these measures. Additionally, global measures maximize the likelihood of capturing the full range of variability within age groups that is represented in one summary score, whereas domain-specific tasks limit variability to the specific cognitive function being assessed. Our findings are consistent with previous multi-national comparisons of centenarian cognitive performance, which have found that the increase in variability with age is an effect that is task-dependent, with tasks that tap fluid abilities or speeded performance showing *less* variability at these levels of advanced age, as centenarians reach a lower limit of performance on these measures (Hagberg, et al., 2001). However, our data represent a significant addition to the literature in that little data beyond mental status tasks have been previously provided for such a large and representative sample of centenarians. The addition of an 80–89 year old “comparison” cohort is also hoped to provide information for appraising level of cognitive ability for those using these normative sets.

Limitations of our study include our exclusion of additional demographic variables in our normative tables (e.g., community dwelling versus institutionalized, performance by racial category or gender). These additional levels of demographic specificity were omitted due to the low sample sizes that would result from a breakdown of performances by these classification schemes. Similarly, our dichotomized breakdown of education was chosen in order to have sufficient samples at each education and age level.

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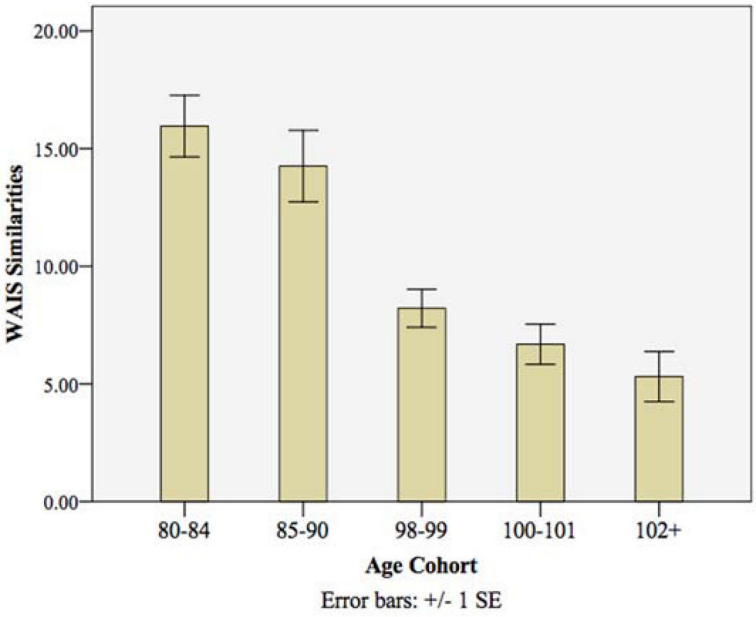


Figure 1.
WAIS-III Similarities raw score by age cohort (Mean score +/− 1 S.E.).

