Metalinguistic Judgments in Normal Aging and Alzheimer’s Disease

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This study compared sentence acceptability judgments from young and healthy older adults and older adults with dementia due to probable Alzheimer’s disease. Two types of sentences were contrasted: one type involved contrasts among verb alternations in which semantic distinctions between verbs regulate the acceptability of phrase structure variations; the second type involved contrasts among directional transformations in which constraints on the movement of noun phrases determine the linear order of main and embedded clauses. The primary findings were that metalinguistic judgments by healthy older adults as well as those with probable Alzheimer’s reflected processing demands on working memory. In addition, metalinguistic judgments by adults with probable Alzheimer’s reflected the breakdown of semantic information about verbs.

PERIODICALLY the regression hypothesis has surfaced in attempts to formulate a comprehensive theory of language development by linking language acquisition to language dissolution. This hypothesis claims that the breakdown of language is the inverse of its acquisition (Jackson, 1958; Jakobson, 1941/1968). Typically, the regression hypothesis is put forth to account for aphasia disorders (Dennis & Wiegel-Crump, 1979; Grodzinsky, 1990; Lesser, 1978) but it has more recently been advanced as an account of the effects of aging on language. In its strongest form the regression hypothesis claims that the development of linguistic competence in childhood is mirrored by the dissolution of linguistic competence in adulthood (Emery, 1985; Grodzinsky, 1990).

While studies of adults' speech production (Bates, Harris, Marchman, Wulfeck, & Kritchewsky, 1995; Blanken, Dittman, Haas, & Wallesch, 1987; Emery, 1985; Kemper, Kynette, Rash, Sprott, O’Brien, 1989; Kempler, Curtiss, & Jackson, 1987; Kynette & Kemper, 1986) and writing (Kemper, 1987a) reveal that older adults are unlikely to produce complex grammatical forms spontaneously, evidence also indicates that their speech does not degenerate into "baby talk." Whereas the speech of young children might be considered “telegraphic” in that grammatical morphemes are lacking and word combinations based on agent-action-object concatenations predominate (Brown, 1973), the speech of older adults nonetheless includes obligatory grammatical morphemes and a wide range of grammatical forms. Thus, it is likely that the similarities between language acquisition in childhood and the nature of language change in adulthood arise from different underlying mechanisms and principles, a weak version of the regression hypothesis.

One mechanism that may play different roles in language acquisition in childhood and language change in adulthood is working memory. References to working memory in the language acquisition literature are limited to occasional, and typically brief, suggestions that working memory limitations may play some role in constraining the length of children’s utterances (Bloom, 1970; Bever, 1970; Valian, 1986) or in some forms of childhood reading impairments (Crain & Shankweiler, 1988, 1990; Shankweiler & Crain, 1986) and individual differences in reading comprehension.

In contrast, working memory limitations play a key role in studies of adult language processing including reading comprehension (Daneman & Carpenter, 1980; Daneman & Tardiff, 1987; Turner & Engle, 1989; Waters, Caplan, & Hilderbrandt, 1987) and discourse processing (Hasher & Zacks, 1988; Kemper, 1992; Light, 1991; Light & Burke, 1988). Working memory in such studies is often conceptualized as a processing resource that affects the capacity of the syntactic parser to temporarily store unanalyzed sentence elements, multiple interpretations of locally ambiguous phrases, and the results of intermediate analyses of discontinuous grammatical elements (Just & Carpenter, 1992).

Working memory limitations appear to affect adults’ ability to process complex syntactic constructions (Kemper, 1986, 1987a, 1987b, 1988; Kemper & Rash, 1988; Kemper et al., 1989; Kynette & Kemper, 1986). Kemper et al. (1989) reported that the mean number of clauses per utterance (MCU), a general measure of the complexity of adults’ language, is positively correlated with the adults’ backward digit span using the Wechsler Adult Intelligence Scales (WAIS) subtest (Wechsler, 1958). Further, Kemper and Rash (1988) calculated Yngve depth (Yngve, 1960), a measure of the working memory demands of sentences, and found that the Yngve depth of adults’ utterances was positively correlated with WAIS digit span as well as with MCU.

