Psychology and Aging
1997, Vol. 12, No. 3, 473–478

0882-7974/97/$3.00

Verbal Knowledge and Speed of Information Processing as Mediators of Age Differences in Verbal Fluency Performance Among Older Adults

Janet Bryan, Mary A. Luszcz, and J. R. Crawford
Flinders University of South Australia

Age-related declines in verbal fluency among a large sample of older adults were investigated. Background variables, verbal knowledge, and speed of processing were examined as predictors of verbal fluency and as mediators of age effects. As expected, age-related declines were greater on the excluded letter fluency task than on the initial letter fluency task. Verbal knowledge was a better predictor of initial letter fluency than speed of processing, whereas the reverse was true for excluded letter fluency. However, speed of processing accounted for more of the age-related variance in both fluency measures than the other predictors. There was no evidence of verbal knowledge compensating for age-related declines in verbal fluency. Results suggest that verbal fluency performance is well maintained in late life and that any age-related decline appears to be mainly due to declines in speed of information processing.

In this research we examined verbal fluency performance among a large community sample of older adults between the ages of 70 and 98 years of age. We investigated age-related declines in two verbal fluency tasks, the extent to which background variables (amount of education, self-rated health, and depression), verbal knowledge, and speed of information processing predicted verbal fluency performance and whether these predictors could account for age-related variance in verbal fluency. Finally, we investigated the hypothesis that verbal knowledge may compensate for age-related declines in verbal fluency performance.

Verbal fluency tasks typically require individuals to produce as many words as they can within a set time limit and according to certain rules (Rosen, 1980). Two fluency tasks were used in the present study: initial letter fluency (Benton, 1968; Spreen & Benton, 1969) and a novel variant on this familiar task, excluded letter fluency. In the initial letter fluency task, participants are required to produce as many words as possible beginning with a designated letter; whereas in the excluded letter fluency task, participants are required to produce as many words as possible not containing a designated letter. These tasks are quite difficult as it is unlikely that words are stored in memory on the basis of an initial letter and even less likely that words are stored on the basis of the absence of a letter (Collins & Quillian, 1969; Howard, 1983). Performance on these tasks is therefore assumed to rely on creative and strategic retrieval activities generated by the individual and on the monitoring of performance in the form of checking the generated words against the rules of the task (Parker & Crawford, 1992). Such activities are thought to rely on higher order cognitive activity or executive processes (Moscovitch & Winocur, 1992; Parker & Crawford, 1992; Shallice, 1988).

Age differences on verbal fluency tasks have not been found consistently. Some researchers have found that younger adults perform better on verbal fluency tasks than do older adults (Hultsch, Hertzog, Small, McDonald-Miszczak & Dixon, 1992; McCrae, Arenberg & Costa, 1987; Parkin & Walter, 1992, Study 1; Salthouse, 1993), whereas others have revealed no age differences (Davis et al., 1990; Mittenberg, Seidenberg, O'Leary, & DiGiulio, 1989; Parkin & Walter, 1992, Study 2; Schaie, 1983). One reason for the equivocal findings could be that these tasks reflect a number of different processes, some of which may be well maintained into old age, whereas others may decline (Rosen, 1980; Salthouse, 1993). First, verbal fluency tasks may rely on the executive processes of strategic retrieval search and performance monitoring, and there is some suggestion that such executive processes may decline with increasing age (Baddeley, 1990; Salthouse, 1991). We assumed that the more difficult excluded letter fluency task relied on these executive processes to a greater extent than the initial letter fluency task. Therefore, we expected age differences to be greater on the excluded letter fluency task than on the initial letter fluency task.

Second, verbal fluency tasks may reflect the extent of an individual's speed of information processing. It is well established that performance on a variety of reaction time and psychometric speed tests declines with increasing age (Birren, 1974; Bryan & Luszcz, 1996; Luszcz, 1992; Salthouse, 1985). In addition, speed measures have been found to mediate age effects on many measures of cognitive ability including fluency performance (Lindenberger, Mayr, & Kliegl, 1993; Salthouse,

Janet Bryan, Mary A. Luszcz, and J. R. Crawford, School of Psychology, Flinders University of South Australia, Adelaide, South Australia.

