Lexical Acquisition in Probable Alzheimer’s Disease

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Patients with probable Alzheimer’s disease (pAD) were exposed to a new verb in a naturalistic fashion. We probed their knowledge of the word’s semantic and grammatical characteristics for several minutes following this exposure, and compared this with their performance on parallel measures assessing known words. Significant differences were seen between pAD patients and controls in the acquisition of the new verb’s semantic meaning and its argument structure, but pAD patients did not differ from controls in the acquisition of the new word’s grammatical form class. Individual patient analyses demonstrated parallel deficits restricted to the semantic meaning and argument structure of the new word and known words in several pAD patients, suggesting that a selective language impairment contributed to their word learning deficit. This pattern is consistent with an intimate relationship between semantic meaning and argument structure in semantic memory. Other pAD patients had difficulty learning about all aspects of the new word, despite good performance with known words, suggesting that compromised memory may have limited their lexical acquisition. © 1997 Academic Press

INTRODUCTION

Patients with probable Alzheimer’s disease (pAD) are said to have significant difficulty appreciating word meaning. Most studies have focused on nouns (Bayles, 1982; Chan, Butters, Paulsen, Salmon, Swenson, & Maloney, 1993; Chertkow, Bub, & Caplan, 1992; Grossman & Mickanin, 1994; Hodges, Salmon, & Butters, 1992; Mickanin, Grossman, Onishi, Auria-combe, & Clarke, 1994; Santo Pietro & Goldfarb, 1985; Silveri, Daniele, This work was supported in part by grants from the United States Public Health Service (NS35867 and AG09399), the American Health Assistance Foundation, and the Charles A. Dana Foundation. We express our appreciation to Ed Kako for his valuable comments on an earlier version of this article and to Trish Giampapa for her assistance in preparing the article. Address correspondence and reprint requests to Murray Grossman, Cognitive Neurology Section, Department of Neurology, Hospital of the University of Pennsylvania, 3400 Spruce Street, Philadelphia, PA 19104-4283. Fax: (215) 349-8464.

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The validity of the word meaning deficit in pAD turns on the demonstration of a similar impairment with another major lexical category such as verbs. Moreover, semantic memory studies of nouns are relatively restricted since they cannot fully assess other aspects of word meaning such as argument structure. In order to evaluate the breadth and nature of word meaning in pAD in a fashion that is minimally colored by previous experience, we assessed pAD patients’ acquisition and mental representation of a new verb. It is important to note in this context that pAD patients also have memory difficulties (Butters, Granholm, Salmon, & Grant, 1987; Deweer, Ergis, Fossati, Pillon, Boller, Agrid, & Dubois, 1994; Petersen, Smith, Ivnik, Kokmen, & Tangalos, 1994; Welsh, Butters, Hughes, Mohs, & Heyman, 1991). In this report, then, we examine the interaction between compromised memory and impaired language processing during complex, real-world learning situations such as lexical acquisition.

The concept underlying a word contains multiple types of information (Miller & Fellbaum, 1991). In addition to its phonological shape, each word represents semantic information and grammatical information. Consider the sentence “The bees wamble to their hive.” Inspection of this sentence reveals a novel phonological shape “wamble.” By performing a grammatical parse of the sentence’s syntactic phrase structure, it can be determined that wamble is in a form class slot assigned to verbs in the verb phrase “wamble to their hive.” Another aspect of wamble more intimately associated with its meaning is its argument structure. While the precise nature of argument structure is somewhat controversial (Grimshaw, 1990), the argument structure of a verb is thought to be projected from the logic underlying the verb’s meaning (Jackendoff, 1983, 1992) and consists of a set of thematic roles associated with the verb. The argument structure of “The bees wamble to their hive” is often associated with a verb of self-motion, that is, a noun phrase–verb–prepositional phrase construction that maps onto an argument structure including an agent, an action, and a goal. The selectional restrictions associated with the argument structure of wamble include that its agent is animate and that a prepositional phrase complement of the verb encodes a path toward a particular location. When wamble is used in the context of a picture illustrating some bees flying toward and into their hive, it is reasonable to hypothesize that it refers to the act of returning home. It is important to note that the form class, argument structure, and selectional restriction information identified with a word are not absolute in any sense. Many words used as verbs can also be nouns; a verb of self-motion can be used with only one argument such as an agent or with three arguments, and it is possible to conceive of circumstances where the selectional restrictions can be violated without rendering a sentence incoherent. Nevertheless, the most typical and informative sentence structure associated with a motion verb such as wamble is agent–action–goal, where wamble is a self-motion verb, the agent is ani-
mate, and the goal for the action is specified (Gruber, 1965; Jackendoff, 1983; Talmy, 1975).

