Published in final edited form as:

J Clin Exp Neuropsychol. 2016 November ; 38(9): 958–966. doi:10.1080/13803395.2016.1179266.

Word retrieval in picture descriptions produced by individuals with Alzheimer's disease

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Abstract

What can tests of single-word production tell us about word retrieval in connected speech? We examined this question in 20 people with Alzheimer's disease (AD) and in 20 cognitively intact individuals. All participants completed tasks of picture naming and semantic fluency, and provided connected speech through picture descriptions. Picture descriptions were analyzed for total word output, percentages of content words, percentages of nouns, and percentages of pronouns out of all words, type-token ratio of all words and type-token ratio of nouns alone, mean frequency of all words and mean frequency of nouns alone, and mean word length. Individuals with AD performed worse than did cognitively intact individuals on the picture naming and semantic fluency tasks. They also produced a lower proportion of content words overall, a lower proportion of nouns, and a higher proportion of pronouns, as well as more frequent and shorter words on picture descriptions. Group differences in total word output and type-token ratios did not reach significance. Correlations between scores on tasks of single-word retrieval and measures of retrieval in picture descriptions emerged in the AD group but not in the control group. Scores on a picture naming task were associated with difficulties in word retrieval in connected speech in AD, while scores on a task of semantic verbal fluency were less useful in predicting measures of retrieval in context in this population.

Keywords

Lexical retrieval; noun frequency; picture naming; semantic fluency; dementia; connected speech; discourse

Word retrieval difficulties are one of the hallmarks of Alzheimer's disease (AD), reflecting impairment either in representation or in access to conceptual knowledge (Adlam, Patterson, Bozeat, & Hodges, 2010; Garrard, Lambon Ralph, Patterson, Pratt, & Hodges, 2005; Laisney et al., 2011). Individuals with AD are thus expected to have deficits in word finding

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We declare no conflict of interests.

across a variety of tasks, whether retrieval is tested for single words or in connected speech. We examine the relationship between measures of word retrieval in isolation and variables of word retrieval in context. Our aim is to determine which measures of word retrieval in isolation best predict indicators of difficulties in word retrieval in connected speech.

Research on production of single words on tasks of picture naming has documented deficient performance in individuals with AD relative to the performance of cognitively intact participants (e.g., Almor et al., 2009; Balthazar, Cendes, & Damasceno, 2008; Cuetos, Gonzalez-Nosti, & Martínez, 2005; Masterson et al., 2007). Lexical characteristics, such as a word's frequency, age of acquisition, imageability, or name agreement, as well as the contexts in which items can appear, were all found to affect word retrieval on picture naming tasks in AD (e.g., Cuetos, Rodríguez-Ferreiro, Sage, & Ellis, 2012; Ivanova, Salmon, & Gollan, 2013). In addition, individuals with AD have been shown to retrieve fewer words on tasks of verbal fluency relative to age-matched healthy participants (e.g., Adlam et al., 2010; Arroyo-Anlló, Lorber, Rigaleau, & Gil, 2012; Haugrud, Crossley, & Vrbancic, 2011). A meta-analysis of 153 studies of verbal fluency with over 8000 patients suggested that the impairment was greater on the semantic than on the phonemic fluency task (Henry, Crawford, & Phillips, 2004). On fluency tasks, persons with AD produce fewer semantic subcategories, generate fewer switches between subcategories, and provide smaller semantic word clusters than do healthy older adults (Haugrud et al., 2011; Weakley & Schmitter-Edgecombe, 2014). Hence, tests of single-word retrieval suggest that word production is impaired in AD. This deficit reflects impoverished conceptual representations or the weakening of word associations within the mental lexicon.