We gratefully acknowledge the work of the Centre for Ageing Studies, Flinders University of South Australia that, under the direction of Gary Andrews, carried out the Australian Longitudinal Study of Ageing. That research was funded in part by a grant from the U.S. National Institute of Aging and by grants from the Sandoz Foundation of Gerontological Research, the South Australian Health Commission, the Australian Rotary Health Research Fund, and Flinders University of South Australia.

Correspondence concerning this article should be addressed to Janet Bryan, School of Psychology, Flinders University of South Australia, G.P.O Box 2100, Adelaide, South Australia 5001. Electronic mail may be sent via Internet to janet.bryan@flinders.edu.au.

Fristoe, & Rhee, 1996). Third, verbal fluency tasks might also reflect verbal ability, especially the extent of an individual's word knowledge. Researchers have commonly found little difference between younger and older adults on word knowledge tasks, and any age differences are often in favor of older adults (Horn, 1982; Salthouse, 1991). This maintained verbal knowledge among older adults may compensate for age-related declines in other processes contributing to fluency performance. That is, the larger the pool of words in memory and the greater the experience in searching for words, the less individuals would need to rely on speed of retrieval or creative search strategies in the performance of verbal fluency tasks.

This notion of verbal knowledge compensating for age differences in verbal fluency performance was investigated by Salthouse (1993). He investigated speed of processing and verbal knowledge as possible determinants of verbal fluency performance among older and younger adults. The findings suggested that speed and knowledge determined verbal fluency performance to a similar extent among older and younger adults, providing limited support for any age-related compensatory influence of verbal knowledge. In the present study we aimed to extend Salthouse's research by introducing the excluded letter fluency task that was expected to place greater demands on retrieval search and monitoring processes than the fluency tasks used by Salthouse. In addition, we sought an Age × Verbal Knowledge interaction in verbal fluency performance as a direct and stringent test of the possibility that age differences in fluency would be reduced among those with higher verbal knowledge compared with those with lower verbal knowledge. Finally, in the present study we investigated verbal knowledge and speed of processing as predictors of verbal fluency performance among a large community sample of older adults.

It could be the case that verbal knowledge compensates for age-related declines in verbal fluency performance, but declines only become evident well into old age. If declines only appear at very old ages, the observed inconsistent age differences in fluency performance may arise from the different age ranges of participants used in previous studies. Specifically, samples including small numbers of older participants, especially those over 80 years, may hinder the detection of age differences in fluency performance (e.g., Mittenberg et al., 1989; Parkin & Walter, 1992). Studies using older samples have found age differences in fluency performance. Lindenberger et al. (1993) found a moderate negative correlation between age and fluency performance among a sample of older adults between the ages of 70 and 103 years, and Hultsch et al. (1992) found evidence of longitudinal age declines in verbal fluency performance among a large sample (N = 297) of adults between the ages of 55 and 86 years. Therefore in this study, we focused on older individuals alone.

In summary, we investigated age-related declines among older adults on two tasks of verbal fluency. We expected greater age declines to appear on the more difficult excluded letter fluency task than on the commonly used initial letter fluency task. On the basis of previous findings we also expected age-related declines in speed of processing but not in verbal knowledge. We expected background variables (amount of education, self-rated health, and depression), verbal knowledge, and speed of information processing to predict verbal fluency and, further, to mediate age-related variance in verbal fluency. Finally, we investigated the possibility that verbal knowledge may compensate for age-related declines in fluency performance with smaller declines among those with higher verbal knowledge compared with those with lower verbal knowledge.