Studies of language processing in pAD have suggested that their appreciation of all aspects of a word may not be equally compromised. Language surveys thus have claimed that pAD patients are relatively impaired in their appreciation of semantic aspects of language (Appell, Kertesz, & Fisman, 1982; Cummings, Benson, Hill, & Read, 1985; Hier, Hagenlocker, & Shindler, 1985; Kertesz, Appell, & Fisman, 1986; Nebes, Brady, & Jackson, 1989). More detailed assessments of word meaning have attempted to confirm these impairments (Chan et al., 1993; Chertkow, Bub, & Seidenberg, 1989; Grossman & Mickanin, 1994; Hodges et al., 1992; Mickanin et al., 1994). The vast majority of these studies have focused on noun comprehension. However, it is not clear that semantic deficits for nouns will necessarily generalize to verbs since the concepts underlying verbs and nouns appear to emphasize different types of information (Levin, 1993; Miller & Fellbaum, 1991). Verbs contain elaborate argument structure information, for example, that has rarely been investigated in pAD. By comparison, language surveys (Appell et al., 1982; Cummings et al., 1985; Hier et al., 1985; Kertesz et al., 1986; Nebes et al., 1989) and more detailed investigations of grammatical aspects of language in pAD (Blanken, Dittman, Haas, & Wallesch, 1987; Kemper, LaBarge, Ferraro, Cheung, & Storandt, 1993; Kempler, Curtiss, & Jackson, 1987) have noted very few grammatical errors in brief samples of spontaneous oral and written production. Other reports have indicated that pAD patients may have some difficulty understanding sentences with subordinate phrases or matrix verbs (Emery & Breslau, 1989; Bayles, 1982; Kontiola, Laaksonen, Sulkava, & Erkinjuntti, 1990; Swihart, Panisset, Becker, Beyer, & Boller, 1989; Tomoeda, Bayles, Boone, & Kaszniak, 1990). However, this has been attributed to factors such as postcomputational limitations in short-term memory or the impaired appreciation of conceptual boundary constraints represented by grammatical features (Grossman, Mickanin, Onishi, & Hughes, 1995; Rochon, Waters, & Caplan, 1994).

The acquisition of information about a new word requires the same processes that are brought to bear in appreciating similar aspects of known words. The acquisition of the form class of wamble, for example, requires parsing its sentence in order to establish that the novel phonological shape is a verb in the verb phrase “wamble to their hive.” This process replicates one that can be used to identify known verbs in sentences. However, alternatives are available for known words that cannot be used for novel words. Substitution of “return” for “wamble” in this sentence, for example, would result in the assignment of this word to the verb form class, even if a grammatical parse could not be performed, since return is known independently to refer to an action on the basis of previous experience with its meaning. Wamble is a novel word, so listeners are obliged to establish the grammatical
Lexical acquisition requires a memory component in addition to a language component. Memory difficulties have been well documented in pAD. Amnesics have impaired retention of new associations between words learned explicitly (Butters et al., 1987; Squire, 1992; Petersen et al., 1994; Welsh et al., 1991) and those learned implicitly (Cermak, Blackford, O’Connor, & Bleich, 1988; Cermak, Bleich, & Blackford, 1988; Deweer et al., 1994; Paller & Mayes, 1994; Shimamura & Squire, 1989). However, these negative studies tested only the ability to learn known phonological shapes in new associative contexts. A negative example of concept acquisition in amnesia has been published as well. H.M. could not learn the meaning associated with eight low-frequency words when explicitly given a definition and a synonym, for example, and he was unable to demonstrate that he had learned new words that had entered the vocabulary since his bilateral temporal lobectomy (Gabrieli, Cohen, & Corkin, 1988). This study attempted to teach new words in an unnatural fashion that is rarely engaged in natural concept acquisition (Carey, 1978) and evaluated new concepts by probing only their phonological shapes. It is thus unclear from this assessment what H.M. would do with a frisbee when given such a novel object or how he would use the word “frisbee” in a sentence. By comparison, recent studies have demonstrated that amnesics are capable of learning a new computer vocabulary (Glisky, Schacter, & Tulving, 1986), of acquiring a new second language (Hirst, Phelps, Johnson, & Volpe, 1988), and of learning an artificial grammar (Knowlton, Ramus, & Squire, 1992; Knowlton & Squire, 1994). Amnesics can learn about some aspects of new natural concepts as well, particularly when probed for more than the phonological shape (Dopkins, Kovner, & Goldmeier, 1990; Grossman, 1987; Van der Linden, Meulemans, & Lorrain, 1994). The acquisition of these rich materials may have been supported in part by their rule-based context (Moscovitch, 1994). Regardless of the specific basis for successful learning on these tasks, it appears that an episodic memory deficit does not necessarily prohibit the acquisition of a new word.

Taken together, several outcomes were possible in this study of lexical acquisition. On the one hand, failure to demonstrate acquisition of a new word could be attributed to extralinguistic factors such as a memory deficit. This source of impairment would be reasonable only if pAD patients could be shown to perform adequately on parallel tasks containing known verbs. Alternatively, pAD patients may have difficulty acquiring certain aspects of a new word due to a language deficit. Lexical acquisition difficulty could be reasonably attributed to a language impairment only if we can show that pAD patients are also selectively impaired in their performance on the corresponding assessment of known words. We can verify that pAD patients are not inferring information about a new word from the materials used to assess
LEXICAL ACQUISITION IN pAD

learning by examining their performance on novel phonological shapes that the patients had never heard.