Assessments of word retrieval in connected speech in AD have used a multitude of measures to document possible difficulties. Individuals with AD have been shown to provide fewer information units that pertain to the topic at hand (e.g., Ahmed, de Jager, Haigh, & Garrard, 2013; de Lira, Minett, Bertolucci, & Ortiz, 2014; Kavé & Levy, 2003). Patients were found to commit more word errors (Forbes-McKay & Venneri, 2005), say more empty phrases and indefinite terms (Nicholas, Obler, Albert, & Helm-Estabrooks, 1985), pause more often (Davis & MacLagan, 2009), and retrieve more frequent words following pauses (Gayraud, Lee, & Barkat-Defrada, 2011) relative to healthy control participants. Garrard, Maloney, Hodges, and Patterson (2005) found a longitudinal decline in the ratio of unique words to total word output in the writings of a renowned author who was subsequently diagnosed with AD. Similarly, Berisha, Wang, LaCross, and Liss (2015) documented a reduction in the number of unique words over time, along with an increase in conversational fillers and non-specific nouns in speeches delivered by President Reagan. Other studies have recorded an increase in the use of pronouns in language samples of individuals with AD (e.g., Ahmed, Haigh, de Jager, & Garrard, 2013; Almor, Kempler, MacDonald, Andersen, & Tyler, 1999). In a detailed computerized analysis of the speech of 167 individuals with AD that defined 370 features, Fraser, Meltzer, and Rudzicz (2015) found that these features loaded on four factors: semantic, acoustic, syntactic, and information. The current study focuses on features that belong in the semantic factor.

Pekkala et al. (2013) suggested that picture descriptions are quite sensitive in detecting early changes in lexical access in AD. Nevertheless, relatively few studies of word retrieval in AD

have compared performance on tests of single-word production with performance on tasks of connected speech. These studies used different means by which to elicit speech as well as different means by which to determine word finding difficulties in connected speech. For example, Almor et al. (1999) asked 11 persons with AD and 9 matched control participants to name pictures and to tell something about their lives. They found no correlation between picture naming scores and the ratio of pronouns to full nouns in spontaneous speech. However, Almor et al. report correlations that were computed for individuals with AD together with control participants, and it is possible that this analysis masked existing associations within the AD group alone. Ash, Moore, Vesely, and Grossman (2007) asked 20 individuals with AD and 10 matched control participants to narrate wordless picture books, and reported a significant negative correlation between picture naming scores and word choice errors. Brandão, Castelló, van Dijk, de Mattos Pimenta Parente, and Peña-Casanova (2009) reported that picture naming scores were negatively correlated with the number of incomplete propositions in autobiographical narratives. Bschor, Kühn, and Reischies (2001) showed that scores on tasks of picture naming as well as verbal fluency correlated positively with retrieval of information units (e.g., target objects, actions, or locations) in picture descriptions. In another study, object naming scores predicted the number of information units as well as the number of indefinite terms (e.g., 'something like that') that patients produced in connected speech, whereas action naming scores predicted only the former (Nicholas et al., 1985). We note that retrieval of information units does not equal retrieval of specific lexical items and in fact may not attest to successful word retrieval at all. That is, the same information could be conveyed with different words, some being less precise than others. Importantly, Nicholas et al. (1985) found no association between naming scores and several indications of errors in retrieval (e.g., paraphasias, pronouns with no antecedents). Therefore, previous research suggests that scores on tests of single-word production might be correlated with certain aspects of connected speech, but most measures of successful word retrieval in context, such as type-token ratio or the frequency of the selected words, have not been investigated.

The current study examines the association between retrieval of single words on structured tasks (i.e., picture naming and semantic fluency) and indications of successful retrieval on a task of picture description. We expected individuals with AD to show significant deficits on tasks of single-word production. We further assumed that indications of successful word finding will be less prevalent in the connected speech produced by patients than in the connected speech produced by cognitively intact participants. We focused on total word output, percentage of content words, percentage of nouns, and percentage of pronouns out of all words, type-token ratio of all words as well as type-token ratio of nouns alone, mean frequency of all words as well as mean frequency of nouns alone, and mean word length. We hypothesized that word retrieval difficulties in connected speech will be related to production of a lower ratio of content words in general and of nouns in particular as well as to production of a higher ratio of pronouns. We also expected that greater retrieval deficits will be associated with reduced lexical diversity, as reflected in lower type-token ratios (indicating more repetitiveness), as well as in production of more frequent and shorter words (indicating simplified lexical selection). Finally, we assumed that scores on tasks of single-word retrieval will correlate with measures of retrieval in connected speech.