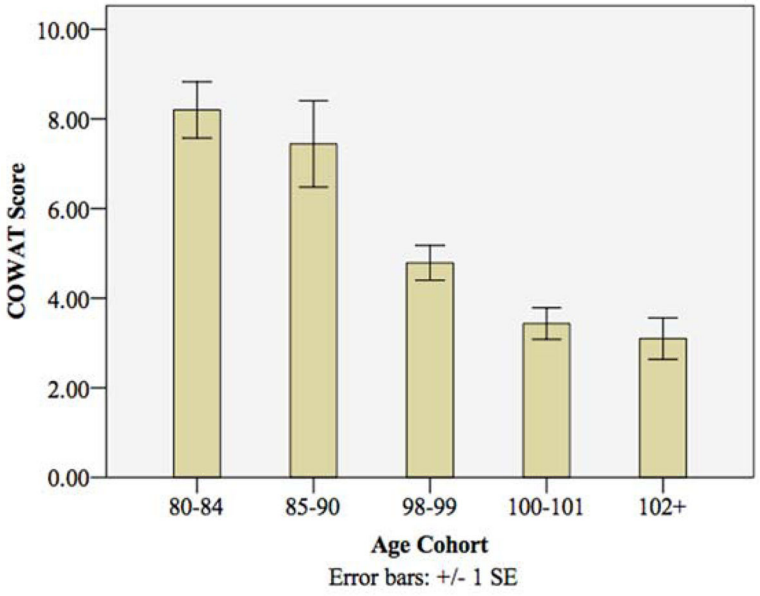
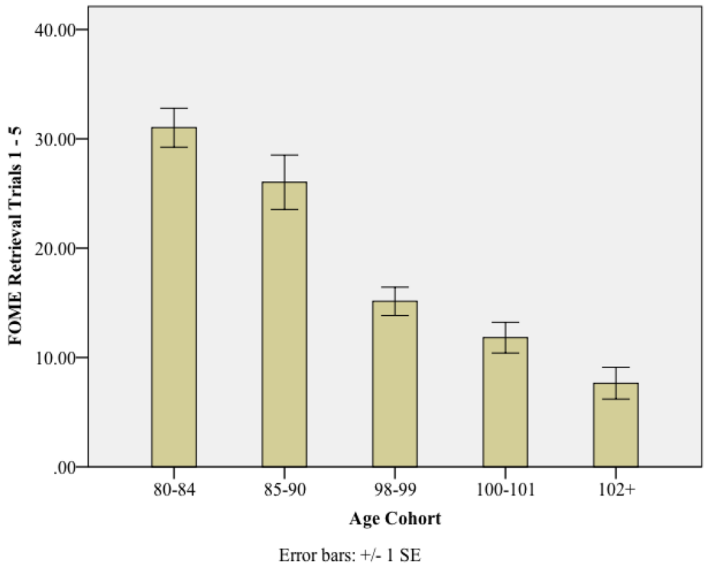
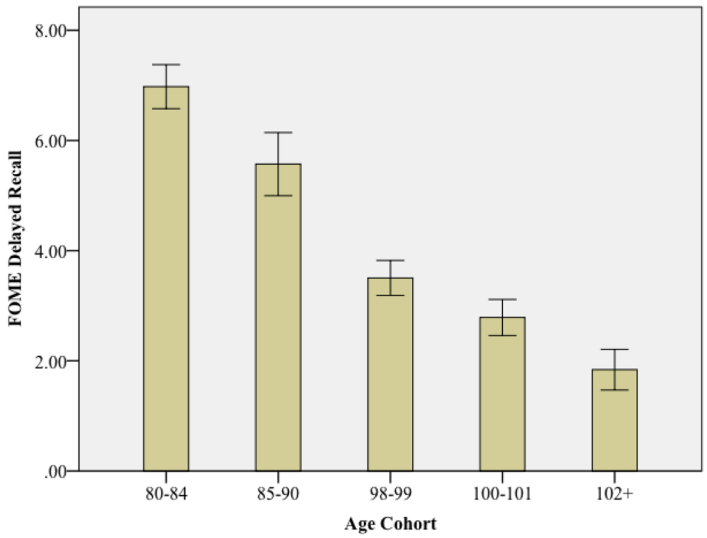


Figure 2.

Abbreviated Controlled Oral Word Association test (COWAT) raw score by age cohort (Mean score +/− 1 S.E.).



Error bars: +/- 1 SE



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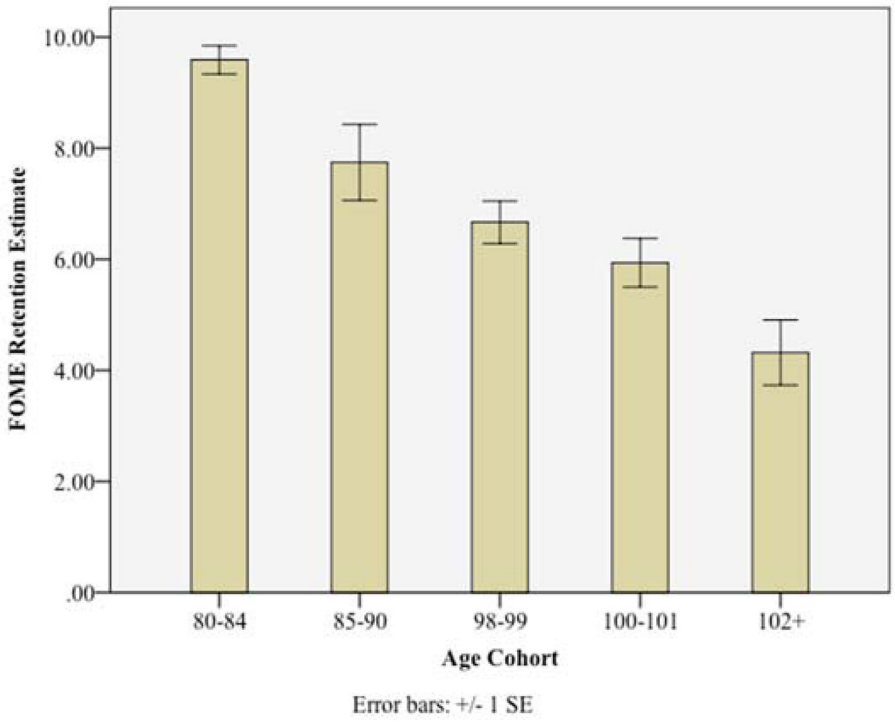