METHODS

Subjects

We studied 16 right-handed, high-school-educated, native English speakers diagnosed with probable Alzheimer’s disease, according to NINCDS-ADRDA criteria (McKhann, Drachman, Folstein, Katzman, Price, & Stadian, 1984). The patients were recruited from the Cognitive Neurology Clinic in the Department of Neurology at the Hospital of the University of Pennsylvania. Patients were mildly demented or moderately demented, according to Mini Mental State Examination (MMSE) scores (Folstein, Folstein, & McHugh, 1975). We also obtained brief measures of short-term memory (digit span) and episodic memory (supraspan list learning) on all but one patient. Clinical and demographic features of these patients are summarized in Table 1. pAD patients were excluded from participation in this study if they had been diagnosed with a primary psychiatric disorder such as depression or psychosis, if they had another neurological disease such as stroke or Parkinson’s disease that compromised central nervous system functioning, or if they had a medical illness that could have an adverse impact on their intellectual functioning. None of the patients were taking sedating medications at the time of testing. These patients were compared with 10 age-matched \[ t(24) = 1.16; ns \] and education-matched \[ t(24) = 1.01; ns \] control subjects recruited from among spouses of the participants and from advertisements in community newspapers. The demographic characteristics of the control subjects are described in Table 1.

Materials

We identified a very-low-frequency verb that was expected to be unfamiliar to all subjects—wamble. We initially assigned to this word the meaning “to return,” with the selectional restriction that it refer to the act of returning to one’s home. Like most verbs of self-motion, the typical grammatical properties associated with wamble in an active voice sentence included taking a subject which is the agent and a prepositional phrase complement as the goal that contains an indirect object of the preposition “to.” It followed regular inflectional rules for bound grammatical morphemes in English (e.g., the third person singular is “wambles” and the past participle is “wambled”). Vocabulary entries in living languages are dynamic and changing, and this description of wamble represents its initial, prototypical characterization. We structured our examination of wamble so that we could establish the nature and extent to which this narrow reading of the new word is generalized to other semantic and grammatical contexts in control subjects and pAD patients.

Exposure Period

Subjects were first exposed to the new verb in a naturalistic fashion that did not involve an explicit pairing of a novel phonological shape with a formal definition but nevertheless guaranteed successful exposure to all critical aspects of the word. Thus, the initial exposure to the verb occurred in the setting of a forced-choice sentence–picture matching task in which patients were asked to match four pictures of bees involved in various activities with four simple sentences about bees. The sentences were presented one at a time while all four pictures were continuously exposed. Three of these sentences contained familiar verbs describing common and distinctive activities illustrated in each of three pictures. These items were presented first. Each was designed to highlight a critical feature of wamble by contrasting with its motion, its direction, or its goal properties. The fourth sentence was “The bees wamble to their hive.”
<table>
<thead>
<tr>
<th></th>
<th>Control subjects</th>
<th>Alzheimer’s patients</th>
<th>Grammaticality judgment</th>
<th>Picture classification</th>
<th>Thematic role judgment</th>
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<tr>
<td>Age</td>
<td>68.60 (7.67)</td>
<td>72.06 (7.20)</td>
<td>0.358</td>
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<td>4.03 (2.15)</td>
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<td>MMSE</td>
<td>29.80 (0.42)</td>
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<td>Digit span&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>7.00 (1.80)</td>
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<td>0.016</td>
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<tr>
<td>Supraspan memory&lt;sup&gt;c&lt;/sup&gt;</td>
<td>—</td>
<td>1.06 (1.44)</td>
<td>-0.178</td>
<td>0.128</td>
<td>0.228</td>
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</table>

* None of these correlations were significant.

<sup>b</sup> The digit span task required patients to repeat a sequence of random digits presented at a rate of 1/s. We report the sequence length at which patients were unable to repeat correctly despite two attempts.

<sup>c</sup> The supraspan memory task required patients to reproduce as many words as possible from a list of 10 concrete words presented at a rate of 1/s. The patients were given three successive list presentation trials, and we report the difference between the number of words successfully repeated on trial 3 and the number of words successfully repeated on trial 1.
Since this item was presented last, a process of elimination allowed this utterance to be paired with a picture that showed several bees flying toward and into a beehive. In this active voice sentence, moreover, the new word was associated with its most representative properties. Thus, it appeared in a verb slot, was used uninflected, took as its subject an animate agent, did not take a direct object, and was associated with a prepositional phrase complement that contained the preposition ‘to’ and a particular indirect object goal, namely, the agent’s home.