These studies support a weak version of the regression hypothesis by suggesting that working memory limitations affect older adults’ ability to apply linguistic rules, in con-
trast to a strong version of the regression hypothesis, which would claim that linguistic rules themselves are lost due to deficits associated with advancing age. Metalinguistic or grammaticality judgments have been used to distinguish the effects of performance limitations from those due to a loss of linguistic competence. The performance/competence distinction assumes that linguistic processing during comprehension or production tasks is distinct from implicit knowledge of linguistic rules, and performance factors such as working memory limitations may disrupt rule-application during comprehension or production. Metalinguistic judgments may, therefore, reveal that competence, the knowledge of syntactic rules, is intact although performance on production tasks is impaired (Crain & Wexler, in press; Linebarger, Schwartz, & Saffran, 1983; McDaniel & McKee, 1993; Tyler, 1988).

Pye, Cheung, and Kemper (1993), in a prior study of grammatical judgments by young and older adults, showed that both college students in their 20s and older adults in their 60s, 70s, and 80s found sentences that violated morphological rules to be ungrammatical. There were no age group differences for ungrammatical sentences such as *The brothers was fixing up the old car [ungrammatical sentences are marked with an *], which violates the rule that requires verbs to agree with their subjects in person and number. The older adults were also able to detect violations of more complex syntactic rules (Chomsky, 1977, 1981; O’Grady, 1987) that regulate, or constrain, the form of various grammatical constructions. For example, the use of reflexives such as “myself” requires that the antecedent of the reflexive pronoun control the reflexive; a mismatch of number leads to the judgment of ungrammaticality, as in I helped myself to the birthday cake versus *I helped themselves to the birthday cake. Metalinguistic judgments of young and older adults are similar for such reflexive sentences.

A surprising finding of the Pye et al. (1993) study was that the older adults, but not younger adults, rejected many of the technically grammatical sentences that involved a main clause and one or more embedded clauses (which are bold italic in the following examples). The older adults, for example, found both The woman in the mink hat and jacket considers herself to have outwitted John and *The woman in the mink hat and jacket considers John to have outwitted herself to be unacceptable although the former is grammatical and the latter violates a constraint on reflexivity. Pye et al. suggested that older adults reject as ungrammatical sentences that violate grammatical rules as well as those they are unable to process fully due to working memory limitations. This interpretation was supported by the finding that the tendency to find multiclause sentences to be unacceptable was asymmetric: multiclause sentences with subject embeddings in which the embedded clause follows the main clause, such as The book about Napoleon’s battles that the author had signed was lost, were judged to be significantly less acceptable than those with predicate embeddings in which the embedded clause followed the main clause, such as Bill lost the book about Napoleon’s battles which the author had signed. Subject embedding imposes demands on working memory for simultaneous storage and processing because the processing of the embedded clause interrupts processing of the main clause. With predicate embedding, the relative clause is to the right of the main clause, and the two clauses can be successively analyzed, resulting in fewer demands on working memory for simultaneous storage and processing (Kemper, 1988, 1992). Pye et al. also found that the older adults’ ratings for grammatical, multiclause sentences were strongly correlated with their digit spans, consistent with the view that working memory limitations affect older adults’ ability to process multiclause sentences, especially those involving subject embeddings.

The present study was undertaken to compare the effects of working memory limitations to semantic impairments by collecting sentence acceptability ratings from young and healthy older adults and from adults with dementia due to probable Alzheimer’s disease (AD). Adults with probable AD experience not only working memory limitations, as indicated by poor performance on span tests, but also semantic impairment, as well as a general deterioration of cognition (Nebes, 1992; Kempler & Zelinski, 1994). Their performance on word retrieval tasks such as vocabulary tests and verbal fluency tests is grossly impaired. In addition, their discourse is disrupted by word finding problems as well as general problems of attention, cognition, and orientation. Kempler and Zelinski as well as Kemper et al. (1993) have suggested that adults with probable AD have preserved syntactic competence although their processing of long and complex sentences may be affected by working memory limitations, semantic impairments, and other cognitive deficits. However, as Hamilton (1994a, 1994b) has noted, adults with probable AD are capable of reflective self-awareness about their speech and language, although such metalinguistic awareness diminishes as the disease progresses.