Method

Participants

Participants for the present study were drawn from the Australian Longitudinal Study of Ageing (ALSA)—a multidisciplinary study investigating the medical, demographic, and psychological profiles of older residents of Adelaide, South Australia (Clark & Bond, 1995; Ranzijn & Luszcz, 1994). The primary sample was constructed from a compulsory register of voters, the South Australian state electoral database. This procedure yielded 1,947 participants. However, only those participants who took part in the initial and a 2-year follow-up study, and who provided data for all the variables of interest for this research, were included in the present study. This yielded a subsample of 683 participants, 311 of whom were women (see Table 1 for descriptive statistics).

Measures

Background measures. Self-rated health was assessed with a 5-point rating scale ranging from 1 (*excellent*) to 5 (*poor*). Table 1 indicates that participants rated their health as moderate to good. Amount of education was assessed with a rating scale reflecting the age participants left school; responses ranged from 1 (*never went to school*), 2 (*under 14 years of age*), 3 (*14 years*), 4 (*15 years*), 5 (*16 years*), 6 (*17 years*), to 7 (*18 or over years of age*). The mean rating of participants was close to 4 on the rating scale, reflecting an average age of 15 for leaving school. Depression was measured by the Center for Epidemiologic Studies–Depression Scale (CES-D; Radloff, 1977) and was included as increased depression may contribute to decrements in cognitive activity (West, Crook, & Barron, 1992). The average score of 7.37 indicates the sample experienced few depressive symptoms. Table 1 also

Table 1
Means and Standard Deviations for Age and Background Variables for the Subsample and Total Sample and for Initial and Excluded Letter Fluency, NART Errors, and DSST Scores

	Subsample		Total sample	
Variable	*M*	*SD*	*M*	*SD*
Age[a]	77.18	5.33	78.93	6.24
Age left school rating[b]	3.86	1.34	3.68	1.38
Health rating[c]	2.86	1.04	2.99	1.06
CES-D	7.37	6.73	8.28	7.27
Initial letter fluency	16.84	7.35		
Excluded letter fluency	13.87	6.20		
NART	21.65	8.18		
DSST	30.38	10.78		

Note. CES-D = Center for Epidemiologic Studies–Depression Scale; NART = National Adult Reading Test; DSST = Digit Symbol Substitution Test.
[a] Range from 70 to 98 years.
[b] Responses ranged from 1 (*never went to school*), 2 (*under 14 years*), 3 (*14 years*), 4 (*15 years*), 5 (*16 years*), 6 (*17 years*), to 7 (*18 or over years*).
[c] Responses ranged from 1 (*excellent*), 2 (*good*), 3 (*moderate*), 4 (*fair*), to 5 (*poor*).

shows the descriptive statistics for these background variables for the total sample of ALSA participants. As can be seen from the table, the differences between the subsample used in the present study and the total sample were small.

Verbal fluency measures. Initial letter fluency was assessed with a shortened version of the Controlled Oral Word Association Test (Benton, 1968; Spreen & Benton, 1969), which requires individuals to generate words according to an initial letter. Participants completed two 60-s trials. In the first trial, participants were required to produce as many words as possible beginning with the letter *F*, and in the second trial words beginning with the letter *A*. As is standard, the number of words correctly generated across the two trials was combined to provide a total initial letter fluency score. The alternate form reliability coefficient (Anastasi, 1988) was, however, only moderate (α = .69). Excluded letter fluency was assessed by the number of words participants could generate in two 60-s trials that did not contain a specified letter. In the first trial participants were required to produce as many words as possible not containing *E*, and in the second trial words not containing *A*. Again the total number of words produced across the two trials was summed. The alternate form reliability coefficient was moderate (α = .61).

Verbal knowledge. Verbal knowledge was assessed with the National Adult Reading Test (NART; Nelson, 1982). This test comprises 50 words of irregular pronunciation that participants were asked to read aloud. The test is constructed so that it is very difficult to provide a correct pronunciation of the words unless the words are known by the participants. Scores on the NART represent the number of errors made. Test–retest reliability was .83.

Speed of information processing. Speed of information processing was assessed with the Digit Symbol Substitution Test (DSST; Wechsler, 1981). Salthouse (1992) suggested this test is a good measure of task-independent information processing speed. Scores represent the number of correct digit–symbol substitutions completed in 90 s.