There were three subsequent exposures to wamble. These took place in a multiple choice setting in which the subject was asked to point to one of four pictures in response to the request ‘Which picture shows `the bees wamble’?’ The pictured choices included bees flying toward and into a hive, bees flying out of and away from a hive, bees sitting on a hive, and bees hovering around a flower. These were presented among other similarly structured sentence–picture matching trials using known verbs. We noted the number of incorrect selections before the picture illustrating wamble was chosen. Feedback was given if a patient did not select the picture depicting wamble, and the patient was allowed to make additional selections until the target picture was chosen. Thus, each patient received three exposures to the new verb paired with a picture depicting an example of its use. These exposures to wamble were designed to be similar to one another (e.g., always used bees as the agent in an active voice sentence), so that we could determine the nature and extent of the subjects’ generalizations of their hypotheses about a word’s meaning and grammatical properties to other contexts.

**Postexposure Period**

Another sentence comprehension task was performed for about 2 min prior to assessment of the information that patients learned about wamble. The following measures were administered in a fixed order established on the basis of the amount of information that could be inferred about wamble from the nature of the task.

**Sentence grammaticality judgments.** This task required subjects to make judgments of the grammatical appropriateness of 102 sentences. Thirty sentences contained the word wamble. Wamble was used as a verb in a fashion that corresponded to its prototypical use during the exposure period in 12 sentences, but deviated systematically from its most representative nature during the exposure phase in 18 sentences. We systematically varied the nature of the uses of wamble so that we could determine whether pAD patients generalized their appreciation of wamble in a fashion that resembled the controls’ performance. Thus, when wamble was used in its most representative manner as a verb, 6 instances were inflected by a bound grammatical morpheme (e.g., ‘-ed,’ ‘-s’) and 6 were without a grammatical inflection. For the 18 items containing wamble used in a nonrepresentative fashion, its sentence context deviated in either a form class aspect or an argument structure aspect of the new word. Form class deviations included errors using the new word as a noun (6 items—e.g., ‘Sally drives the wamble’) or a preposition (3 items—e.g., ‘The baby crawled wamble the crib’); argument structure deviations included its pairing with a direct object (6 items—e.g., ‘The eagles wamble the nest’) or with an inanimate agent (3 items—e.g., ‘Books wamble into the store’). It may be noted that the other words in the sentence were internally coherent and thus would not provide any reason for rejecting a sentence.

In order to place performance with wamble in an appropriate context, we also asked subjects to judge similar sentences containing known verbs. Thus, we presented 58 additional sentences containing known verbs of self-motion that had argument structure parameters similar to those of wamble (e.g., ‘jump,’ ‘enter,’ ‘climb’). Forty of the items included known verbs of self-motion used in a highly representative sentential slot for a verb, and 18 contained known verbs of self-motion used in a less typical fashion. We used the same distribution of verbs used in a prototypical fashion (i.e., half inflected by a bound grammatical morpheme and half uninflected) and in a less representative fashion [i.e., used as a noun (6 items—e.g., ‘The jump returned’) or a preposition (3 items—e.g., ‘Teddy climbed enter the stairs’)]; paired
with a direct object (6 items—e.g., “The baby crawls the crib”) or an inanimate agent (3 items—e.g., “Trees return to their forest”) as with wamble. Our task was designed with these numbers of items to minimize any judgment bias that might be inferred by a subject from the proportions of the various types of items. Thus, the 18 items containing known verbs used in a nonrepresentative fashion equaled the number of atypical sentences with wamble, and the 40 sentences containing known verbs used in a highly representative fashion approximated the total number of sentences with wamble plus the number of sentences with a known verb used in a nonrepresentative fashion.

In order to determine whether wamble was being treated differently from any novel phoneme sequence, 14 additional sentences that contained very-low-frequency words to which the subjects had not been previously exposed (e.g., “touse,” “wisket,” “yark”) were presented. These nonsense words occurred in sentences in a fashion that replicated the uses of wamble and the uses of known verbs. Thus, two each of the nonsense words appeared in a verb sentential slot where they were inflected or uninflected (e.g., “The cow toused to the barn”), were used as a noun or a preposition (e.g., “The wisket returned to the nest”), or were paired with an inanimate agent or a direct object (e.g., “The Indian yarked his teepee”).

Because of the unequal numbers of items where a verb was used correctly or incorrectly in a sentence, the scores for the major types of items were converted to a percentage correct for the purpose of statistical analysis. The sentences were presented in a fixed random order and were read orally to subjects in a naturalistic fashion. Subjects were allowed to request as many repetitions as they desired, and there was no time limit for responding. A training period preceded the experimental portion of the task. During this session, sentences containing known verbs of self-motion and nonsense words were presented to subjects where the target words were used representatively or nonrepresentatively (i.e., a verb used as a noun or a preposition, used with a direct object, or used with an inanimate agent). After a subject’s judgment, each type of item was discussed until the experimenter felt that the subject understood the nature of the task. Sentences with wamble were not included in the training session prior to the task.

