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Category and Letter Fluency in Highly Educated Older Adults*

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ABSTRACT

Performance on letter and category fluency was studied in a group of 478 healthy, highly intelligent and educated, older adults (aged 55 to 94 years). The aim of the study was to determine and contrast the effects of age, sex, and intelligence (estimated by the NAART) on letter (FAS) and category (fruits, animal, vegetables) verbal fluency performance. Significant effects were found for age and NAART error score on all fluency scores. However, these effects were small in magnitude. The NAART was found to be a better predictor of verbal fluency scores than education. The relative sensitivity of letter and category fluency to age was not significantly different. Sex was related to performance for the categories of fruits and vegetables, with women outperforming men. Separate mean values for fluency measures are provided for different ages, NAART error scores, educational level, and sex.

The Controlled Oral Word Association Test (COWAT; Borkowski, Benton, & Spreen, 1967), also known as verbal fluency for categories and letters, is a test of frontal and temporal lobe functioning which involves sustained attention, retrieval of information, speech production fluency, and response initiation and suppression. Impaired performance on this task has been associated with Alzheimer's disease (AD), Huntington's disease, Parkinson's disease, Attention-Deficit Hyperactivity Disorder, and depression (Bayles, Trosset, & Tomeoda, 1993; Koziol & Stout, 1992; Pasquier, Lebert, Grymonprez, & Petit, 1995; Trichard et al., 1995). In fact, the COWAT is known as one of the more sensitive tasks for detecting the early stages of dementia (Ober, Dronkers, Koss, Delis, & Friedland, 1986). However, this task has high sensitivity but low specificity. For example, although useful as a measure of impend-ing dementia, the COWAT is unable to distinguish between early AD and frontal lobe dementia, as both groups tend to perform poorly (Pasquier et al, 1995). This is not surprising because the COWAT is a test of frontal lobe functioning.

There are two types of fluency tasks, semantic category fluency (e.g., animals, fruits, vegetables), and letter fluency (FAS). Semantic category fluency is known to be more impaired than letter fluency in dementia (Barr & Brandt, 1996; Crossley, D'Arcy, & Rawson, 1997; Pasquier et al.,1995). This same effect was also observed with normal aging to a lesser extent (Crossley et al., 1997; Kozora & Cullum, 1995; Tomer & Levin, 1993). However, Bayles et al. (1993) reported that both letter and semantic category fluency showed significant decline with age in persons without dementia, with greater age effects observed for letter fluency. In addition to

these contradictions surrounding age effects, the relative contributions of sex, intelligence, and education on COWAT performance remain unclear.

For instance, in a previous study, we found significant sex effects on the FAS letter-fluency task, with women performing significantly better than men (Bolla, Lindgren, Bonaccorsy, & Bleecker, 1990). This same sex effect was noted by Veroff (1980). In fact, Veroff (1980) found that letter fluency tended to decline with age in men, but not in women. Crossley et al. (1997) also reported that women outperformed men on letter but not category (animal) fluency. On the other hand, other studies indicated only minimal sex effects (Ivnik, Malec, Smith, Tangalos, & Peterson, 1996; Kozora & Cullum, 1995). Therefore, the question of sex-related differences in verbal fluency performance remains unanswered.

Due to these unanswered questions concerning the contribution of age, sex, and education on category and letter COWAT performance, any previously obtained normative values are subject to close consideration. For example, although Benton and Hamsher's (1978) original norms and the new norms by Ivnik et al. (1996) are corrected for education, we have previously demonstrated that a measure of verbal intelligence (such as the Wechsler Adult Intelligence Scale – Revised Vocabulary Subtest; Wechsler, 1981) shows a stronger relationship to level of performance on neuropsychological tests than education (Bolla-Wilson & Bleecker, 1986). This appears to be especially true in older adults, because higher levels of formal education were the exception rather than the rule in past eras, especially for women. For instance, Kozora and Cullum (1995) noted that neither category nor letter fluency were affected by education level. However, several studies indicate verbal intelligence has a significant effect on COWAT performance (Bolla et al., 1990; Borkowski et al., 1967; Cauthen, 1978; Miller, 1984). Therefore, expected mean category and letter fluency scores based on an individual's verbal intelligence may prove to be more accu-

rate when assessing for normal versus abnormal cognitive functioning. This has not been examined in either of the large sample studies of verbal fluency (Crossley et al., 1997; Ivnik et al., 1996).