Figure 3.
Fuld Object Memory Examination summary scores by age cohort (Mean score +/− 1 S.E.)

Table 1

Comparison of task means by age group.

Age Group	N	Mean	*SD*	df	F	Partial η2	Mean Diff
			Similarities				
Octogenarian	80	15.21	8.84	1, 317	58.343*	0.156	8.13
Centenarian	238	7.08	8.03				
			COWAT				
Octogenarian	79	7.87	4.84	1, 313	58.007*	0.157	3.92
Centenarian	235	3.95	3.61				
			Fuld Object Memory Evaluation Retrieval Trials 1–5				
Octogenarian	80	28.84	13.36	1, 317	96.389*	0.234	16.45
Centenarian	238	12.39	12.83				
			Fuld Object Memory Evaluation Delayed Recall				
Octogenarian	79	6.35	3.06	1, 313	74.65*	0.193	3.45
Centenarian	235	2.91	3.07				
			Fuld Object Memory Evaluation Retention Estimate				
Octogenarian	79	8.77	3.09	1, 313	32.731*	0.095	2.85
Centenarian	235	5.92	4.05				
			Number of hand taps				
Octogenarian	80	44.12	15.50	1, 315	47.435*	0.131	15.61
Centenarian	236	28.51	18.14				
			Average grip strength				
Octogenarian	80	21.49	12.22	1, 322	62.294*	0.163	11.17
Centenarian	243	10.32	10.54				

*$p < .001$, two tailed.

Neuropsychol Dev Cogn B Aging Neuropsychol Cogn. Author manuscript; available in PMC 2014 December 31.

Table 2

Correlations between tasks by age group.

Variable		1	2	3	4	5	6	7	8	9
1. Age	r		.025	−.105	−.109	−.196	−.225*	−.279*	−.197	−.221*
	N		80	80	79	80	79	79	80	80
2. Education	r	−.093		.583**	.426**	.283*	.262*	.283*	.317**	.179
	N	237		80	79	80	79	79	80	80
3. WAIS Similarities	r	−.141*	.518**		.682**	.612**	.577**	.550**	.529**	.248*
	N	238	231		79	80	79	79	80	80
4. COWAT	r	−.189**	.415**	.678**		.647**	.616**	.559**	.589**	.427**
	N	235	228	234		79	78	78	79	79
5. FOME Retrieval Trials 1–5	r	−.239**	.253**	.665**	.733**		**.909	.790**	.607**	.386**
	N	238	231	236	234		79	79	80	80
6. FOME Delayed Recall	r	−.223**	.233**	.644**	.702**	.958**		.792**	.539**	.342**
	N	235	228	233	231	235		79	79	79
7. FOME Retention Estimate	r	−.231**	.283**	.586**	.687**	.839**	.796**		.545**	.481**
	N	235	228	233	231	235	235		79	79
8. Number of hand taps	r	−.297**	.281**	.488**	.620**	.619**	**.602	.732**		.351**
	N	236	229	235	234	235	232	232		80
9. Average grip strength	r	−.245**	.205**	.279**	.372**	.382**	**.358	.423**	.381**	
	N	243	236	238	235	238	235	235	236	

Note. Correlations for Octogenarians are shown above the diagonal. Correlations for Centenarians are shown below the diagonal. Age = Age in Years. Education = Highest grade completed. FOME = Fuld Object Memory Evaluation.

