Effects of Aging, Message Repetition, and Note-Taking on Memory for Health Information

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This study investigated whether repetition improves older adults’ memory for health service appointment messages delivered by automated telephone systems. Whereas imposed repetition reduces age differences in memory (Morrow, Leirer, Carver, Tanke, & McNally, 1999), the present study examined the effect of optional repetition. Both older and younger participants in Experiment 1 chose to repeat messages. More repetition, higher cognitive ability (working memory and processing speed), and younger age were associated with better memory for appointment information. The effect of age was eliminated when cognitive ability, but not repetition, was controlled. Thus, older adults used optional repetition in automated systems, but this strategy did not eliminate age differences in memory. In Experiment 2, older as well as younger adults took accurate notes and also repeated messages. Both note-taking and message repetition improved memory for the messages but did not reduce age differences. These findings suggest that older as well as younger adults use presentation strategies in automated messaging systems. Older adults may not take full advantage of these strategies, perhaps because of age-related declines in self-initiated or metacognitive processes.

Missed appointments are a costly health care problem that sometimes reflects poor comprehension and memory for information about health appointments (Deyo & Inui, 1980; Hofmann & Rockart, 1969; Oppenheim, Bergman, & English, 1979). It is a particular concern for older adults, because they use disproportionately more health services (U.S. Department of Health and Human Services, 1990). Our goal was to improve older adults’ comprehension of appointment information so that they can better perform health-related tasks such as attending appointments. More specifically, we investigated whether strategies such as repetition and note-taking would provide environmental support that improves older adults’ comprehension. We also investigated two general issues related to aging and health information. First, we examined factors that influence older adults’ use of health-related technology. Older adults increasingly use computers to obtain health-related information, such as the internet, telephone-based automated services, and computerized kiosks (e.g., Czaja, 1997; Food and Drug Administration, 1995). In the present article, we focus on automated telephone messaging systems, which are routinely used by health organizations to send messages about health services to patients (Leirer, Tanke, & Morrow, 1993). Improving these messages may make it easier for older adults to use automated systems. Second, we explored sources of age differences in understanding and remembering health information. Age differences may reflect age-related differences in cognitive resources such as working-memory capacity or processing speed (e.g., Hartley, 1993; Stine & Wingfield, 1990). They may also reflect differential use of message-presentation strategies such as repetition.

Age Differences in Understanding and Remembering Appointment Messages

Improving the design of health service appointment messages is important, because these messages can be complex, conveying information about who sent the message, the date and time of the appointment, what to do before attending the appointment, whom to call with questions, and other categories (Morrow, Leirer, Carver, & Tanke, 1998). While automated messages have been shown to improve appointment attendance (e.g., Leirer, Morrow, Pariante, & Doksum, 1989; Tanke & Leirer, 1994), these previous studies have not focused on the messages themselves. Our goal was to make automated messages easier to understand and remember.

Comprehension often involves creating a situation model (or mental model) that represents the situations described by the message (van Dijk & Kintsch, 1983). Comprehension processes include recognizing words, parsing syntactic structure, integrating information across sentences, and elaborating this information in terms of background knowledge. A hallmark of the situation level of comprehension is the ability to draw inferences from the message. For example, if a message states that your appointment is at 10:00 a.m. and that you must fast for 12 hr prior to the appointment, you must figure out that you will have to skip breakfast. These comprehension processes must be coordinated in working memory, which is often conceptualized as a limited-capacity mental work space where information is temporarily stored while processed. Thus, working-memory capacity is a fundamental constraint on comprehension (Baddeley, 1986; van Dijk & Kintsch, 1983; Perfetti, 1994).

