REPETITION OF SINGLE WORDS AND NONWORDS IN ALZHEIMER’S DISEASE

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ABSTRACT
Repetition of single words and pronounceable nonwords (pseudowords) was assessed in Alzheimer’s Disease (AD) patients to evaluate how lexical phonological processing might be accomplished when semantic and conceptual knowledge is impaired. AD patients performed significantly worse than healthy elderly controls on all repetition tasks. However, repetition abilities and dementia severity were not correlated, and AD patients produced the same distribution of error types as controls. Furthermore, despite their semantic problems, AD patients, like controls, showed a significant advantage for repeating real words compared to pseudowords, even when repeating low frequency phonologically complex words whose meaning is not likely to have been retained. The results support the postulated existence of a lexical phonological system that is used to repeat both known and novel words and that processes linguistic information independent of its meaning.

INTRODUCTION

Language dysfunction is one of the most prominent symptoms of Alzheimer’s disease (AD). A deficit in semantic processing is generally regarded to be a central feature of the language disorder in AD (Bayles and Kaszniak, 1987; Nebes, 1992; Schwartz, Saffran and Marin, 1979). Phonological processing, on the other hand, has been thought to be less affected (Bayles, Tomoeda and Trosset, 1992; Blanken et al., 1987; Cummings et al., 1985; Cummings, Houlihan and Hill, 1986; Glosser and Deser, 1990; Nebes, 1992). Consequently, while semantic processing in AD has received considerable attention in the literature, nonsemantic lexical phonological processing has not been well-studied.

The aims of the present study were twofold: 1) To assess the phonological processing abilities of AD patients using tests of single word and pronounceable nonword (pseudoword) repetition, and 2) To use data from AD patients to address certain issues of debate within the modeling of normal language processing.

Repetition tasks offer a well-recognized means of exploring the functioning of phonological processing mechanisms (Caplan, 1992). Repetition engages the same phonological and articulatory mechanisms that are used in spontaneous speech, but since repetition does not necessarily require accessing semantic

Cortex, (1997) 33, 653-666
knowledge, this task allows more direct evaluation of mechanisms specialized for phonological processing. Previous studies have been somewhat inconclusive with regard to the integrity of AD patients’ repetition abilities. Most of these studies have examined multiword list and sentence repetition. AD patients have been reported to show impaired repetition of strings of unrelated real words (Bayles and Tomoeda, 1994; Hulme, Lee and Brown, 1993; Morris and Baddeley, 1988), and in patients with semantic dementia. Patterson, Graham and Hodges (1994) demonstrated that repetition is disproportionately impaired when strings are composed of words whose meanings are no longer comprehended. Impairments have also been reported in sentence repetition (Biassou et al., 1996; Holland, Boller and Bourgeois, 1986; Holland et al., 1995), particularly for sentences containing more complex syntactic constructions (Biassou et al., 1995). The relevance of results from multiword repetition tasks to understanding single word production is not so clear (Gathercole and Baddeley, 1993). Because multiword repetition tasks involve many cognitive procedures, including working memory and syntactic procedures, in addition to lexical processes, deficits that are apparent on multiword repetition studies may not be informative with regard to AD patients’ lexical phonological processing abilities.

Studies of single word repetition in AD patients have been more limited (Appel, Kertesz and Fisman, 1982; Cummings et al., 1985). Though the findings generally indicate that single word repetition is one of the best preserved abilities in AD, patients do not always perform completely normally. To our knowledge, qualitative analyses of errors in single word repetition have not been undertaken, and repetition of nonwords has not been systematically evaluated in AD patients. Thus, the extent and nature of the phonological impairment in AD is not definitively known. The present study evaluated repetition of words and matched pseudowords (PWs) varying in phonological complexity (e.g., number of syllables), to better characterize AD patients’ phonological processing capacities.

Most models of language processing include separate procedures for semantic and phonological lexical processing. Various models disagree, however, about the extent to which the phonological and semantic systems operate autonomously. There are different views about the degree to which lexical knowledge influences repetition of PWs and also about the degree to which semantic knowledge influences repetition of real words.

