Complexity Measures in Word Fluency: A Linguistic Analysis in AD Patients

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Running Head: WORD FLUENCY AND ALZHEIMER'S DISEASE

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Abstract

Many researchers have used the Word Fluency Test as an assessment tool for examining areas of cognition such as mental functioning, individual differences, and dementia in adults. Traditionally, word fluency has been evaluated by analyzing the number of words produced quantitatively. Older subjects and individuals with less education tend to produce fewer words. A gender difference, favoring women has also been reported. Results with Alzheimer's patients have shown a decline in responses. Few researchers have examined the qualitative differences between Alzheimer's patients and a control group. This paper examines both grammatical and morphological qualitative changes.

INTRODUCTION

Many researchers have used the Word Fluency Test (Thurstone & Thurstone, 1948) as an assessment tool for examining areas of cognition such as mental functioning, individual differences, and dementia in adults. Traditionally, word fluency has been evaluated by analyzing the number of words produced quantitatively. Individuals with less education tend to produce fewer words. Therefore, education could be considered a confounding variable. It has been reported that there are gender differences favoring women in word frequency tasks (Alvis, Ward, & Dodson 1989; Buckelew & Hannay 1986).

Additional research demonstrates that word fluency scores decline with age (Alexander, Langer, Newman, Chandler, & Davies 1989; McCrae, Arenberg, & Costa 1987; Obler & Albert, 1985). Heller and Dobbs (1993) argue that to examine changes in word retrieval patterns, word fluency should be measured in discourse and non discourse contexts. They found evidence that age related word retrieval deficits remain even when a context (in discourse) is provided.

Although there is no definite diagnosis for Alzheimer's disease except a post mortum autopsy, many researchers have attempted to describe the language impairment associated with the disease. Language symptoms appear similar to both anomic aphasia and transcortal sensory aphasia. A debate exists as to whether Alzheimer patients have aphasia or a language disorder that closely mirrors aphasia. The disagreement is over the use of the term aphasia, which refers to a lesion to a specific area of the brain. When a person suffers from aphasia, the language deficits are disproportionate to their cognitive skills. Alzheimer's patients show a language deficit proportional to their cognitive deficit (Bayles, Tomoeda, and Trosset, 1993). Regardless of whether the aphasia term is used to describe the language deficit, more detailed and through methods for describing Alzheimer's disease language disorders are needed (Murdoch and Chenery, 1987).

Generally the word fluency task shows a decline in answers of people with Alzheimer's Disease when compared to normal control groups. Through various experiments, Miller and Hague (1975) concluded that this difference was due not to word loss but to trouble accessing the

words. Few researchers have examined what types of changes occur in the answers of the word fluency task. Systematically decomposing responses and examining how they are different from control groups could provide researchers with a better understanding of how the word retrieval process changes in adults with Alzheimer's disease. This type of decomposition would allow for exploration of areas of deficit as well as improvement.

An alternative approach to the quantitative analysis of word fluency involves a qualitative linguistic perspective. Linguistic analysis can be approached grammatically or morphologically. Grammatical analysis involves categorizing words into their parts of speech (e.g., nouns, verbs, adverbs and adjectives), while a morphological analysis characterizes words into the appropriate number of morphological parts. These methods examine not only the number of responses produced but also the types or categories of responses that subjects produce. Qualitative changes in word production can be measured using several language characteristics as opposed to one general score.

A morphological analysis of adult speech is a way to examine the complexity of one's word responses. The unit of analysis, a morpheme, is the smallest meaningful unit in any language. Its form and meaning are consistent throughout a language. Words can consist of either one or several morphemes. Words like *tree*, *cat*, *run*, *sad*, *nice*, and *think* all consist of one morpheme, and can not be broken down into smaller lexically meaningful segments. These words are called free morphemes because they can stand alone and express their meaning. The other major type of morpheme is bound and can not express its lexical meaning without being attached to another word or root. Suffixes, prefixes, and roots (i.e., *-ed*, *-ment*, *-ing*, *-ly*, *sub-*, *per-*, *-mit*) can slightly change the meaning of the original word when they are attached to other forms . Newly formed words like *agree+ment*, *sad+ly*, and *sub+marine* have two morphemes. Words can contain several morphemes, like *un+happi+ness*, *un+lik+ly+ness*, and *non+pre+condition+al+ly*.