In the present study, two types of ungrammatical sentences were contrasted. The first type involved verb semantics. Levin (1993) has compiled an inventory of English verbs sorted by semantic properties that determine their syntactic expression. For example, some verbs, such as squirt, can be used in either of two syntactic frames as in Examples 1a and b while other verbs, such as drip, that are closely related in meaning, do not allow both options. The distinction involves the transfer of an object to a location; when the location is expressed with a preposition, as in 1a and 2a, it receives a partitive interpretation. But when the location is expressed without a preposition, as in 1b and 2b, it receives a holistic interpretation of being completely affected by the action (Levin, 1993). In 2b this holistic interpretation of the affected location conflicts with the partitive nature of the action itself; hence, sentence 2b is ungrammatical.

1a. Jane squirted water into the bowl.
   b. Jane squirted the bowl with water.
2a. Judy dripped water into the bowl.
   b. Judy dripped the bowl with water.

Verb alternations provide a critical extension of the Pye et al. (1993) framework. Single-clause verb alternations should impose no processing burden on older adults, unlike the mul-
Mult clause sentences tested previously. Thus, healthy older adults were expected to be able to distinguish between grammatical and ungrammatical variants. In contrast, older adults with probable AD should have difficulty distinguishing between grammatical and ungrammatical verb alternations if their semantic impairments extend to the verb lexicon.

The second type of sentences tested in the present study were mult clause sentences contrasting in the linear ordering of the main and embedded clause. These sentences were termed “directional transformation” sentences. A noun phrase (NP) such as the fact may be modified by an embedded clause such as that John gave Bill all his books producing a “heavy NP” the fact that John gave Bill all his books. This heavy NP may be inserted in a sentence frame, as in the examples in 3. According to Kayne (1994), both 3b and 3c derive from the underlying construction shown in 3a by leftward raising of the NP the fact along with the embedded clause, inserting the NP and embedded clause into the main clause to produce the subject embedded version in 3b. Alternatively, only the NP the fact can be raised into the main clause to produce 3c; the clause that John gave Bill all his old books is stranded to the right of the main clause verb or predicate embedded. From either perspective, 3d is ungrammatical since only part of the embedded clause is raised into the main clause.

3a. The fact is irrelevant the fact that John gave Bill all his old books.
   b. The fact that John gave Bill all his old books is irrelevant.
   c. The fact is irrelevant that John gave Bill all his old books.
   d. *The fact that John gave Bill is irrelevant all his old books.

Healthy older adults as well as those with probable AD were expected to have difficulty with directional transformations. The results were expected to replicate those of Pye et al. (1993): both groups of older adults were expected to rate as unacceptables the mult clause sentences involving raising of the NP plus embedded clause (such as 3b) as a result of working memory limitations on the processing of subject embeddings. Mult clause sentences involving raising of the NP only (such as 3c) should be acceptable to both young and older adults alike since the embedded clause is predicate embedded and can be analyzed after the main clause has been fully analyzed. If syntactic competence is preserved in AD, then older adults with probable AD should be able to distinguish sentences violating grammatical constraints from those imposing severe working memory processing demands. Consequently, both groups of older adults as well as young adults should find sentences that violate grammatical constraints (3d) to be unacceptable.

**Participants**

Three groups of adults participated in this study. All of the participants were native speakers of English. The first group consisted of 20 young adults, ages 18–25 years (M = 21.4), who were university undergraduates. Each was paid $10 for participating. The second group consisted of 20 older adults, ages 60–74 (M = 68.5), who were recruited through newspaper advertisements and personal referrals. All had completed 4-year college degrees. They were healthy, with no history of significant medical conditions such as depression, stroke, or heart disease; all lived alone or with spouses or other family members. All were able to drive themselves to the testing site. They were paid $20 for participating. The third group consisted of 20 older adults with a diagnosis of probable AD. They were matched to the second group of older adults in terms of age (60–74 years, M = 68.9) and gender; all had completed 4-year college degrees. All were living at home with spouses or other family members; they were interviewed at home, most in the presence of a family member. They were paid $20 for participating.

The diagnosis of probable AD was determined by established guidelines (McKhan et al., 1984) on the basis of a full neurological examination. Exclusion criteria included abrupt onset of the dementia, a history of hypertension or stroke, ischemia, focal neurological deficits or lesions, depression, psychosis, alcoholism, or drug abuse. Dementia severity ranged from 14 to 24 (M = 19.2, SD = 3.9) on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975) and 80 to 120 (M = 100.2, SD = 15.4) on the Dementia Rating Scale (Mattis, 1976), indicating mild to moderate dementia.