Method

Participants

Forty community-dwelling volunteers, age range 68-87, participated in the study, 20 with AD and 20 matched controls. Participants were either born in Israel ($n = 16$) or immigrated to Israel before they were 18 years old ($n = 24$), using Hebrew as their primary language at home and at work throughout their adult life. Education ranged between 8 and 18 years. Diagnosis of AD was given according to the NINCDS-ADRDA criteria (McKhann et al., 1984). The AD group was moderately impaired, scoring between 18 and 25 (mean = 22.15; $SD = 1.95$) on the Mini-Mental Status Examination (MMSE, Folstein, Folstein, & McHugh, 1975). Cognitively intact participants reported no history of neurological or psychiatric disease, complained of no cognitive decline, and scored 27 or higher on the MMSE (mean = 28.95, $SD = 1.28$). They were matched to patients in gender, age, education, age at immigration, and country from which they immigrated (see Table 1). The study received Institutional Review Board approval and was completed in accordance with the Helsinki Declaration.

Procedure

Participants were tested on a picture naming task, a semantic fluency task, and a picture description task. All three tasks were administered individually in one session, in the same order for all participants.

Picture naming

We used a picture-naming test that consisted of 48 black and white line drawings (Kavé, 2005a; Kavé, Knafo, & Gilboa, 2010). Each participant was instructed to say in one word the name of the item in the picture. Test items were presented with no time limitation and participants saw all 48 stimuli even when failing to name several consecutive ones. A spontaneously corrected response was given full credit. If a general rather than a specific response was provided (e.g., *kova* 'hat' instead of *migba'at* 'top-hat'), the examiner prompted correct naming by asking: "Is there another word for this picture?". When an item was not spontaneously named or if the participant clearly misperceived the picture, a functional cue was provided (e.g., 'key': 'you lock the door with it'). If naming failed following the functional cue, a phonemic cue was offered. Responses provided after cues were documented but were not included in the total score used in the current study.

Semantic fluency

Participants were asked to provide as many words as possible within one minute for each of the following three semantic categories: animals, fruits and vegetables, and vehicles, in that order (as in Kavé, 2005b; Kavé & Knafo-Noam, 2015). Fruits and vegetables were treated as one category in order to avoid the ambiguity between botanical definitions and common usage (e.g., 'avocado'). For the category of vehicles, the examiner specified that only types of transportation should be provided while brand names were unacceptable. Responses were written verbatim, with errors or repetitions subsequently excluded from the total score. When a questionable response was provided, clarifications were invited at the end of the

one-minute interval. Masculine and feminine forms of the same word (e.g., *par* ‘bull’ and *para* ‘cow’) were counted as one, whereas an animal and its offspring were counted as separate words (e.g., *para* ‘cow’ and *egel* ‘calf’). Synonyms were counted as two (*matos* and *aviron* ‘airplane’). Names of subcategories (e.g., *dag* ‘fish’) were not given credit if specific items within that subcategory were also provided (e.g., salmon, tuna). The fluency score was the sum of correct items provided across all three categories together.

Picture description

Each person was presented with the Cookie Theft picture from the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983). The instructions were “I want you to tell me the story of this picture”. Descriptions were recorded and the recording was stopped when a person indicated that s/he had finished, either by saying so explicitly or by becoming silent. Speech samples were transcribed and analyses were performed on the written transcriptions.