Morphemes are considered as a measure of complexity in child language acquisition studies (Brown, 1973). Morphological analysis is used as a developmental marker to determine if a child has acquired grammatical rules of their language (Berko, 1958). Basically, the more morphemes a

word has the more different lexically meaningful parts it contains, and thus the more complex it becomes. The same type of measure can be applied to adult language. The present investigation used the average number of morphemes per word in the analysis of the data.

In a previous study, Tesluk, McGuire, Schaie, & Willis, 1994 examined word frequency responses longitudinally using grammatical and morphological methods. The first investigation examined how adults' word frequency responses changed over a seven year period. Two main findings concerning longitudinal changes in word fluency responses were discovered. First, although the number of words produced decreased with age; the level of complexity of the words produced increased. Second, a gender difference existed, where women out performed men in the oldest and youngest groups. Men in the middle age group generated more words than the women in that age group. This suggested that gender differences show a reversal from age 64-77. Finally, participants in the old-old group (those over age 77) had a significant decrease in the number of verbs recalled. A possible explanation was that verbs and nouns were the most common parts of speech recalled (as high as 95% of responses). Nouns may have been easier to recall than verbs, because there are more nouns, and they are more concrete concepts. The number of possible verbs is reduced by the lexical rule for this test (which states conjugations of verbs are not allowed).

From the previous descriptions of Alzheimer's patients' language skills, the following hypotheses will be explored. First, it is hypothesized that Alzheimer's patients will produce fewer nouns and verbs and more adjectives and adverbs than the normal controls. This hypothesis is based on some of the work by Appell, Kertesz, and Fisman (1982), who reported that in general parts of speech are affected differently. Nouns show the most decrement. Also Appell et al. (1982) reported that Alzheimer's patients produce fewer low frequency words in fluency tests. Thus higher frequency words for Alzheimer's patients may be the words they use more often. If there are having trouble retrieving nouns, then they may use more descriptors like adjective and adverbs.

The second hypothesis involves the use of the morphological measure. Due to the language and cognitive deficits describe by previous researchers, it was hypothesized that a task as difficult as word fluency would produce differences between the Alzheimer's group and the control group, with the latter producing less complex words.

The final hypothesis concerns the role of gender. Because previous work on word fluency has shown that women outperform men, it is logical to extend this finding to men and women with Alzheimer's disease. Therefore it is expected that women will out perform men on the number of words produced. With less confidence, we hypothesize that women will out perform men on the grammatical and morphological variables.

METHODS

Participants

Eleven Seattle Longitudinal Study volunteers were diagnosed as having probable Alzheimer's Disease. Fifty-five normal controls that matched these individuals with respect to age, number of years of education, gender, and time of testing session. The mean age of the entire sample was 73.55 years (SD = 8.06, range 51-92 years). These variables were used to match subjects because word fluency declines with age (Langer at al., 1989; McCrae et al., 1987; Obler et al., 1985), and gender and education were important variables in previous studies of word fluency (Alvis et al., 1989; Buckelew, et at., 1986). There were no statistical differences between the AD and control sample among categorizing variables (see Table 1).

Insert Table 1 about here

Materials and Procedure

Participants were administered the Word Fluency Test from the Primary Mental Abilities battery (Thurstone & Thurstone, 1948). Word fluency is a task concerned with speeded verbal production. Participants were given five minutes to write down as many words as they could beginning with the letter 's'. Participants were instructed not to list proper nouns or the

conjugation of verbs (i.e., not to include the present and past tense of the same verb) in their responses.

Each word was categorized by parts of speech and by number of morphemes. The parts of speech were determined by The English Oxford Dictionary (1973). Two independent raters trained in Linguistics divided the words into morphemes. When the raters did not agree on the morphological division, the etymology of the word was consulted to determine which morpheme value should be used. Raters disagreed on only 5 % of the corpus of responses. Only words found in the Oxford Dictionary were included in the analysis.