All participants were given the 60-item Boston Naming Test (Kaplan, Goodglass, & Weintraube, 1983) and the Digits Forward and Digits Backward tests from the WAIS (Wechsler, 1958). The results are reported in Table 1. All three groups differed in vocabulary and forward and backward digit span, all p < .01.

**Materials**

Two sets of sentences were constructed. The first set consisted of verb alternations. Five quadruples of sentences were selected from among those given in Levin (1993). Each quadruple consisted of two pairs. In the first pair, one sentence was grammatical but the second sentence was ungrammatical because it violated a semantic constraint on the alternation. In the second pair, both sentences were acceptable; they differed by the application of the verb alternation to the second sentence of the pair. Five examples of each verb alternation were tested. Five different types of alternations were tested. Across the set of sentences as a whole, there were 75 grammatical sentences and 25 ungrammatical sentences (5 examples of each of 5 types of impermissible alternations).

The second set of sentences consisted of directional transformations. Five triplets of sentences were selected from among those given in Kayne (1994). Each triplet consisted of two alternative forms of a grammatical sentence that differed in terms of the linear order of the embedded clause with respect to the main clause. One version involved predicate embedding. It was analyzable as two suc-
Table 1. Summary Comparison of Participants on the Boston Naming Test and Digit Span Tests and Their Ratings of Random Word Strings

<table>
<thead>
<tr>
<th></th>
<th>Vocabulary</th>
<th>Digits Forward</th>
<th>Digits Backward</th>
<th>Random Strings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Young adults</td>
<td>48.1</td>
<td>1.2</td>
<td>9.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Healthy older adults</td>
<td>52.1</td>
<td>6.2</td>
<td>8.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Older adults with AD</td>
<td>34.1</td>
<td>11.8</td>
<td>6.2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Table 2. Examples of Two Types of Verb Alternations and Two Types of Directional Transformations

<table>
<thead>
<tr>
<th>Verb Alternations</th>
<th>Grammatical</th>
<th>Ungrammatical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dative Alternation</td>
<td>Jane squirted water into the bowl.</td>
<td>*Tamara poured the bowl with water.</td>
</tr>
<tr>
<td></td>
<td>Jane squirted the bowl with water.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tamara poured water into the bowl.</td>
<td></td>
</tr>
<tr>
<td>Passive Alternation</td>
<td>George Washington slept on the bed.</td>
<td>*Tuesday was slept on by Thomas Jefferson.</td>
</tr>
<tr>
<td></td>
<td>The bed was slept on by George Washington.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thomas Jefferson slept on Tuesday.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Directional Transformations</th>
<th>Predicate Embedding</th>
<th>Subject Embedding</th>
<th>Ungrammatical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy NP Shift</td>
<td>The fact is irrelevant that John gave Bill all his old books.</td>
<td>The fact that John gave Bill all his old books is irrelevant.</td>
<td>*The fact that John gave Bill is irrelevant all his old books.</td>
</tr>
<tr>
<td>Relative Shift</td>
<td>Plots have been hatched by many conspirators who work for the government.</td>
<td>Plots by many conspirators who work for the government have been hatched.</td>
<td>*Plots by many conspirators have been hatched who work for the government.</td>
</tr>
</tbody>
</table>

Note: Ungrammatical sentences are marked with an * for illustration purposes; actual ungrammatical test sentences were not distinguished.