Analysis of picture descriptions

Samples were first manually stripped of all interjections (e.g., ah...), incomplete words (e.g., co...), and unrelated comments at the beginning or end of the description. They were then submitted to an automated text analysis tool (<https://hlp.nite.org.il/WebStatisticalAnalyzer.aspx>, version 17/6/2015), developed for scoring essays in Hebrew according to lexical and grammatical measures (Ben Simon & Cohen, 2011). This tool provided summary results for each sample, including the total number of words, the percentage of content words out of all words, the percentage of nouns out of all words, the percentage of pronouns out of all words, the type-token ratio of all words, the mean frequency of all words, and the mean length of all words in letters. We note that the tool provides other data that pertain to syntax and morphology (e.g., sentence length, use of subordination, verb tense), which were not examined in the current study.

A further manual analysis focused on the nouns that appeared in the samples. Common nouns were identified, excluding proper nouns (e.g., names of people), pronouns (e.g., *hu*, *hi* ‘he, she’), and empty nouns (e.g., *mashehu*, ‘something’). All nouns were tallied as tokens, including repetitions, plural nouns, and feminine nouns. Namely, *yeled* / *yalda* / *yeladim* (child-masculine/child-feminine/children) were counted as three separate tokens. When a compound was produced we counted only its head (e.g., *cabinet* in the compound *kitchen cabinet*). To calculate the noun type-token-ratio, we identified noun types by excluding repetitions as well as plural or feminine forms of nouns that were also produced in singular or masculine forms. The number of noun types was divided by the number of noun tokens to create the noun type-token ratio variable. A score close to 1 would indicate greater lexical diversity, and a score close to 0 would suggest restricted diversity.

The automated analysis provided a general frequency measure of all words in each sample on the basis of a corpus which is built into the system. In addition, we used data collected in a study in which 136 Hebrew speakers described the same picture stimulus that was used in the current study (Kavé, Samuel-Enoch, & Adiv, 2009). In this earlier study, 240 nouns were identified in the collected picture descriptions and these nouns were rated for frequency in

the language by young and old raters. We relied on the data provided by the 40 older raters (mean age = 63.95, $SD = 2.97$, range 60-72). Participants who were asked to describe the picture in the current study produced additional 36 nouns and these nouns were rated by a new group of ten judges (mean age = 63.90, $SD = 3.35$, range 60-70). Rating was done on a scale of (1) highly infrequent to (5) highly frequent. Examples of an infrequent as well as a frequent word were presented on the questionnaire. For each noun we derived the mean rating across all raters. These mean ratings were used to calculate the average frequency of the noun types produced in each picture description.

Results

As expected, persons with AD demonstrated substantial difficulties on tests of single-word retrieval relative to healthy individuals. Non-parametric Mann-Whitney U tests showed that scores on the picture naming task as well as on the semantic fluency task differed significantly between groups (see Table 1). We also computed Spearman correlations between scores on the two single-word retrieval tasks: AD group, $r = .590$, $p < .01$, control group, $r = .182$, $p > .05$, and $r = .812$, $p < .01$ across groups. Thus, although the tasks measured similar impairments in the AD group, they were not significantly correlated within the control group, most likely due to restricted variance in picture-naming performance (45% of the control sample scored 90% or higher on the naming test).

Table 2 presents the variables that were derived from the picture descriptions, along with Mann-Whitney U tests that compared these variables across groups. No statistically significant differences were found in overall word number, in type-token ratios of all words (automated analysis), or in type-token ratio of nouns alone (manual analysis). The percentage of content words, as well as the percentage of nouns and pronouns out of all words differed significantly between groups. Thus, the AD group used a lower percentage of content words and nouns relative to all words than did the control group, as well as a higher percentage of pronouns relative to all words than did the control group. In addition, participants with AD produced more frequent words overall than did healthy participants, and the same was true when noun types were manually identified and their frequency was calculated through subjective ratings. Furthermore, the AD group produced significantly shorter words than did the control group.