Procedure

Data used in the current study were collected over two sessions in the participant's place of residence, an initial personal interview, and a second session (about 2 weeks later) in which cognitive functioning was measured. Participants' background and CES-D data were collected in the first session, and the cognitive tasks were administered in the second. The DSST and NART tasks were given first, followed by the verbal fluency measures that were presented in counterbalanced order. A quiet well-lit place was selected where each participant could be interviewed alone and without interruption. Short breaks were taken as required. Participants were aware that involvement in the study was voluntary and that they could decline to respond to any item if they so chose.

Results

Preliminary analyses attempting to fit polynomial functions revealed no evidence of nonlinear relationships between age and verbal fluency, NART errors, and DSST scores. Table 1 contains descriptive statistics for initial letter fluency, excluded letter fluency, NART errors, and DSST scores. As expected, participants produced fewer words on the excluded letter fluency task than on the initial letter fluency task, $t(682) = 12.54$, $p < .001$.

Table 2 contains Pearson correlations between age, background variables, verbal fluency scores, NART errors, and DSST scores. As expected, age was negatively correlated with both initial letter fluency and excluded letter fluency scores. Testing for the difference between dependent correlations revealed that age was more highly correlated with excluded letter fluency than with initial letter fluency scores, $t(680) = 3.54$, $p < .001$ (Steiger, 1980). Also as expected, age was negatively correlated with DSST scores but was not correlated with NART errors.

The extent to which background characteristics (age left school, self-rated health, and depression scores), verbal knowledge, and speed of processing predicted verbal fluency performance, and the extent to which these variables mediated age differences in verbal fluency, were assessed with hierarchical multiple regression analyses (see Table 3). Background variables were entered before verbal knowledge, speed of information processing, and age to control for these influences on verbal fluency performance. The amount of variance predictable by age after inclusion of mediating variables was compared with the amount of variance predictable by age when entered alone to determine the amount of age-related variance accounted for by mediating variables.

Equation 1 of Table 3 shows that age contributed 2% to the variance in initial letter fluency and 8% to the variance in excluded letter fluency performance. In Equation 2, the background variables of age left school, self-rated health, and depression were entered as a block, before age, and accounted for 4% of the variance in initial letter fluency and 5% of the variance in excluded letter fluency, a similar and significant amount for both. After background variables had been entered, age contin-

Table 2
Correlations Between Age, Background Variables, Verbal Fluency Scores, DSST Scores, and NART Errors

Variable	Age	1	2	3	4	5	6	7
1. CES-D	.13***	—						
2. Health	.14***	.42***	—					
3. Age left school	.05	−.06	−.07	—				
4. Initial fluency	−.15***	−.14***	−.12**	.14***	—			
5. Excluded fluency	−.27***	−.15***	−.15***	.13***	.59***	—		
6. DSST	−.45***	−.19***	−.21***	.15***	.45***	.58***	—	
7. NART	.06	.10***	.08*	−.30***	−.48***	−.42***	−.32***	—

Note. *N* = 683. DSST = Digit Symbol Substitution Test; NART = National Adult Reading Test; CES-D = Center for Epidemiologic Studies–Depression Scale.
*p < .05. **p < .01. ***p < .001.

Table 3
Hierarchical Multiple Regression Analyses Predicting Initial Letter Fluency and Excluded Letter Fluency Performance From Age, Age Left School Rating, Health Rating, CES-D, DSST, and NART