One view holds that the processing of novel phonological sequences occurs independently of the knowledge of lexical phonological patterns and word meanings (Ellis and Young, 1988). This account posits that there are two lexical mechanisms for processing familiar real words; one mechanism for processing semantic characteristics of words and one for processing phonological characteristics. In addition, this account posits a nonlexical mechanism that is specialized for processing novel phonological forms. The repetition of real word sounds is assumed to take place with reference to knowledge in a phonological lexicon. Hearing a real word activates a corresponding lexical phonological entry in memory, and this representation then guides articulatory production of the word. PWs, on the other hand, are assumed to be repeated through a nonlexical system that translates phonological inputs into articulatory outputs using some abstract system of rules. Phonological inputs are parsed into phonemes or some
other sublexical elements. These units, in turn, activate articulatory output units, completely bypassing word knowledge. Evidence for this so-called “two-route”, lexical and nonlexical, phonological model comes from patients whose repetition of nonwords is extremely poor, but who repeat real words normally (Caramazza, Miceli and Villa, 1986). Data from such cases have been taken to indicate that there are separate lexical and nonlexical processing mechanisms that are vulnerable to selective disruption with different neurological insults. The lexical phonological system is used only for producing and repeating sounds for real words that have been encountered before by the speaker. The nonlexical system is used for repeating novel words (PWs), and if needed, the nonlexical system can also be used as a backup for producing real words. Since this account assumes that words and PWs are normally processed through two completely different systems, there should not be any particular relationship between the ability to repeat real words and PWs. In fact, according to this view real word and PW repetition might even be expected to dissociate as a consequence of different types of neurological disorders.

A contrasting account (Friedman and Kohn, 1990; Kohn and Smith, 1994) suggests that repetition of all linguistic stimuli, words and PWs, takes place through a “single” lexical phonological mechanism. This lexical phonological mechanism is assumed to operate independently of semantic knowledge. According to this model, pronunciations for both familiar and novel linguistic stimuli are derived from the activation of the same set of lexical phonological patterns. Phonological inputs activate representations of previously encountered phonological forms. These representations are assumed to be established through learning and are reflected in different patterns of connections within a network of associated word sounds. This network confers an advantage for processing more frequently occurring phonological patterns, such as high frequency real words. These types of familiar inputs can automatically activate well-established phonological representations. The same network of associated word sounds is also used to derive pronunciations of PWs, but because of their novelty, PWs are not processed as efficiently by this system. This “single route” lexical model predicts that when performance is below ceiling levels, real words should always be repeated better than PWs, reflecting the so-called “lexicality effect”. The model also predicts that if PW processing relies on lexical knowledge then performances on real word and PW repetition tasks should be strongly positively correlated.

The “two-route” and “single route” models described above present differing views of the role of lexical influences on PW repetition. Neither model speaks to the possible role of semantic knowledge on phonological processing of real words. Traditionally, language processing models have assumed that the components for lexical phonological and semantic processing are separate and can operate independently of each other. This view has been challenged recently by Patterson, Graham and Hodges (1994) who propose that semantic knowledge plays an important and interactive role in the phonological processing of real words. According to this account, words are stored in memory as phonological units that must be assembled immediately prior to production. The coherence of the sublexical units into whole word phonological patterns derives from two
sources: 1) The repeated co-occurrence of certain word sounds in actual speech reinforces the association between the phonological units in familiar whole words. 2) Knowledge of the word’s semantic characteristics also serves to bind phonological elements together into whole lexical patterns. Support for the role of semantics as a second source of lexical-phonological coherence was offered by asking semantic dementia patients to repeat sequences of three and four words, varying whether the word meanings were “known” to the patients (Patterson, Graham and Hodges, 1994). More phonological errors were produced in the repetition of semantically “unknown” word strings, and this was attributed to reduced semantic information available to “glue” together the elements of these representations. This “interactive” account of lexical phonological processing seems to predict that disruption in the integrity of the semantic system will lead to a deterioration of the phonological coherence of real words. In the relative absence of semantic activation the distinction between familiar words and PWs becomes blurred and the usual “lexicality” effect, whereby real words are repeated more easily/accurately than PWs, becomes attenuated.