Next, we computed Spearman correlations to examine the association between word retrieval on single-word production tests and measures of word retrieval in picture descriptions. As shown in Table 3, within the control group no correlation reached significance. Within the AD group picture naming scores were positively associated with the percentage of content words as well as with the percentage of nouns, and negatively correlated with the percentage of pronouns. Thus, better performance on the naming test was related to greater production of content words in general and of nouns in particular, as well as to production of fewer pronouns. The correlations between picture naming scores and the two measures of type-token ratio were not significant. Scores on the naming test were negatively correlated with the overall frequency of the words produced on the picture description as well as with the mean word length, as derived from the automated analysis. No significant correlation was found between naming scores and the frequency of the nouns

selected on the picture descriptions. Semantic fluency scores were positively correlated with the percentage of nouns in picture descriptions. No other significant correlations with the semantic fluency scores were found within the AD group.

Discussion

Our results replicate previous work that documented impairment on tests of single-word retrieval in AD (e.g., Almor et al., 2009; Cuetos et al., 2005, 2012; Haugrud et al., 2011; Rogers, Ivanoiu, Patterson, & Hodges, 2006). In addition, several significant differences in word production on picture descriptions emerged between the groups, and scores on the picture naming test were associated with the pattern of word production in context within the AD group.

Inspection of the picture descriptions provided by individuals with AD shows that patients produced a comparable total number of words as did cognitively intact participants, with greater variance in the patient group than in the control group. These findings are in line with previous results (e.g., Almor et al., 1999), suggesting that despite documented reduction in meaningful and relevant content in picture descriptions provided by individuals with AD (e.g., Bschor et al., 2001; Kavé & Levy, 2003; Nicholas et al., 1985), no overall reduction in output is found. Our hypothesis that individuals with AD would repeat themselves more often when providing connected speech, as has been found on verbal fluency tasks (Miozzo, Fischer-Baum, & Caccappolo-van Vliet, 2013), did not receive support from our data. To examine this hypothesis, we looked at type-token ratios of either all words or nouns alone. Although the means of the type-token ratios were in the right direction, with more repetition (lower type-token ratio) in the AD group than in the control group, the differences were not significant, possibly due to sample size or due to within-group variance. We note that type-token ratio is highly affected by the total number of words (e.g., Durán, Malvern, Richards, & Chipere, 2004; Tweedie & Baayen, 1998). While there was no inter-group difference in the total number of words produced, there was intra-group variance in this measure, especially within the AD group, which could have affected the TTR analysis. Another measure of lexical diversity might have led to different results and should be further explored in this context.

Our assumption that individuals with AD would produce a lower proportion of nouns out of all other words as well as a higher proportion of pronouns out of all other words was confirmed, supporting other such reports (e.g., Ahmed, Haigh, et al., 2013; Almor et al., 1999). These findings show that patients might be unable to access full nouns and may resort to the production of more general pronouns instead. Furthermore, the data supported our hypothesis that the speech of persons with AD would be more lexically impoverished. Specifically, we found that individuals with AD produced more frequent words as well as shorter words than did cognitively intact participants, similar to previous studies that demonstrated simplification of word choice in this disease (Garrard, Maloney, et al., 2005). Indeed, Fraser et al.'s (2015) factor of semantic impairment consisted of decreased proportion of nouns, increased proportion of pronouns, increased frequency of words, as well as decreased word length, and this factor best differentiated speech samples produced by patients from samples that were produced by controls. Thus, the group differences that

we documented in measures of word retrieval in connected speech most likely result from the underlying semantic deficit that characterizes AD.