* $p < 0.05$ 0.05 level;

** $p < 0.01$, 2-tailed.

Table 3

Descriptive Statistics by Age Cohort

Age	*N*	*M*	*SD*	Min	Max
Similarities					
80–84	45	15.96	8.76	0	32
85–90	35	14.26	8.97	0	32
98–99	107	8.22	8.37	0	30
100–101	80	6.69	7.66	0	26
102+	51	5.31	7.62	0	26
COWAT					
80–84	45	8.20	4.20	0	17
85–90	34	7.44	5.62	0	19
98–99	103	4.79	3.94	0	17
100–101	81	3.43	3.16	0	13
102+	51	3.10	3.29	0	11
Fuld Object Memory Evaluation Retrieval Trials 1–5					
80–84	45	31.02	11.94	0	48
85–90	35	26.03	14.69	0	45
98–99	105	15.14	13.29	0	40
100–101	82	11.82	12.79	0	42
102+	51	7.65	10.39	0	36
Fuld Object Memory Evaluation Delayed Recall					
80–84	44	6.98	2.65	0	10
85–90	35	5.57	3.39	0	10
98–99	105	3.50	3.25	0	10
100–101	80	2.79	2.93	0	10
102+	50	1.84	2.61	0	9
Fuld Object Memory Evaluation Retention Estimate					
80–84	44	9.59	1.69	0	10
85–90	35	7.74	4.05	0	10
98–99	105	6.67	3.93	0	10

Neuropsychol Dev Cogn B Aging Neuropsychol Cogn. Author manuscript; available in PMC 2014 December 31.

Age	*N*	*M*	*SD*	Min	Max
100–101	80	5.94	3.91	0	10
102+	50	4.32	4.15	0	10
Number of hand taps					
80–84	45	46.86	14.59	0	63.5
85–90	35	40.60	16.13	0	64
98–99	105	33.70	18.03	0	60.5
100–101	81	27.22	16.52	0	59
102+	50	19.69	17.43	0	49
Average grip strength					
80–84	45	23.80	10.76	0	47.5
85–90	35	18.53	13.45	0	63.5
98–99	108	12.59	11.35	0	60
100–101	83	10.28	9.94	0	52
102+	52	5.69	8.06	0	41.5

TABLE 4

Centiles by Age Cohort

Age Cohort (Weighted Score in Parentheses)					
%ile	**80–84**	**85–90**	**98–99**	**100–101**	**102+**
			WAIS Similarities		
5th	0 (0)	- (-)	- (-)	- (-)	- (-)
10th	2 (2)	0 (0)	0 (0)	- (-)	- (-)
25th	10 (9)	8 (12)	1 (0)	0 (0)	0 (0)
50th	16 (15)	16 (14)	5 (5)	3 (4)	0 (1)
75th	22 (22)	21 (20)	14 (13)	12 (14)	9 (11)
90th	29 (30)	25 (23)	23 (20)	20 (20)	20 (22)
95th	31 (31)	29 (27)	26 (26)	23 (25)	23 (26)
N	45 (51)	35 (29)	107 (131)	80 (68)	51 (39)
			COWAT		
5th	0 (0)	- (-)	- (-)	- (-)	- (-)
10th	3 (2)	0 (0)	0 (0)	0 (0)	- (-)
25th	5 (5)	3 (4)	1 (1)	1 (1)	0 (0)
50th	8 (7)	7 (8)	4 (4)	3 (3)	3 (3)
75th	12 (12)	12 (13)	7 (7)	6 (7)	5 (7)
90th	14 (14)	16 (16)	10 (10)	8 (9)	8 (9)
95th	16 (16)	18 (17)	12 (13)	9 (10)	9 (11)
N	45 (51)	34 (28)	103 (126)	81 (71)	51 (39)
			Fuld Object Memory Evaluation Retrieval Trials 1–5		
5th	0 (0)	- (-)	- (-)	- (-)	- (-)
10th	13 (16)	0 (0)	0 (0)	0 (0)	- (-)
25th	25 (26)	17 (26)	1 (1)	0 (1)	0 (0)
50th	34 (35)	32 (33)	12 (12)	7 (12)	2 (4)
75th	40 (40)	37 (38)	27 (28)	24 (29)	13 (13)
90th	42 (42)	39 (40)	33 (34)	31 (34)	28 (28)
95th	45 (45)	43 (43)	39 (38)	35 (41)	31 (36)
N	45 (51)	35 (29)	105 (129)	82 (72)	51 (39)