**Picture classification.** Another task assessed subjects’ appreciation of the meaning of wamble. Subjects were asked whether each of 40 pictures illustrated wamble. The most representative meaning of wamble was operationalized as self-motion toward the agent’s home, and 20 of the pictures illustrated this sense of wamble. To test the generalization of possible agents of wamble, we manipulated the agent used in these pictures such that they were equally divided among insects, birds, nonhuman mammals, and humans. Twenty additional items, systematically manipulated the nature of the action, the direction of the action, and the goal of the action so that we could determine whether controls and pAD patients generalized their appreciation of wamble in a similar fashion. Thus, four of the foils illustrated movement of the agent toward a nonhome object, movement away from the agent’s home, movement away from a nonhome object, some other movement associated with the agent’s home, and some other movement associated with a nonhome object. The same spectrum of agents was equally distributed over the various combinations of movement and goal. The pictures were presented one at a time in a fixed random order, and subjects were allowed as much time as desired to respond.

**Thematic role judgments.** Subjects were asked to judge the coherence of 30 brief sentences that manipulated selectional restrictions associated with the agent, the direction, or the goal of the new verb wamble, a known verb of motion, or a nonsense word. For the agent, we probed an animate and movable object, an animate but nonmovable object, and an inanimate object. For the direction, we probed a preposition indicating a trajectory toward a target, a trajectory beyond a target, and a nonspatial preposition. For the goal, we probed a home that was appropriate for the agent, a nonhome target that was associated with the agent, and a location that was not likely to be associated with the agent. These various items were presented in random order. A practice session was presented prior to this task. Subjects were presented with a similar set of errors in sentences with known verbs and nonsense words, and their
judgments were discussed until the experimenter felt that the subject understood the nature of the task. Wamble did not occur in any of the sentences used in the practice session.

RESULTS

Exposure Period

We evaluated the ability of pAD patients to point to the appropriate picture when initially exposed to the new word in a highly constrained context. pAD patients did not differ from control subjects. Thus, 4 (40%) of 10 control subjects and 5 (30%) of 16 pAD patients pointed appropriately to the picture of bees returning to their hive when they first heard the new word in a sentence paired with a picture.

Subsequently pAD patients required on average more guesses than controls to identify the intended target picture on the first of the less constrained, multiple choice exposures [mean ± SD pAD guesses = 1.69 ± 0.94 vs mean control guesses = 1.00; U = 35.0; p < .01] and the second of these exposures [mean ± SD pAD guesses = 1.67 ± 1.00 vs mean control guesses = 1.00; U = 25.0; p < .02]. By the third of these exposures, however, pAD patients [mean ± SD pAD guesses = 1.27 ± 0.64 vs mean control guesses = 1.00; U = 45.0; p > .10] did not differ from controls at identifying the appropriate picture in response to the new word. Thus 15 (94%) of 16 pAD patients and 10 (100%) of 10 control subjects immediately identified the correct picture. In sum, pAD patients generally required more exposures to match a representative occurrence of a new word to a picture, but they were able to attain the criterion of matching a sentence containing the new word to a target picture after three trials.

Postexposure Period

Sentence grammaticality judgments. We evaluated pAD patients’ judgments of sentences containing the new word with a group (2) × type of word (wamble, known verb of motion, nonsense word) design. This revealed a significant main effect for group [F(1, 24) = 40.02; p < .0001] and a significant group × type of word interaction [F(2, 48) = 6.91; p < .002]. As summarized in Fig. 1, pAD patients differed significantly from control subjects in judging sentences with wamble [t(24) = 6.03; p < .001], pAD patients also differed from controls in their judgments of sentences with known verbs [t(24) = 3.22; p < .005]. Since pAD patients’ overall performance with known verbs was better than random, we suspect that this statistical finding may have been due in part to a ceiling effect in control subjects’ performance. pAD patients did not differ from controls in their judgments of sentences with nonsense words, indicating that pAD patients did not treat wamble like a nonsense word.
We examined this difference in grammaticality judgments in greater detail. When wamble was used as a verb, pAD patients' judgments were not influenced by whether it was inflected (71.87 ± 32.6% accurate) or uninflected (69.79 ± 31.75% accurate). However, pAD patients did not judge wamble in the same way across the various conditions where the new word was used in a less representative fashion. A group (2) × type of word (wamble, known verb of motion, nonsense word) × type of foil (form class violations, argument structure violations) design revealed a significant main effect for group $[F(1, 24) = 16.43; p < .001]$. A significant interaction effect was seen for group × type of word $[F(2, 48) = 3.60; p < .05]$, and a significant group × type of word × type of foil interaction effect was also seen $[F(8, 192) = 2.87; p < .005]$. As summarized in Fig. 2, planned $t$ tests revealed that pAD patients are impaired more in their judgments of wamble used in association with a less representative argument structure than in their own judgments of wamble used in a less representative grammatical form class slot $[t(15) = 4.49; p < .0004]$. A similar but attenuated difference was seen for judgments of less representative argument structures compared to less representative form classes for known verbs $[t(15) = 2.33; p < .03]$. These findings indicate that pAD patients as a group had relatively more difficulty appreciating argument structure properties of wamble compared to form class properties, and a similar pattern was seen with known verbs as well.