RESULTS

Several 2 (gender) by 2 (group) Analysis of Variance (ANOVA) were used to examine the differences between diagnosed Alzheimer's disease patients and matched controls and gender. Although education was is highly correlated with verbal abilities, it was not controlled for in these analyses. Because education was matched between the control and Alzheimer's group. Results are discussed in two sections: the grammatical analyses and the morphological analyses.

Morphological analyses

There was a main effect for group ($p<.001$), with the AD sample reported on average 21 words and the control sample reported on average almost 39 words. There were no significant results for gender or the interaction of group and gender (see figure 1). There were also significant differences for the average number of morphemes per word, resulting in an interaction between the groups and gender. Male AD participants performed worse than their matched controls, whereas female AD participants outperformed their matched controls (see figure 2).

Insert Figures 1 & 2 about here

Grammatical analyses

Significant differences were found between the two groups, and the interaction term (group by gender) for the proportion of nouns generated. The AD group generated a lower proportion of

nouns than the control group. Also female AD participants generate a higher portion of nouns that male AD participants (see figure 3). Significant differences between groups were present for the proportion of verbs produced. The AD sample produced a lower proportion of verbs from the total list than the control group. No gender differences or interaction were found (see figure 4). The analyses also revealed significant differences between groups, gender and an interaction for the proportion of adjectives produced. The words retrieved by the AD sample contained a larger proportion of adjectives than the control group Males in the AD group produced the highest proportion of adjectives than any other group, which is depicted in Figure 5. The proportion of adverbs produced no significant results.

Insert Figures 3-5 about here

DISCUSSION

Our initial hypotheses were partly confirmed. The first hypothesis stated that the control sample would produce a higher proportion of adjectives and adverbs, and lower proportion of nouns and verbs. The categories of nouns, verbs, and adjectives supported our hypothesis, but the adverbs failed to provide significant results (although the trends of the scores were in the right direction). Although the word fluency task is devoid of context, it does reflect words that are used more often in a person's everyday vocabulary. Because Alzheimer patients have trouble with naming objects, we thought they might use a larger proportion of adjectives to describe things they can not name, and thus this could explain their higher use of adjectives and adverbs. We did find this result for adjectives.

Second, it was hypothesized that a task as difficult as word fluency would produce differences between the Alzheimer's group and the control group, with the later producing less complex words. This conclusion was not supported. Actually, the AD sample of women generated on average more complex words than the control group of women. This was an unexpected result. We feel it could be explained by closer examination of the two groups of

women. The AD females had about more year of education, and were about 7 years older than the female control group. From the previous work (Tesluk, et al., 1994), complexity increases with age and also education. This could explain why the female AD group is producing more complex words.

The final hypothesis suggested that women would outperform men on the total number of words, grammatical and morphological variables. The only main effect for gender was found with adjectives, and men out performed women. Although no other significant results were found, examining group means revealed that women had more words, proportion of nouns, verbs, adverbs and higher average number of morphemes per word than the men. This lack of significant findings could be due to a power issue of small sample size. The lack of significant gender differences supports the findings of Monsch, Bondi, Butters, Salmon, Katzman, & Thai (1992), who did not find any gender differences within a group of Alzheimer patients.

The implications this study has are mainly limited to diagnostic testing for probable Alzheimer's disease. Word fluency had been used as a diagnostic tool for quite some time. But researchers may now what to examine more qualitative variables than just the total number of words generated. Looking for higher proportions of adjectives and lower numbers of average morphemes per word may help clinicians diagnosis probable Alzheimer cases either earlier or with more certainty.

The limitations for this study include that the language sample is devoid of context. Therefore, its results are not easily generalizable to everyday speech, although there is a connection between frequency of words and word fluency (Appell et al., 1982). This study is a beginning for stronger diagnostic methods. It has a low number of participants in the Alzheimer's sample, and needs replication with larger groups before the results for diagnostic purposes can be considered conclusive.

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Table 1.