Procedure

The young adults and the healthy older adults were tested in small groups of 3 to 4 participants. Each adult was given a response booklet consisting of a randomly ordered sequence of 175 test sentences (5 verb alternations x 5 examples x 4 sentences plus 5 directional transformations x 5 examples x 3 sentences). To more closely equate the number of grammatical and ungrammatical sentences in each booklet and to provide a check on the participants' ability to recognize ungrammatical sentences, 25 additional ungrammatical random word strings were included. Thus, each booklet included 125 grammatical sentences plus 75 ungrammatical sentences. Each sentence was accompanied by a 7-point rating scale ranging from −3 "completely unacceptable" to 0 "neutral" to +3 "completely acceptable." The adults were instructed to read each sentence and place an X on the rating scale to indicate how acceptable or unacceptable they judged the sentence to be. Ten examples, consisting of five simple, one-clause sentences and five random word strings such as Tim was found asleep under the apple tree and Under Tim tree was asleep found, were included on the first page of the response booklet. Five different types of directional transformations were tested. Five examples of each type of directional transformation were used. Across the set of sentences as a whole, there were 50 grammatical sentences and 25 ungrammatical sentences (5 examples of each of 5 types of impermissible transformations). Table 2 provides examples.
accompanied each sentence. The verbal labels for the midpoints and endpoints of the rating scale were replaced by yellow-colored stylized faces with neutral, happy, or sad expressions for the 0, +3, and -3 scalar locations, respectively. The experimenter read each sentence slowly with neutral expression while the adult with probable AD pointed successively to each word in the sentence. The adult with probable AD then pointed to a locus on the response scale to indicate her or his judgment, and the experimenter recorded the rating on a response form. The 10 example sentences were tested in the same way at the beginning of each testing session to remind the older adults with probable AD about the task and response requirements. Four different random orders of sentences were used in testing the adults with probable AD.

The modified task was also administered to a new group of 4 young adults and 4 healthy older adults who did not participate in the main task. These individuals were tested twice on the same sentences. They first completed the ratings task using the original procedure, working independently with response booklets; 1 week later they again completed the ratings task using the modified procedure. Their ratings were unaffected by procedure: 87% of their sentences received identical ratings on the two tasks (range 82–100%), and no sentence that was rated as grammatical (e.g., +1, +2, or +3) using one method was rated as ungrammatical (e.g., −1, −2, or −3) or vice versa) using the other method.

The 10 example sentences were included in both variants of the task to clarify the task and procedures. They were not used to preselect or screen out healthy older adults or adults with probable AD who had intact linguistic competence. All 20 adults with probable AD who were tested were able to distinguish consistently and accurately between the grammatical example sentences, assigning them acceptability ratings of +2 or +3, and the random word strings, assigning them acceptability ratings of −2 or −3. Seven additional older adults with probable AD were also initially recruited but were dropped from the study due to behavioral management problems; each was unable to complete the vocabulary and digit span tests and, consequently, was not tested further.

Table 3. Means and Standard Deviations for Acceptability Ratings for the Verb Alternations and Directional Transformations for the Three Groups of Participants

<table>
<thead>
<tr>
<th>Verb Alternations</th>
<th>Grammatical</th>
<th>Ungrammatical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Young adults</td>
<td>+2.65</td>
<td>0.59</td>
</tr>
<tr>
<td>Healthy older adults</td>
<td>+2.25</td>
<td>0.79</td>
</tr>
<tr>
<td>Older adults with AD</td>
<td>+2.00</td>
<td>0.79</td>
</tr>
</tbody>
</table>

Directional Transformation

<table>
<thead>
<tr>
<th>Predicate Embedding</th>
<th>Subject Embedding</th>
<th>Ungrammatical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Young adults</td>
<td>+2.25</td>
<td>0.85</td>
</tr>
<tr>
<td>Healthy older adults</td>
<td>+1.55</td>
<td>0.99</td>
</tr>
<tr>
<td>Older adults with AD</td>
<td>+2.20</td>
<td>0.97</td>
</tr>
</tbody>
</table>

RESULTS

As an initial check on the participants’ ability to recognize ungrammatical sentences, their ratings for the 25 random word strings were averaged and compared. Young adults assigned the random word strings an average rating of −2.40 (SD = .5); normal older adults assigned these random word strings an average rating of −2.60 (SD = .4), t(38) < 1.0, p > .10. The older adults with probable AD assigned these random word strings an average rating of −1.90 (SD = 1.2), which was significantly higher than that assigned by the young adults, t(38) = 2.93, p < .05 and significantly higher than that assigned by the normal older adults, t(38) = 3.71, p < .05. However, the average ratings by the adults with probable AD were negative, e.g., they all judged the random word strings to be ungrammatical. The adults with probable AD appeared to have a bias against extreme judgments of ungrammaticality but they were able to judge random word strings to be ungrammatical. Each participant’s ratings were averaged for the grammatical and ungrammatical sentences of each type. Results for the verb alternations and directional transformations are discussed separately.