Fig. 1. Mean (SD) accuracy of pAD patients and control subjects on the sentence judgment task for sentences with wamble, known verbs, and nonsense words.
Inspection of individual control subject performance profiles revealed that 8 (80%) of 10 subjects were better than random in their judgments of sentences with wamble. Half of controls did not differ in their judgments of argument structure and form class, and all but 1 of the remaining controls differed by 1 error in their judgments of argument structure violations compared to form class violations. All subjects were quite accurate in their judgments of sentences with known verbs and nonsense words. The majority of control subjects thus were able to learn about sentential uses of a new word following a brief, naturalistic exposure.

Individual patient performance profiles of pAD patients are summarized in Table 2. We found that 14 (88%) of 16 pAD patients did not differ from random in their judgments of sentences with wamble. Twelve (92%) of 13 pAD patients with nonzero differences encountered greater difficulty with argument structure than with form class judgments. Fourteen (88%) of 16 pAD patients were better than random in their judgments of sentences with known words, emphasizing their relative difficulty with the new word, but 8 (80%) of 10 pAD patients with nonzero differences encountered relatively more difficulty in their judgments of the argument structure associated with
### TABLE 2
Word-Learning Characteristics of Individual Alzheimer’s Patients

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<th>Thematic role judgment</th>
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<td>6172</td>
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The basis for these profiles is provided in the text. “Poor meaning” indicates difficulty with argument structure, picture classification, and selectional restriction judgments for wamble and known words, but relatively intact form class appreciation; “poor memory” refers to compromised learning of all aspects of wamble, but relatively intact performance with known words; “selective mem” indicates selectively compromised performance with thematic roles and selection restrictions, but relatively preserved form class judgments of wamble, together with intact performance for known words; “them specific” indicates difficulty with all aspects of wamble except thematic role judgments; “lang specific” refers to difficulty with performance on measures requiring judgments of language material; “pic specific” indicates selective difficulty on measures requiring judgments of picture material.
known verbs than in their judgments of a known word’s form class. These findings confirm that pAD patients were impaired in making grammaticality judgments about a new word in a sentence. Individual pAD patients found it relatively difficult to make judgments of a representative argument structure associated with a new verb and, to some extent, a known verb, although they were better in their ability to judge the most representative form class use of a new word and a known word.

**Picture classification.** We examined pAD patients’ classification of pictures depicting wamble with a group (2) × direction (toward, away) × goal (home, other) design. This revealed a significant main effect for group \([F(1, 24) = 26.03; \ p < .0001]\), a significant group × goal interaction \([F(1, 24) = 6.23; \ p < .01]\), and a group × direction interaction effect that approached significance \([F(2, 48) = 2.51; \ p < .06]\). As can be seen in Fig. 3, planned \(t\) tests revealed that pAD patients differ significantly from controls in their judgments of foils probing directionality \([t(24) = 2.57; \ p < .01]\) and goal \([t(24) = 8.92; \ p < .001]\) attributes of wamble. We also examined the nature of the agent that pAD patients were willing to accept in association with wamble using a group (2) × type of agent (insect, bird, mammal, human) design. This analysis revealed a significant main effect only for group

Fig. 3. Mean (SD) accuracy of pAD patients and control subjects on the picture classification task for classifying picture foils that displayed direction and goal features not typically associated with wamble.
indicating that pAD patients did not fail to generalize their appreciation of wamble from bees to other potential agents. Inspection of individual subjects’ performance revealed that all controls were better than random in their appreciation of the agent, the direction, and the goal associated with wamble. Individual pAD patient performance profiles are summarized in Table 2. We found that 12 (75%) of 16 pAD patients did not differ from random in their ability to classify pictures illustrating wamble. In sum, these findings suggest that pAD patients differ from controls in their grasp of the meaning of wamble on a picture classification task.

**Thematic role judgments.** We examined pAD patients’ judgments of selection restrictions in thematic roles associated with wamble using a group \( (2) \times \text{type of word (wamble, known verb, nonsense word)} \) design. This revealed a significant main effect for group \( [F(1, 24) = 36.93; p < .0001] \) and a significant group \( \times \) type of word interaction effect \( [F(2, 48) = 4.81; p < .01] \). Planned \( t \) tests revealed that pAD patients (53.13 ± 14.9% accurate) differ from controls (89.00 ± 7.4% accurate) in their judgments of sentences with wamble \( [t(24) = 7.04; p < .0001] \). They did not differ from control subjects in their judgments of selection restrictions associated with argument structures of known verbs of self-motion, but this was marginal \( [t(24) = 1.97; p < .07] \). pAD patients did not differ from controls in their judgments of nonsense words, indicating that they treated wamble differently from nonsense words. We examined judgments of selection restrictions associated with specific thematic roles of wamble using planned \( t \) tests. As summarized in Fig. 4, we found that pAD patients differ from controls in their judgments of agents \( [t(24) = 4.52; p < .0001] \) and directional properties \( [t(24) = 7.79; p < .0001] \) associated with wamble. However, pAD patients did not differ from control subjects in their appreciation of a goal toward which an agent might wamble \( [t(24) = 1.87; \text{ns}] \).