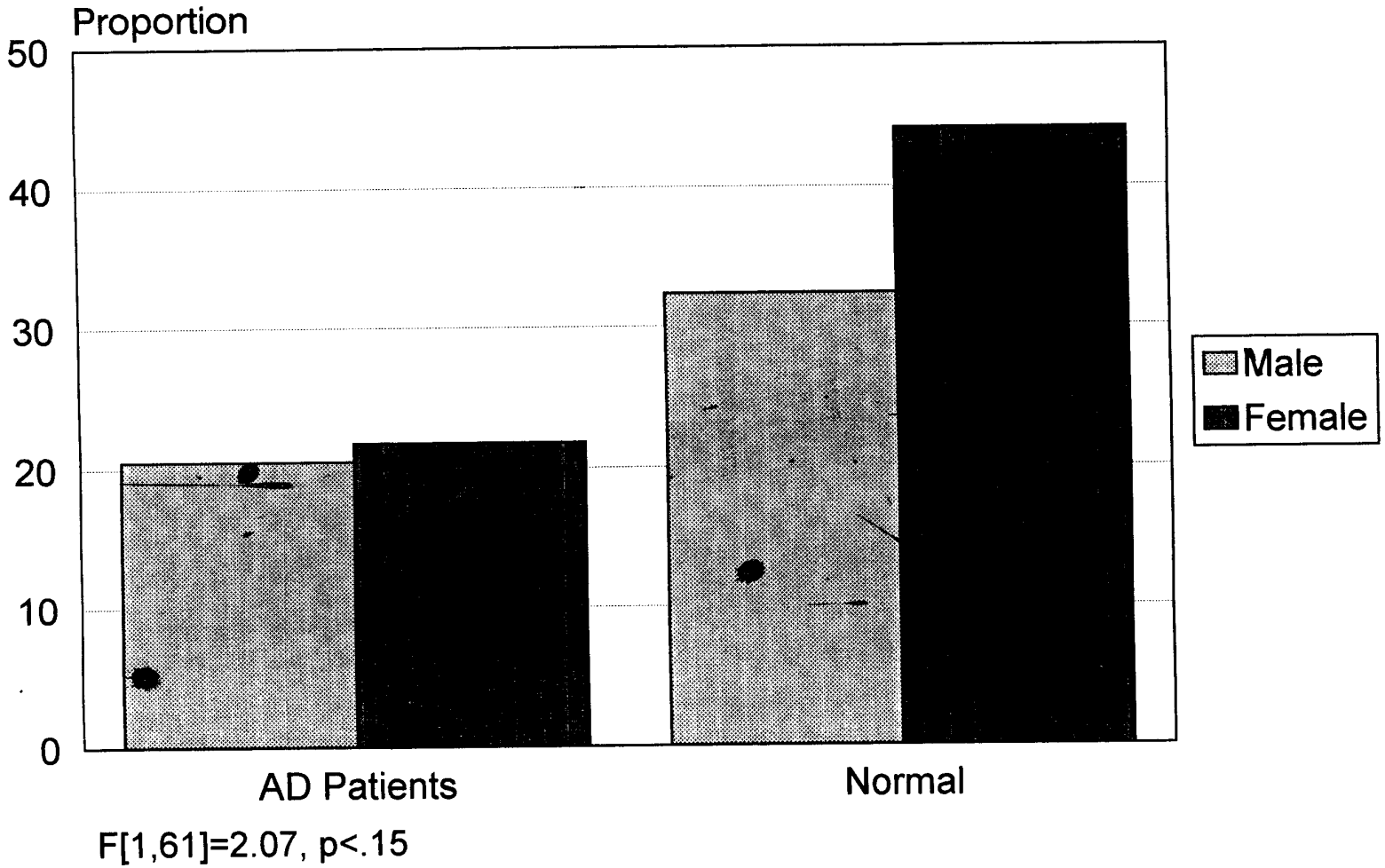
Sample by gender and age cohort.