Verb Alternations

A preliminary analysis revealed no significant differences for the five types of verb alternations, so each participant’s ratings were averaged for the 75 grammatical sentences and the 25 ungrammatical sentences. Means and standard deviations are given in Table 3. The averaged ratings were analyzed with a 3 Groups × 2 Types (grammatical versus ungrammatical) analysis of variance. Both main effects were significant as was the two-way interaction, F(2,57) = 13.75, MSE = .043, p < .01. All three groups of raters judged the grammatical verb alternations to be acceptable by assigning positive ratings. But only the young adults and the healthy older adults judged the ungrammatical verb alternations to be unacceptable; the adults with probable AD assigned positive ratings to the ungrammatical verb alternations. Young adults found the grammatical and ungrammatical sentences to differ significantly in acceptability, t(19) = 18.30, p < .01, as did the
healthy older adults, t(19) = 12.99, p < .01; older adults with
probable AD found the two types of sentences to be only
marginally different in acceptability, t(19) = 3.29, p < .05.
The older adults with probable AD did rate the ungrammati-
cal verb alternations as somewhat more acceptable than the
ungrammatical, random word strings.

Directional transformations. — A preliminary analysis
revealed no significant differences for the five types of
directional transformations, so each participant’s ratings
were averaged for the 50 grammatical sentences and the 25
ungrammatical sentences. Means and standard deviations
are given in Table 3. The averaged ratings were analyzed
with a 3 Groups x 3 Types (subject embedding, predicate
embedding, and ungrammatical) analysis of variance. Both
main effects were significant as was the two-way interac-
tion, $F(3,56) = 102.81$, $MSE = .062$, $p < .01$. The young
adults, the healthy older adults, and the older adults with
probable AD judged the predicate embedded sentences to
be acceptable, but only the young adults judged the sub-
ject embedded sentences to be acceptable by assigning
positive ratings; the young adults found the subject and
predicate embedded sentences to be equally acceptable,
t(19) < 1.0, p > .10. The young adults found the ungram-
matical directional transformations to be unacceptable,
assigning them negative ratings. The healthy older adults
found both the grammatical subject embedded sentences
and the ungrammatical directional transformation sentences
to be unacceptable, assigning them negative ratings. Their
mean ratings for the subject and predicate embedded sen-
tences were significantly different, t(19) = 35.34, p < .01.
They found the ungrammatical sentences to be somewhat
less acceptable than the subject embedded sentences, t(19) =
2.89, p < .05, but somewhat more acceptable than the
random word strings ($M = -2.60$), t(19) = 7.27, p < .05,
suggesting that they could distinguish sentences that vio-
lated directional constraints as well as those that imposed
severe processing demands from random word strings. The
older adults with probable AD rated predicate embedded
sentences as acceptable ($M = 2.20$) and subject embedding
($M = -2.10$) and ungrammatical sentences ($M = -1.45$) as
unacceptable. Their mean ratings for the subject embedding
and ungrammatical sentences did not differ, $p > .10$. Note
that the older adults with probable AD rated the random
word strings as unacceptable ($M = -1.90$) as the ungram-
matical directional transformation sentences, $p > .05$, sug-
gestng that the older adults with probable AD could not
distinguish sentences that violate constraints on directional
transformations from those imposing severe processing
demands or random word strings.

Correlations with vocabulary and digit span. — To
investigate how verbal ability and working memory ability
contribute to metalinguistic judgments of sentence accept-
ability, the scores on the Boston Naming and Digits
Forward and Backward tests were correlated with each par-
ticipant’s mean acceptability judgments for each type of
sentence. An averaged digit span score was computed as an
index of working memory by averaging each participant’s
score on the Digits Forward and Digits Backward tests.

Scores on the Boston Naming Test were used as an index of
verbal ability.