It should be noted that multi-word repetition was chosen as the experimental paradigm by Patterson, Graham and Hodges (1994) because they found that their dementia subjects were unimpaired in repeating single words and PWs. There are two possible explanations of the effects of word meaning knowledge on multi-word repetition: 1) Semantic influences on multi-word repetition may be explained by properties of auditory verbal short-term memory. Meaningful phonological patterns are easier to recall than those without meaning, because of semantic and phonological interactions that take place in short-term memory, outside of the lexical processing system. 2) On the other hand, it is possible that semantic influences on repetition reflect interactions between semantic and phonological information within the lexical processing system. This explanation, if shown to be correct, would have important implications for revising traditional views regarding separability among components in the lexical processing system. This alternative explanation could be tested in semantically impaired patients, such as those with probable AD (Chertkow and Bub, 1992; Hodges, Salmon and Butters, 1992; Martin and Fedio, 1983; Nebes, 1992), if they demonstrate sufficient difficulty in single word repetition. Using phonologically complex words, that are not repeated perfectly by AD patients, we would expect to find an attenuation of the lexicality effect when repetition is compared for single real words whose meaning is not likely to be known and PWs that have no meaning.

This study employed data from AD patients and healthy age-matched controls on various repetition tasks to test hypotheses generated from different lexical processing models described above: 1) According to the “two route” phonological model, processing of real words and PWs takes place though independent lexical and nonlexical systems. Since there is no necessary relationship between the processing of real words and PWs, this model predicts that real word and PW repetition scores should not be correlated in either AD patients or controls. 2) A model that posits a “single” lexical phonological system, on the other hand, predicts that real word and PW repetition scores should be positively correlated in both AD patients and controls. If it is the case that words and PWs are both

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processed through a lexically based system, then both AD patients and controls should demonstrate an advantage for repeating real words compared to nonwords. Furthermore, if the lexical phonological system operates in relative independence from the semantic system, the magnitude of this lexicality effect should be equal in AD patients and controls. 3) If phonological processing relies on access to lexical semantic knowledge, and if AD patients have an impairment in lexical semantic processing, then according to the “interactive” processing model the lexicality effect should be smaller in AD patients compared to controls. Specifically, AD patients’ repetition of low frequency, phonologically complex words, whose meanings are not likely to be retained, should begin to approximate repetition of equally “meaningless” PWs.

MATERIALS AND METHODS

Subjects

Two groups of native English speakers participated in the two experiments reported below. All participants completed at least the eighth grade and had no history of learning disabilities or prior psychiatric illness: 1. Twenty-one elderly patients (mean age = 74.8) met NINCDS-ADRDA research diagnostic criteria (McKhann et al., 1984) for probable AD. All had undergone medical, neurological and neurodiagnostic evaluations to assure that the dementia symptoms could not be attributed to any other cause. All had normal corrected hearing. Mean duration of reported symptoms for these noninstitutionalized patients was 3.9 years (range 1-8 years). Dementia severity ranged from mild to moderately severe. The mean score on the Dementia Rating Scale (Mattis, 1976) was 97.0 (range 34-134). The mean level of education for these participants was 12.4 years. 2. Seventeen elderly controls were age-matched to the AD patients (mean age = 70.0). Controls were interviewed to ascertain that they had no neurological or major medical illness and had no known hearing problems. The mean level of education for these participants was 14.7 years. Because the AD patients were less well educated (t = 2.66; d.f. = 35; p <.05) than controls, years of education was entered as covariate in all subsequent group comparisons.

Twenty AD patients and 17 controls participated in Experiment 1. Twenty one AD patients and 17 controls completed the repetition tasks in Experiment 2, but only 18 patients completed the cognitively more demanding lexical decision task.

Stimuli

Experiment 1

Two stimulus lists were presented for repetition: 1) Sixty-four real words were primarily morphomorphemic. The list included 16 single syllable words (e.g., snail), 24 two-syllable words (e.g., lemon) and 24 three syllable words (e.g., transition). Word frequency (Francis and Kucera, 1967) was equated across the three syllable lengths (F = .25; d.f. = 2, 61; p >.50). 2) Sixty-four PWs pronounceable in English were matched to the real words in number of syllables and consonant-vowel (CV) complexity. These PWs were constructed by changing approximately half of the consonants in the real words by one or two distinctive features (e.g., snail → spail, lemon → fepon, transition → flaksition).

Experiment 2

A single list included 30 low frequency (rare) multi-syllable real words of 2-6 syllables in length composed of relatively complex CV combinations (e.g., ‘protuberance’), and 30 PWs constructed by changing approximately half of the consonants in the real words and preserving number of syllables and CV complexity (e.g., ‘prozuberank’). All of the stimuli
on this list contained a marked CV structure (e.g., complex onsets and/or codas) that resulted in a larger proportion of stimuli with complex phonological forms than in Experiment 1.