In addition, previously obtained mean fluency scores for the COWAT are questionable due to the limited sample sizes used when generating these values, the small number of studies conducted, and differing methodologies. The largest sample sizes of normal aging subjects ranged from 89 subjects (Tomer & Levin, 1993) to 199 subjects (Bolla et al., 1990). Although Ivnik et al. (1996) report mean scores for 743 participants, these values were only for letter and not category fluency, and only for the letters C, F, and L. Because the letters FAS are used extensively, additional information on mean level of performance and the relative contribution of age, sex, intelligence, and education on this performance is needed for these letters. Crossley et al. (1997) report on 645 community-dwelling, cognitively intact participants. This study examined performance for letter fluency (FAS) and category fluency, but only for the category of animals. Because decrements in semantic category performance (i.e., animals, fruits, vegetables) may be more sensitive in detecting the early stages of dementia, expected average fluency scores for different semantic categories are also needed for a large population. It is also of interest to determine whether there are differences in the level of word production for each specific semantic category (e.g., animals vs. fruits). In addition, mean performance values have not been reported for a highly educated (e.g., greater than 17 years of education) group of older adults. Diagnosis of early abnormal cognitive decline in highly intelligent individuals is especially problematic for the clinician. The primary aim of this study was to determine and contrast the influences of the demographic variables of age, sex, education, and intelligence on both letter and category COWAT in highly educated, older adults. A second aim was to provide mean performance scores based on these findings.

METHODS

Subjects

Participants were 478 volunteers (173 women, 305 men; 98% Caucasian) enrolled in the Baltimore Longitudinal Study of Aging (BLSA). The BLSA is an ongoing prospective study of normal aging conducted by the National Institute on Aging (NIA) (Shock et al., 1984).

The 478 participants used in this analysis were selected from the larger pool of BLSA volunteers using the following method: we initially identified 923 BLSA participants who received their first verbal fluency test in the Gerontology Research Center between 1986 and 1996. Of those, 104 were excluded because they were not cognitively intact at the time of testing. Cognitive status of BLSA participants is determined at each visit from history obtained from the participant and family members, and performance on a larger battery of neuropsychological tests. We also wanted to include only participants who remained free of any signs of dementia for a minimum of 2 years beyond the COWAT testing date. Because of this, the 35 who began to show signs of dementia in the 2 years after testing were excluded, and the 216 who lacked more than 2 years of follow-up at the time of this analysis were excluded. This procedure allowed us to control for the possibility that our sample could have included individuals who were in the early stages of a progressive dementia. Of the 568 remaining, 90 participants were excluded because they did not receive The North American Adult Reading Test (NAART) which was one of the variables of interest.

Participant age ranged from 55 to 94 years of age, with an average age of 72.2 years. Level of education was above average, with a median of 18 years and a range of 4 to 20 years. Forty-five participants had a less-than-or-equal-to a high-school education (9%), 166 participants had between one and four years of college (35%), and 267 held graduate degrees (between 17 and 20 years of formal education, 56%). NAART error scores averaged 10.3 points, with a range of 0 to 44 points (with a lower score indicating better performance). Table 1 provides demographic information on the participants by age and sex. Informed consent was obtained from all participants. This protocol was approved by the Institutional Review Board.

Procedure

The COWAT for the letters (FAS; Borkowski et al., 1967) and the categories (animals, fruits, and vegetables; Benton & Hamsher, 1978) were administered to all participants as part of a compre-hensive neuropsychological battery. Each participant was required to name as many animals, fruits, and vegetables as possible in 60 s. Likewise, they were required to say as many words as possible beginning with the letter F, A, or S in 60 s. The North American Adult Reading Test (NAART; Nelson & Willison, 1991) was administered to estimate intelligence. For an elderly population, the NAART is strongly correlated with the WAIS-R Verbal Intelligence Quotient ($r = -0.78$; Ryan & Paolo, 1992). This suggests that performance on the NAART (error score) is a reliable estimate of an individual's verbal intellectual ability.

Statistical Analysis

Statistical analysis was based on the three separate semantic fluency scores and the total score for FAS, as these are the measures typically employed in clinical and research applications. Multivariate analysis of variance (MANOVA) was performed first to determine if age and sex had significant main effects on COWAT scores and if these effects differed across the four fluency measures. MANOVA was also used to determine if NAART and/or education had significant main effects on COWAT scores after adjusting for age and sex. Significant multivariate effects involving within subject factors are reported as Wilks' lambda. Next, a separate multivariate regression analysis was performed for each of the COWAT measures to determine the relative effect and significance of age, sex, NAART, and education on each measure. Finally, forward stepwise regressions were performed for each COWAT measure to examine the incremental increase in explainable variance associated with each independent variable.