	Control Group			Alzheimer's Group		
	M	F	T	M	F	T
N	30	25	55	5	6	11
Age	77.72	69.17	73.13	75.00	76.40	75.64
SD	4.46	8.87	8.24	4.42	10.06	7.13
Range	71-85	51-84	51-85	69-79	67-92	67-92
Education	14.28	14.96	14.64	12.17	16.20	14.00
SD	4.10	1.35	2.97	5.11	1.09	4.29
Range	5-20	13-17	5-20	5-19	15-18	5-19

Total N = 65

Figure 1.

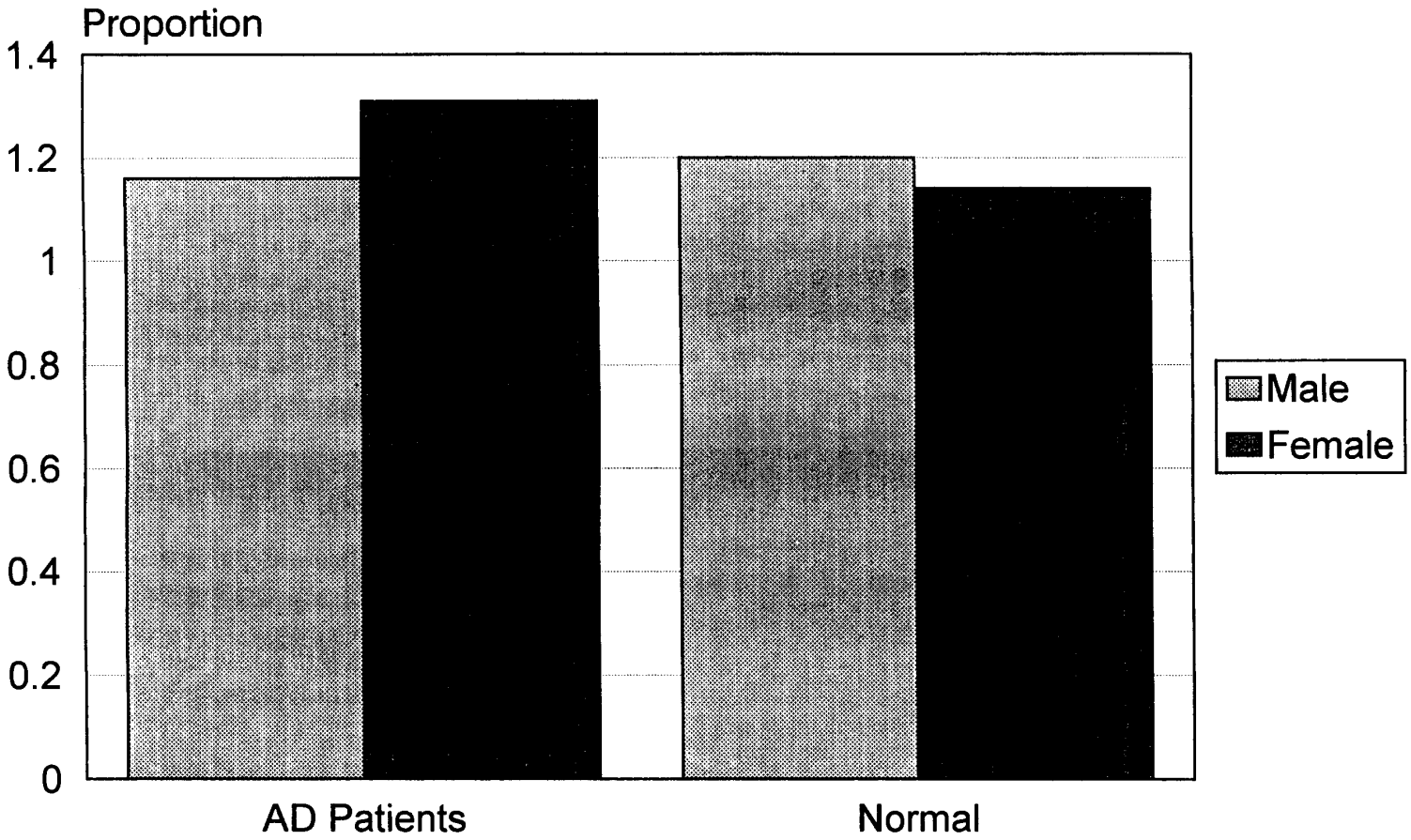
Gender and Group Interaction for Number of Words



F[1,61]=2.07, p<.15

Figure 2.