	Age Cohort (Weighted Score in Parentheses)				
%ile	**80–84**	**85–90**	**98–99**	**100–101**	**102+**
	Fuld Object Memory Evaluation Delayed Recall				
5th	0(0)	- (-)	- (-)	- (-)	- (-)
10th	4(4)	0(0)	- (-)	- (-)	- (-)
25th	5(5)	3(5)	0(0)	0(0)	0(0)
50th	8(8)	7(7)	3(3)	2(3)	0(1)
75th	9(9)	8(9)	6(6)	5(6)	3(3)
90th	10(10)	9(9)	8(8)	7(7)	6(6)
95th	10(10)	10(10)	9(9)	8(10)	8(9)
N	44(50)	35(29)	105(129)	80(71)	50(38)
	Fuld Object Memory Evaluation Retention Estimate				
5th	6 (5)	- (-)	- (-)	- (-)	- (-)
10th	10 (10)	0 (0)	0 (0)	0 (0)	- (-)
25th	- (-)	8 (9)	4 (4)	2 (4)	0 (0)
50th	- (-)	10 (10)	9 (9)	7 (8)	4 (6)
75th	- (-)	- (-)	10 (10)	10 (10)	9 (10)
90th	- (-)	- (-)	- (-)	- (-)	10 (10)
95th	- (-)	- (-)	- (-)	- (-)	- (-)
N	44 (50)	35 (29)	105 (129)	80 (71)	50 (38)
	Hand Taps				
5th	3 (11)	0 (0)	- (-)	- (-)	- (-)
10th	27 (26)	11 (26)	0 (0)	0 (0)	- (-)
25th	44 (43)	33 (34)	26 (28)	16 (15)	0 (0)
50th	51 (50)	46 (44)	41 (41)	31 (32)	22 (19)
75th	57 (57)	52 (52)	46 (45)	40 (40)	36 (37)
90th	60 (60)	55 (56)	52 (53)	46 (46)	45 (45)
95th	62 (62)	58 (56)	55 (57)	49 (49)	47 (47)
N	45 (51)	35 (29)	105 (128)	81 (71)	50 (38)
	Grip Strength				
5th	7 (6)	0 (0)	- (-)	0 (0)	- (-)
10th	11 (10)	0 (3)	0 (0)	0 (1)	- (-)

Age Cohort (Weighted Score in Parentheses)					
%ile	**80–84**	**85–90**	**98–99**	**100–101**	**102+**
25th	17 (18)	12 (13)	4 (5)	4 (7)	0 (0)
50th	22 (22)	17 (18)	10 (12)	8 (9)	3 (2)
75th	32 (28)	26 (33)	20 (20)	12 (16)	9 (8)
90th	38 (36)	35 (64)	27 (28)	24 (35)	18 (12)
95th	46 (44)	51 (64)	37 (40)	33 (41)	23 (20)
N	45 (51)	35 (29)	108 (132)	83 (72)	52 (39)