Examination of individual control subjects’ performance revealed that they all were better than random in their judgments of selectional restrictions associated with the agency and directionality properties of wamble. Two control subjects were unsure about the nature of the goal associated with wamble on this task, explaining in part the marginal group-wide performance of controls in their judgments of this aspect of wamble. Control subjects were relatively accurate in their judgments of selectional restrictions associated with known verbs and nonsense words.

Table 2 summarizes individual pAD patients’ judgments of representative selection restrictions for thematic roles associated with wamble. We found that 13 (82%) of 16 pAD patients did not differ from random in their judgments of selection restrictions associated with wamble. Moreover, 10 (63%) of 16 pAD patients did not differ from random in their judgments of representative selection restrictions associated with known verbs, although they were accurate at rejecting sentences containing nonsense words. pAD patients’
difficulty appreciating selection restrictions thus was not restricted to the new verb they were learning, but appeared to involve known verbs as well.

Analysis of Individual Patient Profiles

One possibility is that a memory deficit explains in part the word learning difficulty of pAD patients. This account does not receive strong support from the poor correlations in Table 1 between tasks assessing wamble and measures of overall dementia severity, disease duration, and memory. Closer inspection of the individual patient profiles summarized in Table 2 indicates, however, that a memory deficit may have contributed to the word learning performance of three pAD patients (Cases 6011, 6025, and 6115). These three patients differed from controls on grammaticality and thematic role judgments assessing wamble, and they were random in their judgments of pictures of wamble, although they performed well on assessments of known words. One additional pAD patient (Case 6126) exhibited a similar pattern of performance except that he was better than random at judging pictures of wamble.

We also sought to determine the proportion of individual patients who
had difficulty learning about wamble because of a language deficit. In particular, we sought to identify patients with specific deficits in learning about meaning-related aspects of wamble, including difficulty with argument structure, picture classification, and selectional restriction information associated with wamble. We found that five patients (Cases 6005, 6037, 6158, 6166, and 6172) consistently did not differ from random in judging the argument structure of wamble, sorting pictures, and judging the selectional restrictions associated with wamble, although they differed from random in their judgment of the form class of wamble. We added to this cohort Case 6013, who was accurate in grammaticality judgments of sentences with wamble but did not differ from random in judgments of pictures or thematic roles. These six patients had similar patterns of impairment with known verbs as well. In sum, these patients appeared to have a selective impairment in appreciating the meaning-related aspects of wamble because of a language-based deficit, and their adequate performance with the form class of wamble suggested that a memory deficit could not fully account for their word learning difficulty.

Although our study was not designed to classify all patients, it is possible to speculate on the nature of the deficit in the remaining six patients. A material-specific impairment for pictures (Case 6017) or words (Cases 6032, 6126, and 6151) was apparent in some patients. Two additional patients (Cases 6001 and 6013) appeared to find thematic role judgments relatively easy.

**DISCUSSION**

Group-wide findings indicated that pAD patients are compromised in their acquisition of the meaning-related information associated with a new verb, but were relatively successful in their acquisition of the form class associated with wamble. Difficulty with meaning was manifested in several ways: pAD patients differed from controls at sorting pictures illustrating wamble; their judgments of the argument structures associated with wamble differed from controls; and they were compromised at appreciating the typical selectional restrictions associated with the thematic roles of the new verb’s argument structure. Inspection of individual patient profiles suggested that patients were impaired at learning about wamble for at least two reasons: Some patients appeared to have a language-based deficit that compromised their appreciation of meaning-related aspects of the new verb as well as known words, but other patients had word learning difficulty because of a memory impairment.

Potential explanations for word learning difficulty in pAD patients include a memory impairment that interferes with their ability to acquire a new natural concept. We found that three pAD patients apparently are able to learn little about a new verb, despite reasonable performance on comparable measures probing known words and nonsense words. Previous reports of natural
concept acquisition in amnesics have been equivocal. One study purporting to demonstrate compromised concept acquisition in H.M used quite unnatural techniques to expose the patient to a new concept, and investigations of his historic concept acquisition—the acquisition of words that entered the lexicon after the onset of his amnesia—probed only the phonological shape of the words (Gabrieli et al., 1988). Other studies have reported the ability of amnesics to acquire a second natural language or learn a computer language (Hirst et al., 1988; Glisky et al., 1986). The current study is consistent with these and other reports of lexical acquisition (Dopkins et al., 1990; Grossman, 1987; Van der Linden et al., 1994), emphasizing that declarative memory difficulty does not prohibit word learning. It is nevertheless important to point out the relatively small memory requirements for success on this experiment: pAD patients were challenged to learn only one word. Additional work is needed to establish the memory limitations in pAD patients’ acquisition of a new natural concept.