RESULTS

Table 2 presents the descriptive statistics separately for four fluency measures: animals, fruits, vegetables, and the total performance across the three letter-fluency measures. Overall means (number of words produced) and standard deviations for the total sample of 478 participants were: animals, 19.1 (4.5); fruits, 14.7 (3.5); vegetables, 13.5 (3.6); and FAS, 47.3 (12.6).

Effects of Age and Sex on COWAT Scores

Multivariate analysis of variance (MANOVA) was performed to determine whether age and sex contributed to COWAT performance gener-

Table 1. Demographic Data by Age Group.

	Age Group (years)											
	Men						Women					
	55–69 (n = 135)		70–79 (n = 125)		80–94 (n = 45)		55–69 (n = 61)		70–79 (n = 70)		80–94 (n = 42)	
	M	(SD)	M	(SD)	M	(SD)	M	(SD)	M	(SD)	M	(SD)
Age (years)	64.9	(3.1)	74.4	(2.9)	83.1	(2.5)	64.9	(3.1)	74.7	(2.8)	83.9	(3.3)
NAART	12.2	(8.3)	10.4	(7.7)	7.6	(7.9)	10.1	(6.2)	8.9	(6.3)	9.0	(7.2)
Education (years):	16.8	(2.5)	17.4	(2.9)	18.1	(2.4)	15.9	(2.6)	16.0	(2.9)	15.8	(2.6)
Median	18		18		19		16		16		16	
	%		%		%		%		%		%	
Education												
High school or less	8.1		8.0		0.0		16.4		11.4		14.3	
1–4 years college	37.8		26.4		26.7		37.7		42.9		40.5	
Graduate school	54.1		65.6		73.3		45.9		45.7		45.2	
Race												
Caucasian	99.3		97.6		97.8		98.4		97.1		95.2	

Table 2. COWAT Scores for Men and Women by Age, Education, and NAART Group.

Task	Men						Women					
	Age (years)											
	55–69 (n = 135)		70–79 (n = 125)		80–94 (n = 45)		55–69 (n = 61)		70–79 (n = 70)		80–94 (n = 42)	
Animals	19.9	(4.3)	19.2	(5.0)	18.8	(4.5)	19.3	(3.8)	18.3	(4.3)	17.9	(4.9)
Fruits	14.8	(3.3)	14.2	(3.8)	12.6	(2.9)	16.1	(3.1)	15.9	(3.1)	14.5	(3.7)
Vegetables	12.8	(3.1)	12.7	(3.4)	12.0	(4.1)	15.5	(3.0)	15.7	(3.5)	13.2	(2.9)
FAS	48.0	(12.2)	46.8	(13.4)	45.9	(11.7)	48.7	(11.2)	48.7	(13.0)	43.7	(14.0)
	Education (years)											
	4–12 (n = 21)		13–16 (n = 96)		17–20 (n = 188)		4–12 (n = 24)		13–16 (n = 70)		17–20 (n = 79)	
Animals	17.1	(3.9)	19.0	(4.8)	19.9	(4.5)	16.7	(3.7)	18.1	(4.3)	19.5	(4.3)
Fruits	13.4	(2.9)	13.2	(3.4)	14.8	(3.5)	14.8	(3.0)	15.6	(3.3)	15.9	(3.4)
Vegetables	10.7	(2.8)	12.7	(3.4)	12.8	(3.4)	14.5	(3.3)	14.7	(3.3)	15.5	(3.3)
FAS	37.0	(10.6)	46.3	(12.6)	48.8	(12.3)	43.6	(11.5)	46.7	(13.3)	49.4	(12.5)
	NAART (error score)											
	13+ (n = 96)		6–12 (n = 117)		0–5 (n = 92)		13+ (n = 55)		6–12 (n = 62)		0–5 (n = 56)	
Animals	18.2	(4.5)	19.5	(4.2)	20.7	(4.9)	17.1	(4.0)	19.2	(4.1)	19.2	(4.4)
Fruits	13.5	(3.3)	14.2	(3.1)	15.0	(4.1)	14.4	(2.8)	16.7	(3.3)	15.7	(3.4)
Vegetables	12.2	(3.4)	12.3	(3.1)	13.5	(3.6)	14.1	(3.0)	15.8	(3.4)	15.1	(3.4)
FAS	41.3	(11.5)	47.2	(11.7)	53.4	(11.9)	42.0	(11.3)	49.7	(13.3)	50.5	(11.9)

ally and whether these effects differed across the four fluency scores. Grouping factors were sex and age group (55–69, 70–79, 80 and older) with the four fluency measures treated as a within-subjects factor. Results showed significant main effects of sex ($F(1,474) = 5.28$, $p = .02$) and age ($F(2,474) = 6.18$, $p < .01$), indicating higher overall performance in women compared with men, and younger compared with older subjects, respectively. There were no significant age by sex or age by fluency measure interactions, indicating similar effects of age for men and women and across the four measures. In contrast, there was a significant sex by fluency measure interaction ($F(3,472) = 20.88$, $p < .001$), revealing different effects of sex across the four measures.