Unlike the increase in word frequency seen in the current study within the AD group, previous research has shown that healthy older participants select less frequent words in picture descriptions relative to younger adults (Kavé et al., 2009). Such findings may reflect the larger vocabulary available to healthy older adults relative to younger adults (e.g., Goral, Spiro, Albert, Obler, & Connor, 2007; Verhaeghen, 2003), which helps them bypass retrieval difficulty in context. In contrast, individuals with AD might retrieve more frequent words in context because their semantic network is impoverished (Adlam et al., 2010; Garrard, Lambon Ralph, et al., 2005), thus leading to production of the most preserved and the most accessible items. Indeed, it has been argued that more frequent words are better preserved in AD and are accessed more readily even when the semantic system deteriorates (Garrard, Lambon Ralph, et al., 2005). Hence, the differences in word frequency and word length documented in the current study might represent opposing trends of healthy aging and disease. While healthy aging is associated with an increase in lexical richness of selected words in context, indications of reduced lexical richness in connected speech might serve as early signs of AD.

When the correlations between scores on tests of single-word retrieval and variables that indicate word retrieval in connected speech were examined within the AD group, performance on the picture naming task was associated with the majority of the connected speech measures, except for the total number of words and the type-token ratios. These results suggest that the correlations reflect the semantic deficit that characterizes AD. In contrast, and contrary to our expectation, semantic fluency scores correlated with only one variable derived from the picture descriptions, namely the percentage of nouns out of all words. The picture naming task could be a better predictor of word retrieval in context than the semantic fluency task for two main reasons. First, the speech elicitation method that we used most likely involved cognitive demands that were similar to the ones required for the picture naming task (i.e., visual analysis, specific labeling). Future research should examine whether similar findings emerge when speech is elicited with no pictorial support, for example, by asking participants to recall a personal experience. Second, the verbal fluency task is highly dependent on executive functions (Kavé, Heled, Vakil, & Agranov, 2011), perhaps more so than it depends on semantic stores (Kavé & Mashal, 2012). Hence, the lack of correlations between semantic fluency scores and measures of connected speech could reflect the fact that retrieval difficulties in connected speech in AD are determined more by semantic difficulties and less by impairment in executive control. We note further that within the control group there were no correlations between either the picture naming or the verbal fluency scores and any of the connected speech variables. The lack of correlation between naming scores and connected speech variables could be accounted for by the restricted variance in naming scores within the control group. As healthy older adults varied in their performance on the verbal fluency task, the lack of correlation between fluency scores and connected speech variables implies that each task exerts differential retrieval demands.

The group differences documented in the current study, together with the correlational data, suggest that the percentage of content words, the percentage of nouns, the percentage of

pronouns, as well as word frequency and word length can provide good indications of word retrieval difficulties in connected speech in AD. Nevertheless, the correlations between scores on structured tests and connected speech variables were far from perfect. Thus, performance on picture naming and verbal fluency tasks might reflect difficulties that are different from the ones experienced in natural settings. Namely, while on tasks of single-word retrieval individuals must retrieve pre-determined lexical items, in connected speech they are free to select their own words. In addition, the context might prime the to-be-retrieved item, thus leading to more successful retrieval in connected speech than in isolation. Cognitive assessments often use picture naming and semantic fluency tasks to evaluate word retrieval difficulties, with the implicit assumption that these tasks predict difficulties in functional communication as well. Our study provides partial support for this assumption with regard to picture naming in AD, but at the same time it draws attention to the fact that the skills assessed in isolation and in context are not identical.

We acknowledge that our study has some limitations. First, we did not analyze the correctness of the words that participants retrieved in their picture descriptions. We wanted to focus on indications of successful word retrieval in context, and future studies should further examine the association between performance on single-word retrieval tasks and word errors in context. It would also be interesting to compare the type of mistakes that participants make across tasks. Second, our study did not include testing of other cognitive functions, such as executive functions, working memory, mental speed, or visual perception that could help us identify what contributes to the documented difficulties in word retrieval in the different tasks. Such an examination awaits further research. Third, word retrieval in context might be affected by grammatical deficits, which were not assessed here and deserve a separate study. We note, though, that Fraser et al. (2015) found that semantic and syntactic aspects of connected speech are much more strongly associated in healthy participants than they are in individuals with AD.