TABLE 5

Centiles by Age Cohort and Education Group

	Age Cohort (Weighted Scores in Parentheses)									
	80–84		85–90		98–99		100–101		102+	
Education %ile	**< H.S.**	**H.S.+**	**< H.S.**	**H.S.+**	**< H.S.**	**H.S.+**	**< H.S.**	**H.S.+**	**< H.S.**	**H.S.+**
					WAIS Similarities					
5th	- (-)	3 (4)	- (-)	0 (0)	- (-)	- (-)	- (-)	0 (0)	- (-)	- (-)
10th	0 (-)	9 (9)	0 (0)	0 (3)	- (-)	0 (0)	- (-)	1 (0)	- (-)	0 (0)
25th	1 (0)	15 (13)	1 (0)	13 (12)	0 (0)	2 (3)	0 (0)	3 (3)	- (-)	3 (8)
50th	8 (8)	19 (19)	4 (3)	17 (16)	3 (2)	9 (8)	1 (0)	8 (11)	0 (0)	8 (11)
75th	14 (13)	24 (24)	10 (11)	21 (20)	10 (9)	17 (17)	6 (6)	18 (18)	1 (1)	19 (22)
90th	15 (14)	30 (30)	12 (12)	26 (24)	16 (14)	24 (25)	12 (18)	23 (25)	11 (15)	24 (26)
95th	15 (15)	31 (31)	12 (12)	30 (29)	18 (18)	29 (29)	18 (20)	25 (25)	15 (16)	26 (26)
N	12 (13)	33 (39)	6 (4)	29 (25)	45 (46)	60 (74)	42 (31)	37 (36)	27 (23)	21 (14)
					COWAT					
5th	- (-)	1 (2)	- (-)	0 (0)	- (-)	- (-)	- (-)	0 (0)	- (-)	1 (1)
10th	0 (0)	4 (5)	- (-)	0 (1)	0 (0)	0 (0)	- (-)	1 (1)	- (-)	2 (2)
25th	3 (2)	7 (7)	0 (0)	4 (5)	1 (1)	2 (1)	0 (0)	2 (1)	- (-)	3 (3)
50th	6 (5)	9 (9)	2 (2)	9 (9)	4 (4)	5 (4)	2 (3)	5 (5)	0 (0)	5 (6)
75th	8 (8)	12 (12)	3 (4)	12 (14)	7 (7)	8 (9)	3 (4)	7 (8)	3 (3)	8 (10)
90th	9 (9)	15 (15)	4 (4)	16 (16)	9 (10)	11 (11)	6 (6)	9 (9)	5 (7)	10 (11)
95th	10 (10)	16 (17)	4 (4)	18 (18)	10 (14)	14 (13)	9 (10)	10 (10)	8 (9)	11 (11)
N	12 (13)	33 (39)	6 (4)	28 (24)	43 (53)	58 (71)	42 (34)	37 (36)	27 (23)	21 (14)
					Fuld Object Memory Evaluation Retrieval Trials 1–5					
5th	- (-)	4 (11)	- (-)	0 (0)	- (-)	- (-)	- (-)	- (-)	- (-)	0 (0)
10th	0 (0)	20 (21)	- (-)	0 (14)	0 (0)	0 (0)	- (-)	0 (0)	- (-)	0 (1)
25th	19 (10)	26 (29)	0 (0)	27 (30)	2 (2)	1 (0)	0 (0)	1 (5)	- (-)	2 (4)
50th	34 (28)	36 (37)	7 (7)	34 (35)	14 (16)	13 (12)	4 (11)	11 (14)	0 (0)	10 (10)
75th	37 (37)	40 (41)	25 (25)	38 (38)	28 (29)	27 (28)	17 (24)	29 (30)	5 (4)	21 (16)
90th	41 (42)	43 (43)	26 (26)	39 (41)	33 (33)	35 (35)	28 (29)	35 (41)	19 (34)	30 (31)
95th	42 (42)	46 (47)	26 (26)	44 (44)	38 (34)	39 (38)	33 (34)	40 (42)	33 (36)	32 (31)