Equation	Variable	R^2	ΔR^2	*df*	ΔF	Equation	Variable	R^2	ΔR^2	*df*	ΔF
	Initial letter fluency						Excluded letter fluency				
1	Age	.024	.024	1,681	16.72***	1	Age	.075	.075	1,681	54.94***
2	Age left school					2	Age left school				
	Health rating						Health rating				
	CES-D	.040	.040	3,679	9.37***		CES-D	.046	.046	3,679	10.98***
	Age	.059	.019	4,678	13.97***		Age	.111	.065	4,678	49.47***
3	Age left school					3	Age left school				
	Health rating						Health rating				
	CES-D	.040	.040	3,679	9.37***		CES-D	.046	.046	3,679	10.98***
	NART	.241	.201	4,678	179.40***		NART	.193	.147	4,678	123.08***
	Age	.253	.013	5,677	11.39***		Age	.247	.054	5,677	48.25***
4	Age left school					4	Age left school				
	Health rating						Health rating				
	CES-D	.040	.040	3,679	9.37***		CES-D	.046	.046	3,679	10.98***
	DSST	.221	.172	4,678	147.57***		DSST	.335	.289	4,678	294.24***
	Age	.214	.002	5,677	2.05		Age	.335	.000	5,677	0.38
5	Age left school					5	Age left school				
	Health rating						Health rating				
	CES-D	.040	.040	3,679	9.37***		CES-D	.046	.046	3,679	10.98***
	NART	.241	.201	4,678	179.40***		NART	.193	.147	4,678	123.08***
	DSST	.332	.092	5,677	92.81***		DSST	.395	.202	5,677	225.65***
6	Age left school					6	Age left school				
	Health rating						Health rating				
	CES-D	.040	.040	3,679	9.37***		CES-D	.046	.046	3,679	10.98***
	DSST	.211	.172	4,678	147.57***		DSST	.335	.289	4,678	294.24***
	NART	.332	.121	5,677	122.49***		NART	.395	.060	5,677	66.74***
7	Age left school					7	Age left school				
	Health rating						Health rating				
	CES-D	.040	.040	3,679	9.37***		CES-D	.046	.046	3,679	10.98***
	NART	.241	.201	4,678	179.40***		NART	.193	.147	4,678	123.08***
	Age	.253	.013	5,677	11.39***		Age	.247	.054	5,677	48.25***
	NART × Age	.254	.002	6,676	1.51		NART × Age	.246	.000	6,676	0.00

Note. Empty cells within table indicate that there are no data for age left school and health rating as all of the background variables (including CES-D) were entered into the regression as a block, therefore, all together they account for .040 and .046 of the variance in fluency. CES-D = Center for Epidemiologic Studies–Depression Scale; DSST = Digit Symbol Substitution Test; NART = National Adult Reading Test.
$^{***}p < .001$.

ued to contribute a significant 2% of the variance in initial letter fluency and 7% in excluded letter fluency performance. Therefore, background variables accounted for 21% of the age-related variance in initial letter fluency and 13% of the age-related variance in excluded letter fluency.

In Equation 3, NART errors added 20% to the variance in initial letter fluency and 15% to the variance in excluded letter fluency performance after background variables had been entered. Age then contributed a significant 1% to the variance in initial letter fluency and 5% to the variance in excluded letter fluency performance. Therefore background variables and NART errors accounted for 46% of the age-related variance in initial letter fluency and 28% of the age-related variance in excluded letter fluency performance.

Equation 4 shows that DSST scores predicted 17% of the variance in initial letter fluency and 29% of the variance in excluded letter fluency after background variables had been controlled. Age then no longer significantly contributed to the variance in either initial letter fluency or excluded letter fluency performance. Background variables and DSST scores accounted for 92% of the age-related variance in initial letter fluency and 100% of the age-related variance in excluded letter fluency performance.

Equations 5 and 6 examined the extent to which verbal knowledge mediated the variance in verbal fluency predicted by speed of processing and the extent to which speed of processing mediated the variance in verbal fluency predicted by verbal knowledge. In Equation 5, NART errors were entered after background variables and before DSST scores; in Equation 6, DSST scores were entered after background variables and before NART errors. Equation 5 shows that DSST scores continued to predict 9% of the variance in initial letter fluency and 20% in excluded letter fluency after background variables and NART errors had been entered. NART errors therefore accounted for 47% of the variance in initial letter fluency and 30% of the variance in excluded letter fluency originally predicted by DSST. Equation 6 shows that NART errors continued to predict 12% of the variance in initial letter fluency and 6% of the variance in excluded letter fluency after background variables and DSST scores had been entered. Therefore DSST accounted for 40%

of the variance in initial letter fluency and 59% of the variance in excluded letter fluency originally predicted by NART errors.