There was also some evidence that a selectively compromised memory system corresponding to a particular aspect of a word may have interfered with the acquisition of a new word. Selective success acquiring only grammatical aspects of a new word thus was observed in one patient. This patient performed normally on the corresponding measures of known words. This pattern is consistent with the hypothesis that rule-based learning may be relatively intact in some pAD patients (Glisky et al., 1986; Hirst et al., 1988; Knowlton et al., 1992; Knowlton & Squire, 1994). Moscovitch (1994) has suggested that this form of learning is implicit in nature, consistent with other evidence that some forms of implicit memory are relatively preserved in pAD (Butters, Salmon, Heindel, & Granholm, 1988; Deweer et al., 1994). By comparison, the declarative memory impairment in pAD (Butters et al., 1987; Squire, 1992; Petersen et al., 1994; Welsh et al., 1991) may have limited the ability of this patient to acquire semantic aspects of a new word (Tulving, 1994). Regardless of the specific explanation for the deficit in this individual, our observations emphasize the importance of performing both group-wide and individual patient analyses in learning measures.

An alternative to the memory-based explanation for lexical acquisition difficulty in pAD patients is that a widespread language-processing deficit compromised their appreciation of the new verb. We failed to find convincing evidence for such an account. Individual patient analyses thus demonstrated that most pAD patients are able to learn at least something about a new verb, and thus were able to implement the corresponding language process. It is unlikely that pAD patients were able to demonstrate this apparent knowledge of wamble by inferring the correct answer to a probe given their different pattern of performance with the nonsense words examined for each task.

Word learning difficulty in pAD instead may be due in part to selectively compromised lexical processing that interferes with the acquisition of a par-
ticular aspect of a new word. Several studies have suggested that semantic processing is compromised in pAD (Chan et al., 1993; Chertkow et al., 1989; Grossman & Mickanin, 1994; Hodges et al., 1992; Mickanin et al., 1994), although grammatical processing is relatively preserved (Emery & Breslau, 1989; Bayles, 1982; Kontiola et al., 1990; Swihart et al., 1989; Tomoeda et al., 1990). Consistent with this observation, we observed that pAD patients find it difficult to identify pictures that illustrate the new verb, although they were relatively accurate at learning about the new word’s form class. Importantly, there is another aspect of meaning that we assessed, that is, argument structure. Argument structure was investigated in the present study with two tasks: We examined certain types of thematic roles associated with wamble and the selection restrictions typically licensed to participate in the thematic roles associated with wamble. Group-wide and individual patient analyses demonstrated significant differences between pAD patients and controls in their judgments of sentences probing these aspects of argument structure. Parallel impairments in picture judgments and argument structure aspects of wamble in pAD begin to suggest that there may be a special relationship between these components of a word.

The apparent linguistic nature of the semantic difficulty experienced by six pAD patients is emphasized by their parallel deficit with known verbs. These patients were relatively compromised in their judgments of the same aspects of argument structure and selectional restrictions associated with known verbs. The relationship between argument structure and semantic meaning in pAD has been investigated in another recent study of semantic processing and verb appreciation (Grossman, Hughes, Mickanin, Carvell, & D’Esposito, 1996). On a triadic comparison task, we found that pAD patients are compromised in their ability to cluster verbs with similar meanings. pAD patients also were compromised in their judgments of the argument structures that match these verb meanings. Finally, unlike controls, pAD patients failed to demonstrate a correlative relationship between argument structure and semantic meaning aspects of verbs. It is also noteworthy that the kind of category membership recognition difficulty for pictures seen in the present study has been demonstrated for known concepts in pAD (Grossman & Mickanin, 1994). The generalization of semantic deficits from nouns to verbs and the demonstration that grammatical form class appreciation of single words is relatively preserved suggest that claims of intact semantic processing in pAD (Nebes, 1994; Ober, Shenaut, Jagust, & Stillman, 1991) may be tempered. Taken together, these findings indicate that some pAD patients may be compromised in their appreciation of linguistic aspects of word meaning.

Several caveats must be kept in mind when interpreting our findings. We assessed pAD patients who were mildly or moderately demented, so our findings can be generalized only to these cohorts within the larger population of patients with Alzheimer’s disease. The pAD patients were recruited from
a clinic specializing in the diagnosis and treatment of cognitive disorders, and this may have resulted in some inadvertent selection bias in our patients. Patients with pAD are heterogeneous, and our attempts to define relevant subgroups with particular performance profiles was limited by the nature of the observations that we could make. Thus, we attempted to sample the representative semantic meaning, grammatical, and argument structure aspects of the new verb, but we were limited in terms of the amount of time that pAD patients could be expected to perform at their optimal level. Clearly, additional observations of grammatical and semantic aspects of verbs must be performed for our hypothesis to be confirmed. Although lexical acquisition is a complex task that involves learning several types of information, only one new word was taught to pAD patients in the present study. An adequate investigation of the relationship between language and memory processing in pAD would require more complete assessments of memory functioning in pAD as well. With these shortcomings in mind, we conclude that many pAD patients are able to acquire at least some information about a new verb. Several pAD patients appear to have a discrete semantic processing deficit that interferes with their lexical acquisition performance, but other pAD patients have compromised episodic memory that interferes with new word learning.

REFERENCES