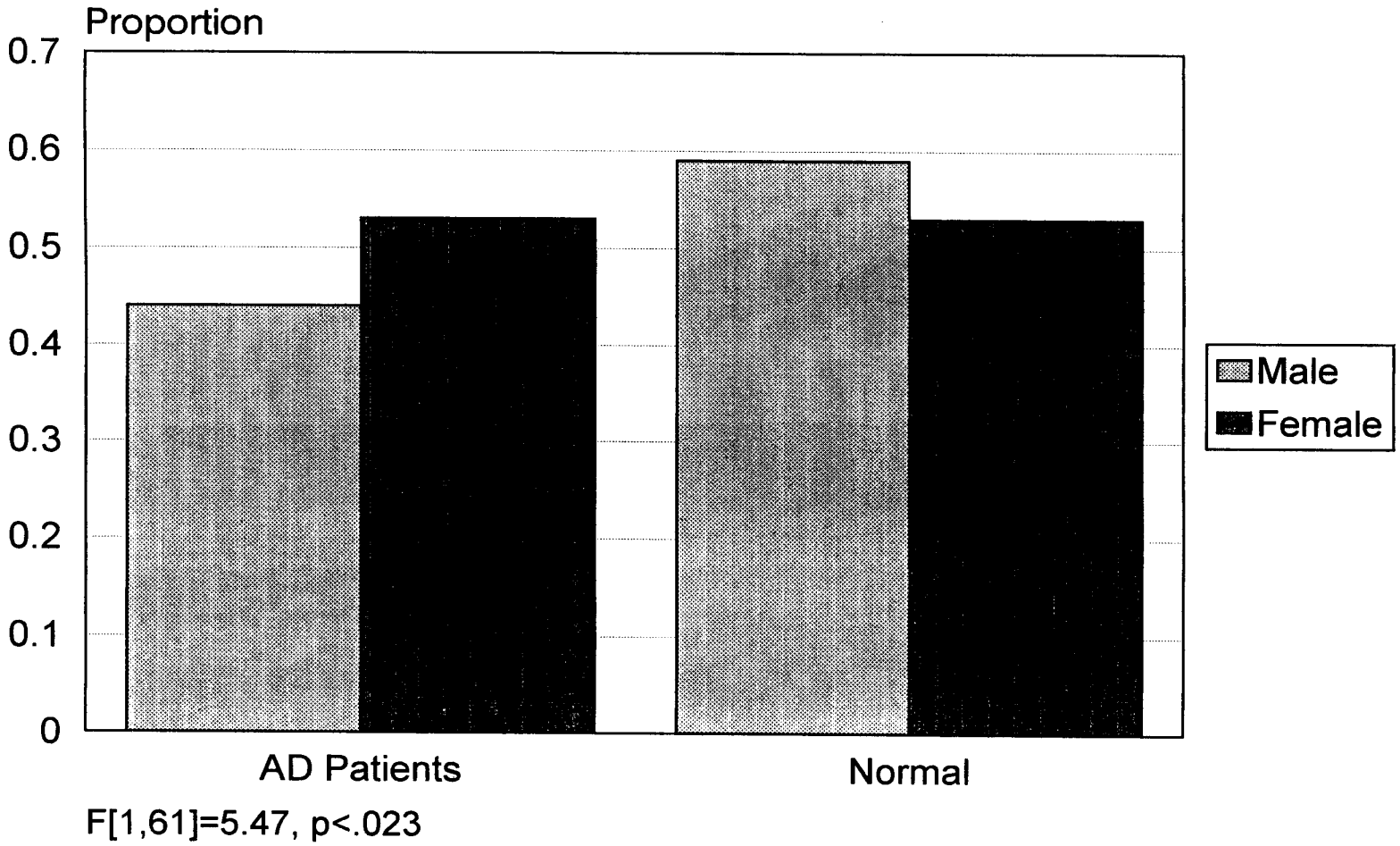
Gender and Group Interaction for Proportion of Morphemes



F[1,61]=7.45, p<.008

Figure 3.