**Procedures**

**Experiment 1**

Single words and pronounceable PWs were presented individually auditorally via computer for immediate repetition. At participants’ request, multiple presentations of the stimuli were allowed. All responses were audiotaped for later transcription, and only the best response was considered for scoring. The real word and PW lists were presented in separate tasks. Prior to presentation of each task, participants were instructed as to whether they were going to hear “real words” or “made up words”. One half of the participants completed the word repetition task first and one half completed the PW repetition task first.

**Experiment 2**

The procedures for this experiment were similar to those described for Experiment 1, except that words and PWs were presented in an interspersed fashion within a single list, to encourage participants to treat the two types of stimuli similarly. Following completion of the repetition task, the same list of low frequency real words and matched PWs was presented for untimed lexical decision. Stimuli were presented auditorally on computer, and participants were required to indicate whether the stimulus was “real” or “made up”.

**Scoring**

Both accuracy of response and error type were scored for repetition. Audiotapes were reviewed by the experimenter who administered the test and an independent rater to arrive at a consensus on each response prior to analyses of the data. Because of unequal numbers of stimuli in the different test conditions in Experiment 1, accuracy scores were computed in terms of proportion correct responses within each condition. Given the distributional qualities of proportions, it was necessary to apply the arcsin transformations to accuracy scores for all of the analyses (Cohen, 1988). For Experiment 2, the measure of accuracy was the raw number of correct responses.

Errors were classified as follows: 1) Lexicalizations or real word substitutions (“lift” → “lip”; “fless” → “flesh”), 2) nonword responses that preserved at least 50% of the phonemes in the target stimulus (“pragmatic” → “fragmatic”; “frictamize” → “frictamize”), and 3) all other errors, including null responses and aborted responses.

**Results**

**Experiment 1**

The arcsin transformed proportions of correct repetition responses were dependent variables in a three-way mixed analysis of covariance (ANCOVA) with groups (Alzheimer, controls) as the between subjects factor and lexical status (real word, PW) and number of syllables (1, 2 and 3 syllables) as the within subjects factors and education as the covariate (Table I). There were significant main effects of subject group (F = 11.23; d.f. = 1, 34; p < .01) and lexical status (F = 30.0; d.f. = 1, 34; p < .001). There were no significant interactions between group and either of the lexical variables. AD patients performed below the level of healthy controls in all conditions, but AD patients and healthy controls both declined equally when repeating PWs compared to real words.
Both AD and control subjects performed better when repeating real words than PWs, and in both group there was a very strong relationship between scores on the two tasks. The correlation between real word and PW repetition for the two groups combined was $r = .89$; d.f. = 35; $p < .001$, and this relationship remained strong when examined separately in the AD ($r = .86$; d.f. = 18; $p < .001$) and control ($r = .85$; d.f. = 15; $p < .001$) groups separately. The magnitude of the relationship between real word and PW repetition was equivalent in the two groups.

The proportions of different error types produced in single real word and nonword repetition are presented in Table II. Because of the relatively small number of null or other responses, analyses focused only on lexicalization and nonword errors. A chi-square analysis comparing the number of lexicalization and nonword errors produced by AD and control subjects when repeating real words, revealed no significant group difference (chi-square = .04; $p > .10$). Both groups produced about equal proportions of real word and nonword errors. There was also no difference between the groups in the type of errors produced when repeating PWs (chi-square = .03; $p > .10$). Nonword errors predominated in response to PW stimuli for both groups. Lexicalization errors were relatively rare in response to PW stimuli, suggesting that both groups distinguished the novel nature of these stimuli. Analyses of errors, like the analyses of accuracy scores, indicated that the AD and control groups responded in a qualitatively similar manner across different repetition tasks.