Notwithstanding these limitations, our main conclusion is that scores on a task of picture naming are associated with difficulties in word retrieval in connected speech in AD, while semantic verbal fluency performance is less useful in predicting retrieval in context in this population.

Acknowledgments

Gitit Kavé received funding from the Open University of Israel, grant 100887. Mira Goral received funding from the National Institutes of Health, grant DC009792.

This research was partly supported by research fund # 100887 from the Open University of Israel to Gitit Kavé, and by National Institutes of Health Grant DC009792 to Mira Goral. We thank Talia Pertman for her help in data collection and preparation. We declare no conflict of interests.

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Table 1
Demographic characteristics and raw scores on tasks of picture naming and semantic fluency, by group

	AD (n=20)	Control (n=20)	Mann-Whitney U	Significance
Number of women	13	13		
Age				
Mean	76.10	76.20	199.5	.995 ^a
SD	5.16	4.50		
Range	68-87	71-85		
Education				
Mean	11.00	11.10	193.0	.854 ^a
SD	1.81	2.38		
Range	8-14	8-18		
Age at immigration				
Mean	9.23	8.73	178.0	.546 ^a
SD	5.17	6.23		
Range	0-15	0-17		
Picture naming				
Mean	27.05	42.90	10.0 [*]	.000 ^b
SD	9.92	3.04		
Range	7-40	36-48		
Semantic fluency				
Mean	24.00	51.05	6.5 [*]	.000 ^b
SD	8.46	8.95		
Range	9-43	34-68		

Note: The mean age at immigration was calculated only for participants who were born outside Israel.

^{*} Significant group difference.

^a Two-tailed comparison;

^b One-tailed comparison.

Table 2
Variables derived from connected speech, by group

		AD (n=20)	Control (n=20)	Mann-Whitney U	Significance (1-tailed)
Total number of words	Mean	68.90	56.10	175.5	.258
	SD	52.87	14.81		
% content words of all words	Mean	66.57	71.67	116.5*	.012
	SD	10.43	4.82		
% nouns of all words	Mean	29.50	34.76	118.5*	.013
	SD	8.97	7.23		
% pronouns of all words	Mean	12.52	8.50	137.0*	.045
	SD	7.53	4.59		
Type-token ratio of all words	Mean	.82	.87	144.0	.066
	SD	.12	.05		
Type-token ratio of nouns	Mean	.71	.76	165.0	.175
	SD	.16	.10		
Mean frequency of all words	Mean	32.65	30.85	122.0*	.018
	SD	3.10	1.80		
Mean frequency of nouns	Mean	4.47	4.32	84.0*	.001
	SD	.10	.16		
Mean word length in letters	Mean	3.90	4.09	115.0*	.010
	SD	.28	.17		

Note: Mann-Whitney U compared scores in the two groups.

* Significant group difference.

Table 3
Spearman correlations between word retrieval on structured tests and variables derived from connected speech, by group

		Naming	Semantic fluency
Total number of words	AD	-.164	.161
	Control	.324	.278
% content words of all words	AD	.583 **	.152
	Control	.002	-.284
% nouns of all words	AD	.658 **	.453 *
	Control	-.134	.062
% pronouns of all words	AD	-.483 *	-.200
	Control	-.046	.087
Type-token ratio of all words	AD	.338	-.056
	Control	-.210	.261
Type-token ratio of nouns	AD	.131	-.039
	Control	.048	-.344
Mean frequency of all words	AD	-.667 **	-.366
	Control	.291	.023
Mean frequency of nouns	AD	-.152	-.138
	Control	-.228	.093
Mean word length in letters	AD	.459 *	.236
	Control	-.065	-.136

Note:

* $p < .05$;

** $p < .01$.