The predicted compensatory effect of verbal knowledge on age differences in verbal fluency was tested by entering the interaction between age and NART errors after controlling for background variables and the main effects of NART errors and age. If verbal knowledge compensates for age differences in verbal fluency performance, then such an interaction would predict a significant amount of the variance in verbal fluency. As can be seen from Equation 7, the interaction between NART errors and age did not add to the variance in either fluency measure. The hypothesis that verbal knowledge would compensate for age-related declines in verbal fluency therefore was not supported.

Discussion

The results suggest that there are significant, albeit small, declines in verbal fluency performance with increasing age among older adults. As expected, age-related declines in verbal fluency were greater for excluded letter fluency than for initial letter fluency performance. These declines in fluency appear to be accounted for by individual differences in education, self-rated health, and depression scores; by speed of information processing; and by verbal knowledge, with most of the age-related variance in fluency being accounted for by speed of processing. There was, however, no evidence of verbal knowledge compensating for age effects in verbal fluency. Although those with fewer NART errors had lower verbal fluency scores (see Table 3), the lack of a significant Age × NART interaction effect suggests that the effect of age on verbal fluency was similar regardless of level of verbal knowledge. High verbal knowledge may help maintain older adults' verbal fluency performance at a high level relative to those with low verbal knowledge but may not compensate for age-related declines.

The relatively small amount of age-related variance in verbal fluency suggests that verbal fluency performance is well maintained with increasing age. Indeed age differences in verbal fluency have not always been found, or have been minimal, even when older adults' performance has been compared with that of younger adults' (Davis et al., 1990; Mittenberg et al., 1989; Parkin & Walter, 1992; Salthouse, 1993; Schaie, 1983). However, these results do not support the findings of Lindenberger et al. (1993) who found that 20% of the variance in fluency was accounted for by age among a sample of older adults. The difference between our findings and those of Lindenberger et al. is curious and not easily explained as the samples of the two studies were similar with regard to amount of education, health ratings, and age.

Also as expected, age-related declines were greater on the excluded letter fluency task than on the initial letter fluency task. We predicted this finding on the assumption that the excluded letter fluency task may rely on those processes that decline more with increasing age to a greater extent than the initial letter fluency task. This was supported to some extent by the regression analyses. Background variables contributed a similar yet small amount to the variance in both fluency tasks. After background variables had been controlled, verbal knowledge contributed more to the variance in initial letter fluency than in excluded letter fluency; whereas speed of processing predicted excluded letter fluency to a greater extent than it did initial letter fluency. It could be that the initial letter fluency task relies on an individual's word knowledge base to a greater extent than does the excluded letter fluency task. In contrast, the excluded letter fluency task may rely on an individual's cognitive processing capacity, such as speed of processing.

However, age differences on both fluency measures were accounted for more by DSST scores than by NART errors. It is likely that this is because speed of processing declines with increasing age, whereas verbal knowledge is generally well maintained into older age. Age differences in DSST performance are extremely reliable and well documented (Salthouse, 1992) and have been found to mediate age differences in a wide variety of cognitive measures, including fluency performance (Lindenberger et al., 1993; Salthouse et al., 1996)

In summary, although higher verbal knowledge was associated with better verbal fluency performance, it appears that verbal knowledge does not compensate for age differences in verbal fluency performance. Initial letter fluency performance seems to rely more on participants' verbal knowledge than on speed of processing, and excluded letter fluency performance seems to rely more on speed of processing than on verbal knowledge. However, age differences on both of the verbal fluency tasks appear to be mediated by speed of information processing rather than by verbal knowledge. These results support the claims of Salthouse (1985) and Birren (1974) that age-related declines in cognitive performance are due to a generalized slowing with increasing age.

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Received August 7, 1996
Revision received January 5, 1997
Accepted January 5, 1997 ■