The relationship between the participants’ verbal ability
as measured by the Boston Naming vocabulary test and
their acceptability ratings was investigated by correlating
scores on the vocabulary test with averaged ratings for each
type of sentence. There was an inverse relationship between
verbal ability and the acceptability of the ungrammatical
verb alternations for the older adults with probable AD, $r =
-.48$, $p < .05$; those older adults with probable AD who had
relatively well preserved verbal ability tended to find the
ungrammatical verb alternations to be unacceptable, whereas
those with impaired verbal ability tended to rate the
ungrammatical verb alternations as acceptable. There was
no relationship between verbal ability and metalinguistic
judgments for young adults or healthy older adults, perhaps
as a result of the truncated range of their vocabulary scores
as well as the truncated range of their acceptability ratings
for the grammatical and ungrammatical verb alternations.

The relationship between the participants’ working mem-
ory and their acceptability ratings was investigated by cor-
relating the averaged digit span scores with the mean
acceptability rating for each type of sentence. Table 4 pre-
sents the significant correlations for young adults, healthy
older adults, and older adults with probable AD and for the
three groups combined. Digit span was negatively corre-
lated with acceptability ratings for ungrammatical direc-
tional transformation sentences for the young adults and the
healthy older adults. This indicates that young adults and
healthy older adults with larger digit spans tended to rate
these sentences as less acceptable than did participants with
smaller digit spans. No relationship between digit span and
ratings of ungrammatical directional transformation sentences
was found for the older adults with probable AD, reflecting
the truncated range of their digit span scores and their
acceptability ratings. Digit spans were positively corre-
lated with ratings of the acceptability of the subject
embedded sentences for the young adults as well as both
groups of older adults. Young and older adults with larger

| Table 4. Significant Correlations with Averaged Digits Forward and Digits Backward Span Scores |
|---------------------------------------------------------------|-----------------------------|
| Averaged Digit Span |
| Young Adults |
| Subject embeddings | +.36* |
| Ungrammatical transformations | −.44* |
| Healthy Older Adults |
| Subject embeddings | +.48* |
| Ungrammatical transformations | −.49* |
| Older Adults with AD |
| Ungrammatical verb alternations | −.48* |
| Subject embeddings | −.49* |
| All Groups Combined |
| Predicate embeddings | +.42** |
| Subject embeddings | +.38* |
| Ungrammatical transformations | −.47** |

*p < .05; **p < .01.
DISCUSSION

The present study provides considerable support for the hypothesis that syntactic knowledge is preserved in both normal older adults and older adults with probable AD despite working memory limitations on sentence processing and deficits of verb semantics. When a metalinguistic judgment task is used, healthy older adults and older adults with probable AD are able to recognize ungrammatical sentences formed from random word strings and distinguish ungrammatical sentences from grammatical ones. Both healthy older adults and older adults with probable AD who exhibit working memory limitations on digit span also exhibit working memory limitations on syntactic analysis during a metalinguistic judgment task.

In the present study the effect of working memory limitations on syntactic analysis was evident in the differential pattern of acceptability judgments for complex sentences involving subject and predicate embeddings. One type of directional transformation produced predicate embedded sentences that both healthy older adults and older adults with probable AD judged to be acceptable, whereas a different type of directional transformation produced subject embedded sentences that both groups of older adults judged to be unacceptable. Using Kayne’s (1994) formulation, the predicate embedding versions resulted from the leftward raising of the NP from a structure such as (____ verb NP [embedded clause]) producing a structure such as (NP verb [embedded clause]) in which an embedded clause is stranded to the right of the main verb. The subject embedded versions resulted from the leftward raising of the NP as well as its embedded clause, producing a structure such as (NP [embedded clause] verb) in which the entire embedded clause precedes the main clause predicate. Working memory in older adults is, apparently, overtaxed by directional transformation that produce subject embeddings.

The present study also demonstrates that syntactic and semantic abilities are dissociated in normal aging and AD. Whereas nondementing, healthy older adults are able to recognize violations of verb transformations resulting from subtle aspects of verb semantics, older adults with probable AD cannot distinguish between acceptable and unacceptable verb transformations. The breakdown of semantic memory, evidenced by word finding problems and other impairments of verbal fluency that are often viewed as markers of probable AD, extends to the verb lexicon as well as the more thoroughly studied noun lexicon. Older adults with probable AD are unable to distinguish between pairs of verbs such as *squirt and *drip that share many semantic elements in common yet differ with regard to their compatibility with the dative transformation.