Effects of NAART and Education on COWAT Scores

To determine if NAART and education influenced COWAT scores after adjusting for age and sex, the MANOVA described above was repeated adding NAART (0–5, 6–12, 13 or greater errors) as an additional grouping factor in one analysis and adding education (4–12, 13–16, and 17–20 years) as an additional grouping factor in a second analysis. After adjusting for the effects of age and sex, NAART had a significant main effect on COWAT scores ($F(2,472) = 40.23$, $p < .001$), with lower NAART errors associated with better COWAT performance. Moreover, there was a significant interaction between NAART scores and the four COWAT scores ($F(6,940) = 10.26$, $p < .001$),

indicating differential effects of NAART on the four measures. Similarly, there was a significant main effect of education on COWAT performance, ($F(2,472) = 16.13$, $p < .001$), with better COWAT performance associated with higher education. There was also a significant interaction between education and the four COWAT scores ($F(6,940) = 3.94$, $p < .001$), indicating that education had different effects on the four fluency measures.

Effects of Sex, Age, NAART, and Education on Individual COWAT Measures

The results of the MANOVA indicated differential effects of sex, NAART, and education on the four COWAT measures, but similar effects of age across the four measures. To clarify the pattern of these effects and to estimate their relative magnitudes, we performed separate multiple regressions for each of the four fluency measures. In an initial series of analyses, the full model, including age, age-squared, sex, NAART, and education was examined for each measure. Although the model for each fluency score could be reduced by excluding nonsignificant terms, the full models are presented for comparison purposes. In two additional series of analyses, the incremental increases in explainable variance are examined for each measure using forward stepwise entry with a fixed order. In one series, age was entered first, age-squared next, followed by sex, then NAART, then education. In a second series, the order of entry was reversed for NAART and education. For the regression analyses, age, NAART, and education were treated as continuous variables.

Table 3 presents the regression estimates, standard errors of the estimates, and associated p values from the multiple regression analyses. The covariates (age, age-squared, sex, NAART, and education) combined accounted for 11% of the total variance for animals, 15% for fruits, 17% for vegetables, and 17% for FAS. Note that despite the large number of statistically significant associations between the covariates and COWAT scores, many of the effects were relatively small. We also examined interactions among the independent variables, but none were significant.

Table 4 presents the results of the stepwise regression analyses and indicates the incremental increase in explained variance as each independent variable is entered into the model. Consistent with the results of the MANOVA, age had a significant effect on each of the four fluency measures. As shown in Table 4, the linear effects of age accounted for 1–3% of the variance for each of the four measures. Fluency performance decreased in older compared with younger subjects. In addition to the linear effects of age across measures, a significant nonlinear effect of age for vegetables was suggested when adjusting for all other variables in the model (Table 3).

As shown in Tables 3 and 4, there were significant effects of sex on vegetables and fruits, but no significant sex effects on animals and FAS. The effects of sex on fluency performance ranged from almost no contribution on letter fluency and animals to approximately 12% of the variance on vegetables, after adjusting for age effects. Sex also accounted for a significant percent of the variance (5%) in performance for the fruits category. For both vegetables and fruits, women obtained higher scores than men (Tables 2 and 3). After adjusting for age, NAART, and education, women were estimated to perform on average 2.6 points higher on vegetables and 1.7 points higher on fruits compared with men.

After adjusting for the remaining terms in the model, there were significant effects of NAART on all four fluency measures. In contrast, education was found to contribute significantly only for animals and fruits. To examine the relative contributions of NAART and education to each measure, we varied the order of entry as shown in Table 4. When NAART preceded education in the model, it accounted for approximately 7% of the variance for animals, 6% for fruits, 3% for vegetables, and 16% for FAS. Education explained small but significant additional variance for animals and fruits, but did not explain additional variance beyond that accounted for by NAART on the vegetables or FAS measures. Conversely, when education was entered before NAART, education accounted for approximately 4% of the variance for animals and fruits, 2%

Table 3. Regression Estimates from Full Model.