### TABLE I

<table>
<thead>
<tr>
<th></th>
<th>Alzheimer’s disease Mean (SD)</th>
<th>Control Mean (SD)</th>
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</thead>
<tbody>
<tr>
<td>Real words total</td>
<td>.90 (.09)</td>
<td>.98 (.03)</td>
</tr>
<tr>
<td>1-Syllable</td>
<td>.84 (.20)</td>
<td>.98 (.05)</td>
</tr>
<tr>
<td>2-Syllable</td>
<td>.91 (.10)</td>
<td>.99 (.02)</td>
</tr>
<tr>
<td>3-Syllable</td>
<td>.93 (.17)</td>
<td>.99 (.02)</td>
</tr>
<tr>
<td>Pseudowords total</td>
<td>.66 (.22)</td>
<td>.86 (.18)</td>
</tr>
<tr>
<td>1-Syllable</td>
<td>.74 (.22)</td>
<td>.95 (.08)</td>
</tr>
<tr>
<td>2-Syllable</td>
<td>.70 (.23)</td>
<td>.89 (.09)</td>
</tr>
<tr>
<td>3-Syllable</td>
<td>.54 (.23)</td>
<td>.82 (.17)</td>
</tr>
</tbody>
</table>

### TABLE II

<table>
<thead>
<tr>
<th></th>
<th>Real word stimuli</th>
<th>Pseudoword stimuli</th>
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<tbody>
<tr>
<td></td>
<td>Alzheimer’s disease</td>
<td>Control</td>
</tr>
<tr>
<td>Real word error</td>
<td>.51</td>
<td>.59</td>
</tr>
<tr>
<td>Nonword error</td>
<td>.40</td>
<td>.42</td>
</tr>
<tr>
<td>Other</td>
<td>.09</td>
<td>0</td>
</tr>
</tbody>
</table>
Experiment 2

A two-way ANCOVA compared Alzheimer and control subjects’ repetition of low frequency phonologically complex real words and matched PWs (Table III). As in Experiment 1, there were significant main effects of group ($F = 18.75$; d.f. = 1, 35; $p < .001$) and the lexical status of the stimulus ($F = 16.56$; d.f. = 1, 35; $p < .001$). Unlike in Experiment 1, there was also a significant interaction between group and lexical status ($F = 7.07$, d.f. = 1, 35; $p < .05$). When repeating relatively rare words for which it is unlikely that AD patients had adequate semantic representations, they showed a significantly greater difference between real word and PW repetition than controls.

<table>
<thead>
<tr>
<th>Table III</th>
<th>Number Correct Responses for Repeating Rare Real Words and Matched Pseudowords</th>
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<tbody>
<tr>
<td></td>
<td>Alzheimer’s disease</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Rare real words</td>
<td>24.5 (4.2)</td>
</tr>
<tr>
<td>Pseudowords</td>
<td>13.4 (7.0)</td>
</tr>
</tbody>
</table>

Interpretation of these results depends critically on the assumption that our AD patients had an impairment in semantic processing that disrupted their knowledge of word meanings. The AD participants were tested on two measures of verbal semantic knowledge in the context of their participation in a longitudinal study of language deterioration in dementia. One measure consisted of a 25 item comprehension test in which subjects were required to match a written noun to a pictured object embedded in an array of three foils from the same Battig and Montague (1969) semantic category. Of the 19 AD patients completing this task, 74% scored at impaired levels, below the 5th percentile of the control sample and more than two standard deviations below the mean of the healthy controls. On another measure of semantic knowledge, the Conceptualization section of the Dementia Rating Scale, of 20 AD patients tested 70% performed below the suggested cutoff for impaired performance (Mattis, 1988). Altogether 80% of the AD patients in this study performed at impaired levels on one or both of these relatively undemanding tests of verbal semantic processing. Despite significant semantic impairment, these subjects still failed to show the expected attenuation of the lexicality effect in repetition.

As in Experiment 1, in the second experiment real word and PW repetition were highly correlated when examined in the two groups combined ($r = .87$; d.f. = 35; $p < .001$) and in each of the subject groups separately ($r = .83$; d.f. = 19; $p < .001$ for the AD patients, and $r = .65$; d.f. = 15; $p < .001$ for the controls).

An ANCOVA revealed that groups differed significantly in the number of correct responses on the lexical decision task ($F = 13.45$; d.f. = 1, 32; $p < .01$). Whereas controls discriminated real words from PWs with 96.4% accuracy (96.6% correct for words and 96.2% for PWs), AD patients were correct on only 80.2% of trials (83.3% correct for words and 77.2% correct for PWs). The
ability to make conscious lexical decisions about words and PWs correlated significantly with dementia severity as assessed on the DRS and performance on the word comprehension test (Table IV). This relationship most likely reflects the fact that lexical decision requires the application of higher level, controlled cognitive processes that are not available to the more demented patients. By contrast, there were no significant relationships between either dementia severity or semantic word comprehension and repetition accuracy for low frequency hard real words and matched PWs (Table IV).