Fodor (1983) suggested that syntactic knowledge is "modular" or buffered from other cognitive operations or limitations. The present study, like previous studies of syntactic processing by older adults and adults with probable AD, suggests that the modular thesis must be modified. While syntax does appear to be spared from the general deterioration of cognition that results from AD, its use by healthy older adults as well as adults with probable AD is affected by working memory limitations even during a metalinguistic judgment task.Semantic knowledge also does not appear to be modular: whereas young and healthy older adults are able to distinguish between acceptable and unacceptable verb transformation, the semantic knowledge that permits such distinctions is highly vulnerable to cognitive impairments and may be disrupted by probable AD.

Although metalinguistic judgments are often viewed as privileged “direct” access to underlying linguistic rules (Baker, 1995), the results of the correlational analysis suggest that metalinguistic judgments, like other aspects of linguistic performance tested with comprehension or production tasks, are affected by individual differences in underlying abilities. Individual differences among young adults, healthy older adults, and older adults with probable AD affected how acceptable they found the verb alternations and directional transformation sentences to be. Working memory seems to be particularly important for evaluating multiclause ungrammatical sentences. To determine if a multiclause sentence violates a constraint on the movement of linguistic elements, it is necessary to hold multiple grammatical relations in working memory simultaneously. Most linguistic accounts (Chomsky, 1995) would agree that to detect the ungrammaticality of *Plots by many conspirators have been hatched who work for the government, it is necessary to identify plots as the subject of the main clause, recognize that the embedded relative clause who work for the government must modify a noun phrase, determine that who must be coreferential with conspirators, identify conspirators as the subject of the embedded clause, and recognize that the entire, complex noun phrase conspirators who work for the government must move together if any element is moved. The present results suggest that working memory limitations can affect how accurately older adults can detect such violations of syntactic constraints; a variety of explanations is available in terms of specific assumptions of different syntactic parsing models (Kemper, 1988, 1992).

The present results also suggest that working memory limitations affect how accurately older adults can process multiclause sentences that do not violate grammatical constraints but do require extensive, simultaneous processing of multiple grammatical relations. To detect the grammaticality of Plots by many conspirators who work for the government have been hatched, plots must be held in memory while the embedded clause is processed. This in turn requires that conspirators be held in memory to be recognized as coreferential with who and then recognized as the subject of the embedded clause, and plots must be retained in memory until it can be assigned as the subject of the main clause. These requirements, apparently, overburden the working memories of older adults and older adults with probable AD, resulting in the judgment that such sentences are unacceptable.

Working memory is not required to detect the unacceptability of *Tuesday was slept on by Thomas Jefferson. Its unacceptability results from the recognition that “sleeping on Tuesday” conveys a temporal or durational sense of sleep
whereas “sleeping by someone” conveys a spatial or locative sense of sleep. Hence, the contrast between temporal/durational and the spatial/locative interpretations of sleep results in the judgment of unacceptability. The bed was slept on by Thomas Jefferson is acceptable since only a spatial/locative sense of sleep is conveyed. These sorts of subtle semantic distinctions among verb uses are apparently related to lexical knowledge more generally and can be lost or disrupted by probable AD in the same way that semantic distinctions among nouns and adjectives are lost or disrupted.

Normal aging and Alzheimer’s disease have different effects on adults’ language; the working memory limitations typical of normal aging affect older adults’ ability to process complex grammatical constructions. Processing deficits have been observed for production, imitation, and recall tasks as well as for metalinguistic judgment tasks. AD not only leads to working memory limitations and associated processing deficits for complex sentences, but also to semantic impairments that affect the production and retrieval of lexical items and metalinguistic judgments about sentence acceptability. These findings may help to establish criteria for distinguishing normal age-related changes to adults’ language from pathological ones due to AD and related dementias and to refine screening instruments for the early diagnosis of Alzheimer’s and related dementias.

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References


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ANNOUNCEMENT

After many years of dedicated and much appreciated service, Andrea Nevins has stepped down as Audiovisual Review Editor for The Gerontologist. Members of the Society with a strong critical interest in film, video, and related media who might be interested in serving in the position are invited to apply. Please send a letter of interest, accompanied by a resume and a one-page statement indicating what you would desire regarding the future mission and format of the Audiovisual Review section, including what changes, if any, you would make to its current form. Correspondence should be sent directly to me.

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