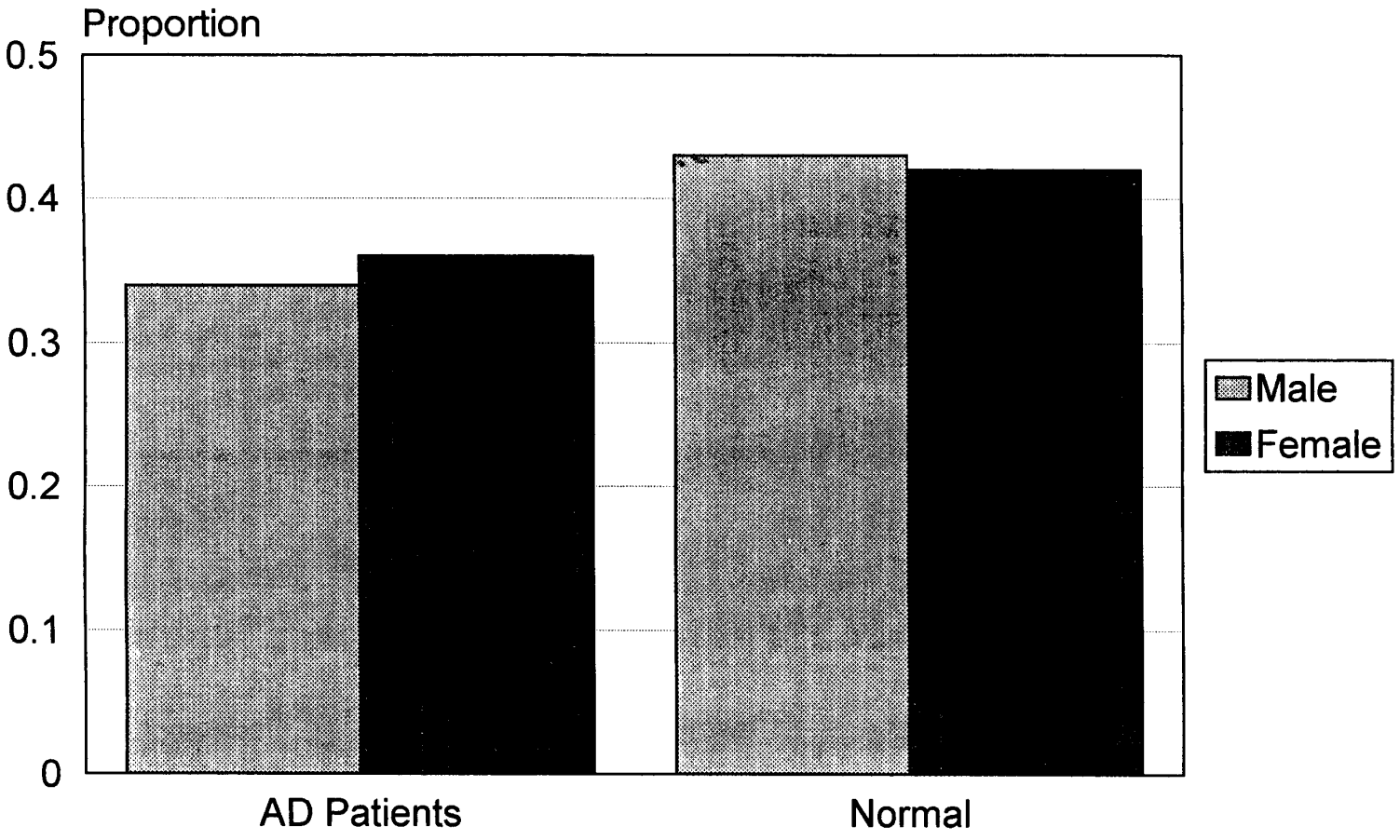
Gender and Group Interaction for Proportion of Nouns



F[1,61]=5.47, p<.023

Figure 4.