	Age Cohort (Weighted Scores in Parentheses)									
	80–84		85–90		98–99		100–101		102+	
Education %ile	**< H.S.**	**H.S.+**	**< H.S.**	**H.S.+**	**< H.S.**	**H.S.+**	**< H.S.**	**H.S.+**	**< H.S.**	**H.S.+**
N	12 (13)	33 (39)	6 (4)	29 (25)	43 (54)	60 (74)	42 (34)	38 (37)	27 (23)	21 (14)
Fuld Object Memory Evaluation Delayed Recall										
5th	- (-)	3(-)	- (-)	0(-)	0(-)	0(-)	0(-)	0(-)	0(-)	0(-)
10th	0(0)	4(4)	- (-)	0(0)	0(-)	0(-)	0(-)	0(0)	0(-)	0(0)
25th	4(2)	6(7)	0(0)	5(6)	0(0)	0(0)	0(0)	0(1)	0(-)	0(2)
50th	7(5)	8(8)	3(3)	7(7)	3(4)	3(3)	2(3)	3(3)	0(0)	3(3)
75th	8(8)	9(9)	5(5)	9(9)	6(6)	6(6)	5(5)	6(7)	1(2)	6(4)
90th	10(10)	10(10)	-(-)	9(9)	8(8)	9(9)	6(6)	8(10)	4(8)	8(7)
95th	-(-)	10(-)	-(-)	10(10)	10(9)	9(9)	7(6)	10(-)	8(9)	8(-)
N	12(13)	32(38)	6(4)	29(25)	43(54)	60(74)	40(34)	38(37)	26(23)	21(14)
Fuld Object Memory Evaluation Retention Estimate										
5th	0 (-)	8 (10)	- (-)	- (-)	- (-)	- (-)	- (-)	0 (0)	- (-)	0 (2)
10th	2 (0)	10 (-)	- (-)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	- (-)	1 (4)
25th	9 (9)	- (-)	0 (0)	10 (10)	5 (5)	3 (3)	0 (3)	4 (5)	- (-)	6 (6)
50th	10 (10)	- (-)	6 (6)	- (-)	9 (9)	9 (8)	7 (8)	9 (10)	0 (0)	8 (8)
75th	10 (10)	- (-)	10 (10)	- (-)	10 (10)	10 (10)	9 (9)	10 (-)	4 (10)	10 (10)
90th	10 (10)	- (-)	10 (10)	- (-)	- (-)	- (-)	10 (10)	- (-)	10 (-)	- (-)
95th	10 (10)	- (-)	10 (10)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
N	12 (13)	32 (38)	6 (4)	29 (25)	43	60 (74)	40 (34)	38 (37)	26 (23)	21 (14)
Hand Taps										
5th	0 (0)	16 (24)	- (-)	10 (19)	- (-)	- (-)	- (-)	0 (0)	- (-)	0 (0)
10th	3 (8)	42 (42)	0 (0)	26 (28)	0 (0)	0 (0)	0 (0)	8 (11)	- (-)	2 (0)
25th	29 (29)	46 (46)	0 (5)	33 (35)	19 (28)	30 (29)	8 (0)	24 (25)	- (-)	23 (14)
50th	42 (42)	51 (51)	41 (41)	47 (46)	40 (37)	41 (41)	26 (29)	36 (36)	0 (0)	29 (30)
75th	50 (46)	57 (57)	47 (49)	53 (52)	50 (48)	45 (45)	37 (37)	42 (41)	27 (33)	41 (45)
390th	60 (60)	61 (61)	52 (52)	56 (56)	54 (54)	52 (51)	47 (48)	46 (46)	42 (43)	46 (46)
95th	60 (60)	63 (62)	52 (52)	60 (58)	56 (61)	55 (56)	49 (49)	55 (57)	48 (49)	49 (48)
N	12 (13)	33 (39)	6 (4)	29 (25)	44 (55)	59 (71)	42 (34)	37 (36)	26 (23)	21 (14)
Grip Strength										

	Age Cohort (Weighted Scores in Parentheses)									
	80–84		85–90		98–99		100–101		102+	
Education %ile	< H.S.	H.S.+	< H.S.	H.S.+	< H.S.	H.S.+	< H.S.	H.S.+	< H.S.	H.S.+
5th	6 (6)	7 (11)	- (-)	0 (0)	- (-)	- (-)	- (-)	0 (2)	- (-)	0 (0)
10th	7 (6)	12 (14)	0 (0)	- (6)	0 (0)	0 (0)	0 (0)	2 (4)	- (-)	- (1)
25th	11 (8)	19 (19)	2 (4)	12 (14)	4 (6)	5 (3)	3 (5)	5 (8)	- (-)	2 (2)
50th	21 (19)	23 (22)	11 (11)	18 (18)	10 (14)	11 (11)	8 (9)	9 (11)	0 (0)	6 (4)
75th	24 (23)	33 (29)	25 (30)	26 (33)	19 (19)	20 (20)	12 (16)	13 (20)	6 (4)	11 (11)
90th	37 (36)	43 (37)	37 (37)	34 (64)	24 (28)	31 (31)	23 (36)	24 (37)	11 (10)	22 (21)
95th	38 (38)	46 (46)	37 (37)	56 (64)	36 (40)	40 (45)	38 (40)	34 (42)	19 (14)	39 (21)
N	12 (13)	33 (39)	6 (4)	29 (25)	46 (57)	60 (74)	42 (34)	39(37)	27 (23)	22 (14)