Task	Estimate	(SE)	p	
Animals				$R^2 = 0.11$
Intercept	17.28	1.54	< 0.01	
(Age-70)	–0.12	0.03	< 0.01	
(Age-70)2	0.002	0.003	0.62	
Gender (male)	0.66	0.43	0.13	
NAART	–0.13	0.03	< 0.01	
Education	0.17	0.08	0.04	
Fruits				$R^2 = 0.15$
Intercept	14.97	1.16	< 0.01	
(Age-70)	-0.08	0.02	< 0.01	
(Age-70)2	-0.004	0.002	0.08	
Gender (male)	-1.73	0.33	< 0.01	
NAART	-0.09	0.02	< 0.01	
Education	0.13	0.06	0.04	
Vegetables				$R^2 = 0.17$
Intercept	15.29	1.17	< 0.01	
(Age-70)	-0.05	0.03	0.06	
(Age-70)2	-0.006	0.002	0.02	
Gender (male)	-2.60	0.33	< 0.01	
NAART	-0.08	0.02	< 0.01	
Education	0.07	0.06	0.29	
FAS Total				$R^2 = 0.17$
Intercept	51.01	4.14	< 0.01	
(Age-70)	-0.19	0.09	0.03	
(Age-70)2	-0.009	0.01	0.29	
Gender (male)	-0.25	1.16	0.83	
NAART	-0.64	0.08	< 0.01	
Education	0.24	0.22	0.29	

for vegetables, and 5% for FAS. Even after accounting for the effects of education, NAART explained significant additional variance: 4% for animals, 3% for fruits, 2% for vegetables, and 11% for FAS.

DISCUSSION

In a highly educated, intelligent, older adult population, both semantic category and letter fluency performance are associated with verbal intelligence and age. Sex had a significant effect on the semantic categories of fruits and vegetables with women outperforming men across decades. The strong relationship between verbal intelligence and COWAT performance replicates our earlier report on letter fluency (Bolla et al., 1990). Whereas our earlier report employed the WAIS-R Vocabulary Subtest as an estimate of verbal intelligence, the present report employed the NAART, which may be easier and briefer to administer. Again, we would like to reiterate that a measure of verbal intelligence (i.e., WAIS-R Vocabulary or NAART) is a stronger predictor of performance than educational level, especially in older adults. Therefore, expected mean values that take verbal intelligence into consideration are preferential to expected mean values based on educational level. The modest Pearson correlation of 0.44 between NAART and educational level found in this study suggests that years of education may only be moderately related to verbal intellectual level in an older adult population.

The present finding of significant aging effects on all aspects of the COWAT is in contrast to our earlier work, which reported no age ef-

Table 4. Stepwise Increase in R^2 Associated with the Addition of Each Covariate into a Multiple Regression Model.

Regression Term	Animals	Fruits	Vegetables	FAS
Intercept	——	——	——	——
Age	0.022**	0.031**	0.011*	0.008*
Age^2	0.000	0.005	0.007	0.003
Gender	0.006	0.051**	0.121**	0.001
NAART, Education	0.072**, 0.043**	0.058**, 0.037**	0.033**, 0.016**	0.161**, 0.052**
Education, NAART	0.008*, 0.038**	0.008*, 0.029**	0.002, 0.020**	0.002, 0.111**
Total R^2	0.11	0.15	0.17	0.17

Note. The order of the variables education and NAART was varied.
* $.01 < p < 0.05$; ** $p < .01$.

fects on letter fluency. However, the magnitude of the present effect was small and probably not clinically significant. This discrepancy between our present and past findings could be due to a much larger sample size, especially in the older ages, lending more statistical power to detect a small effect.

The sex of the participant is related to performance on the specific semantic categories of fruits and vegetables but not animals. However, no sex-related effect was found for letter fluency. This finding for letter fluency failed to replicate our past study findings and those of Veroff (1980) but is consistent with the reports of Kozora and Cullum (1995) and Ivnik et al., (1996).

Although the aging effect was significant, it was small in magnitude for both semantic category and letter fluency. Whereas others have shown that semantic category fluency is more sensitive than letter fluency to early signs of aging and dementia (Barr & Brandt, 1996; Crossley et al., 1997; Pasquier et al., 1995), we found that the effect of age was similar for all four fluency measures. These data do not support the thesis that in normal aging, semantic knowledge (used for category fluency) is more affected than phonological knowledge (necessary for letter fluency) (Crossley et al., 1997). Differences in study results may be related to discrepencies in the control of confounding/modifying variables such as sex, educational level, and verbal intelligence. These factors must also be considered when examining the interaction between category and sex. For example, after controlling for the effects of age, education, and NAART score, women and men show a different category-dependent pattern of word production.

Because our population is highly educated, intelligent, and predominantly Caucasian, it will be difficult to generalize these results to the general population. However, these mean scores on category and letter fluency will be useful to the clinician when required to determine the presence of abnormal cognitive decline in a highly intelligent and educated individual.

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