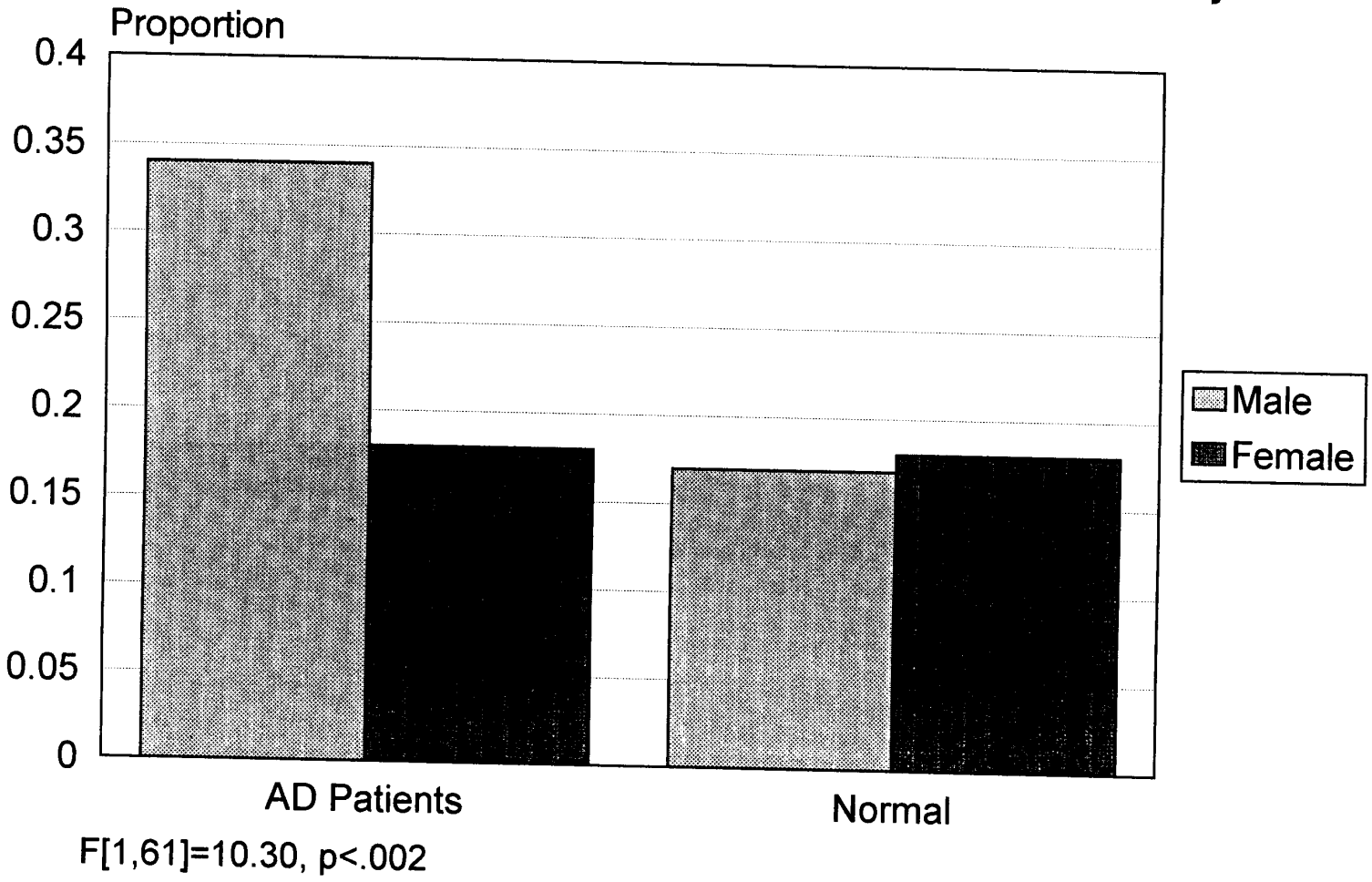
Gender and Group Interaction for Proportion of Verbs



F[1,61]=.15, p<.698

Figure 5.

Gender and Group Interaction for Proportion of Adjectives



F[1,61]=10.30, p<.002