<table>
<thead>
<tr>
<th>Correlations between Dementia Severity and Performances on Single Word Repetition and Lexical Decision Tasks for Alzheimer’s Disease Patients</th>
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</thead>
<tbody>
<tr>
<td><strong>Dementia rating scale</strong></td>
</tr>
<tr>
<td>Real word repetition</td>
</tr>
<tr>
<td>Pseudoword repetition</td>
</tr>
<tr>
<td>Lexical decision</td>
</tr>
</tbody>
</table>

* p < .05.

The data for two moderately demented AD patients are presented in Figure 1 to illustrate apparent dissociations between capacities for repeating single words and PWs and abilities for making meaning judgements and lexical decisions about words. V.E., a 73 year old, former factory worker, with a three year history of progressive cognitive decline, obtained a DRS score of 106 at the time she completed the experimental tasks. C.A., a 74 year old, former kitchen worker, had a two year history of cognitive decline and obtained a DRS score of 93. Both patients were significantly impaired in the word comprehension test, and C.A. was also profoundly impaired in her ability to make overt lexical decisions. Both patients, however, scored within one standard deviation of the
mean for healthy controls for word and PW repetition. Six months following participation in this study, C.A. was reevaluated with some of the same experimental tasks. Although her performance on the DRS, word comprehension and lexical decision tasks declined during this interval, the score on the word repetition task improved slightly, and the PW repetition score was unchanged.

**DISCUSSION**

The major findings of this study were that AD patients were impaired in their repetition of both real words and pseudowords, but despite lower overall rates of repetition accuracy, the performance of AD patients was qualitatively similar to those of healthy age-matched controls. In both AD patients and controls, repetition of real words and PW was influenced significantly by prior lexical knowledge. Real word and PW repetition scores were highly correlated within both groups, suggesting that the same system was being used to repeat both types of linguistic stimuli. The two subject groups produced similar types of repetition errors. When repeating real words, AD patients and controls made approximately equal proportion of phonemically based errors that resulted in either a phonologically closely related real word (e.g., “flap” → “flat”) or a nonword that was closely related phonologically to the target (e.g., “surf” → “surk”). When repeating PWs, errors for both groups consisted mostly of nonwords that were phonologically related to the target. Both groups showed a significant advantage for repeating real words, which have existing phonological representations in memory, compared to PWs, which have no representations in memory. When presented with low frequency words whose meanings they were not likely to have known, AD patients still showed a very significant advantage for repeating real words compared to PWs. AD patients’ repetition abilities were not correlated with the severity of their semantic/conceptual disturbance, suggesting that these are independent processes. Though in their repetition responses AD patients distinguished between real words and PWs, they were very impaired in their ability to make overt lexical decisions about spoken words. Unlike repetition ability, lexical decision ability was significantly related to dementia severity in AD patients.

The results of these experiments bear on the questions raised earlier regarding interactions among the various components within the language processing system:

Data from the present study are most compatible with the notion that a single lexical phonological system is responsible for processing PWs and familiar real words. The strong and consistent relationships between real word and PW repetition, in both AD and control subjects, suggest that these two classes of stimuli were being processed through the same system. The “two-route” phonological model can not account for these positive correlations. If, as the latter model claims, PWs are processed by a nonlexical set of translation rules, and familiar words are processed through a lexical system, then there should be no necessary relationship between the ability to reproduce these two types of phonological inputs.
The impact of lexical phonological knowledge on PW processing that was demonstrated in the present investigation confirms results of another recent study conducted with AD patients (Glosser et al., 1996). That study compared repetition for PWs that contained pronounceable consonant sequences that do not occur in English words (e.g., vlobe) and PWs with consonant clusters that conform to the structure of English words (e.g., slobe). Both AD patients and healthy controls exhibited more difficulty repeating phonologically unusual PWs, and AD patients actually showed proportionately greater difficulty than normals when presented with the unusual PWs. Although controls made more errors when repeating phonologically unusual PWs than in other conditions, they appeared able to institute some strategies for computing the pronunciations of the strange PWs. Their errors tended to maintain the basic phonological form of the target PW, but involved minor phonemic substitutions. The demented AD patients, in contrast, seemed less able to mobilize these types of strategies. Instead of producing phonemic approximations, AD patients, particularly those with more severe dementia, tended to produce real word responses to the phonologically unusual PWs. These data are relevant to the present discussion of how novel phonological forms are reproduced generally, and how repetition takes place for PWs containing phonemic combinations that do not occur in the speaker’s store of lexical phonological knowledge. If, as the “two-route” model posits, PW pronunciations are derived by an extra-lexical set of conversion rules, then there should be no difference or advantage for repeating novel phonological forms with familiar versus unfamiliar consonant clusters. On the other hand, if a single system is used for producing both real words and PWs, then the system might be expected to encounter difficulties when constructing unusual phonemic sequences that do not occur in real words. In such situations more controlled, higher level, metalinguistic strategies may be required to compute pronunciations for the unusual sequences (Friedman et al., 1992). Since these types of procedures are less likely to be available to demented individuals, AD patients would be expected to make disproportionately more errors and resort to lexicalization when attempting to reproduce novel phonological sequences. Thus, the combined results from our two studies are compatible with the notion that PW pronunciation is accomplished normally through a system that draws on information contained within a single lexical network.

Data from the present investigation also speak to the proposed interactions between semantics and phonology in lexical processing. According to the “interactive” account of lexical processing, knowledge of a word’s meaning is expected to confer a significant advantage for assembling its phonological constituents in speech production or repetition. This hypothesis was tested in a group of AD patients with semantic impairment. Because AD patients show greater semantic loss for low frequency words (J.R. Hodges, personal communication), we chose infrequently occurring real words for repetition. We expected that access to the meanings of rare words, such as “abscond” and “adjudicate”, would be most likely degraded in these patients. We chose words with complex combinations of phonemes, on the assumption that semantic knowledge would be especially important for “binding” these phonological elements into coherent whole word patterns. Phonologically complex rare words
were presented for repetition in a single list interspersed with matched PWs, to encourage patients to treat the real words and PWs in a similar fashion. Despite all of these manipulations, AD patients still showed a very significant advantage for repeating the real words compared to PWs. In fact, when repeating the low frequency phonologically complex words, the lexicality effect was actually greater in AD patients compared to controls. In repetition AD patients clearly treated the real words and PWs differently, even though it is likely that for these individuals both classes of stimuli were equally meaningless. There were no significant relationships between AD patients' semantic deficits and their word repetition abilities, but dementia severity and verbal semantic performances correlated significantly with the ability to make overt lexical decisions about words they were asked to repeat.

In a related recent study we tested the proposed interaction of semantic knowledge and lexical phonological processing by comparing directly repetition of words whose meanings are known to a subject to repetition of words whose meanings are unknown. Repetition was evaluated in a mentally retarded child with developmental hyperlexia (Glosser, Grugan and Friedman, 1996). This youngster showed severely impaired semantic processing, like AD patients. The semantic impairment, however, did not seem to impact on his repetition of real words or PWs. His repetition of words whose meanings he knew was identical to the repetition of real words whose meanings he did not know, and both classes of lexical stimuli were repeated significantly better than PWs.

These combined results are most consistent with the idea that phonological lexical processing can operate independently of the semantic processing system. That is not to say that semantic and phonological processing do not interact and support each other normally. The evidence suggests, however, that interaction between phonology and semantics is not a necessary feature of the language processing system.

Throughout this discussion we have emphasized many similarities between AD patients and healthy elderly controls in the manner in which they process phonological inputs through a lexically based system for speech production. Although their repetition of words and PWs was qualitatively similar to that of controls, AD patients performed significantly below normal levels on all tasks. AD patients showed deficits in phonological processing on the repetition tasks, but their difficulties were quantitative rather than qualitative. While it appears that AD patients as a group are demonstrating deterioration in the functioning of the lexical phonological system, this disturbance is not severe enough to alter phonological processing qualitatively. Thus, it seems that this population may offer a unique opportunity to further examine the operation of the phonological processing system, independent of semantic influences.

**Acknowledgements.** This research was supported by research grants DC 02320 and DC 02517 from the National Institute of Deafness and Other Communication Disorders, National Institutes of Health.
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(Received 23 July 1996; accepted 5 February 1997)