People are more likely to create an accurate situation model despite working-memory limits when the message has appropriate information (i.e., content) and organization, when it contains explicit and simple terminology, and when it is presented by an appropriate modality (speech or print). Such messages may reduce comprehension demands on older adults’ cognitive resources. More difficult messages, on the other hand, may magnify age differences by increasing demands on working memory (Salthouse, 1991). We earlier investigated the effect of
message content and organization on memory for appointment information. Older and younger adults had similar preferences for organizing appointment messages (e.g., the message should present the appointment time before preappointment procedures), reflecting a shared schema for appointment information. Moreover, they better recalled schema-compatible and shorter messages, although schema organization and shorter length did not reduce age differences in recall (Morrow, Leirer, Andrassy, & Tanke, 1995; Morrow et al., 1998). We then investigated the presentation of these automated messages, focusing on whether repetition reduced age differences in memory for appointment information.

Repetition and Memory for Appointment Messages

Repetition provides an opportunity to elaborate comprehension by correcting an initial interpretation or identifying new information missed during the first pass (Bromage & Mayer, 1986). This additional processing may reduce the effect of age-related declines in working-memory capacity or processing speed on comprehension. There is considerable evidence that repetition improves older and younger adults’ comprehension of and memory for verbal information (e.g., Bromage & Mayer, 1986; Crowder, 1976; Verhaeghen, Marcoen, & Goossens, 1993). Repetition also improves sentence memory for older adults with mild to moderate Alzheimer’s disease (Small, Kemper, & Lyons, 1997). In the health domain, Morrow, Leirer, Carver, Tanke, and McNally (1999) found that repeating appointment messages reduced differences associated with age and cognitive ability for cues but not free-recall measures of message memory (also see Morrow et al., 1995). Thus, older adults only differentially benefited from repetition when they were provided retrieval support, suggesting the importance of multiple forms of support for improving older adult memory (Bäckman, Mäntylä, & Herlitz, 1990; Craik & Jennings, 1992). We also found that repetition especially improved the ability to draw inferences from the messages, suggesting that it helps older adults create situation models from health care messages.

Repetition is optional rather than imposed in most automated messaging systems, in part to reduce the overall amount of time needed to deliver messages over the telephone. Therefore, it is important to determine whether optional as well as imposed repetition reduces age differences in memory. Benefitting from this type of repetition requires monitoring and evaluating comprehension during the first message presentation, deciding whether to repeat the message, and engaging in additional processing when listening to the message again. Optional repetition will improve comprehension and memory if listeners realize that they did not fully understand a message after the first presentation and that they can benefit from reviewing it. If older as well as younger listeners accurately monitor comprehension and initiate additional processing, they will listen to the message more times than younger adults do, thereby maximizing memory.

At least two findings suggest that this should be the case. First, there are minimal age differences in such comprehension monitoring processes as noticing inconsistencies in text (e.g., Zabrucky, Moore, & Schultz, 1987). Second, allowing unpaced study time of word lists or text tends to reduce age differences in recall, but only when review is possible (for a meta-analysis, see Verhaeghen et al., 1993). This is similar to the present case where repetition provides a structured form of review for spoken text.

On the other hand, optional repetition may be less likely than imposed repetition to reduce age differences. First, it imposes heavier demands on self-initiated processing. Listeners must decide whether to repeat the message and perform an action to do so (press a number on the telephone keypad) as well as initiate additional processing during message review. This may put older adults at a disadvantage because of declines in self-initiated processing (Craik & Jennings, 1992). Second, older adults may not benefit as much as younger adults do from optional repetition because of age differences in metacognitive processes. For example, they may recognize that they could benefit from additional processing but then have trouble coordinating monitoring with the additional processing required to elaborate comprehension (Dunlosky & Conn, 1997). Zabrucky and Moore (1994) found that older adults slowed when reading sentences containing inconsistencies, suggesting that they monitored comprehension as well as younger adults did. However, they were less likely to reread the relevant prior text in response to the inconsistency, suggesting an age-related difficulty with resolving problems that have been identified. Moreover, this age decline in strategic rereading accounted for age differences in recall. In short, it is unclear whether optional repetition will reduce age differences in memory for appointment information.

Participants in the present study listened to appointment messages as many times as they wanted before their memory for the message was tested. We investigated three questions. First, who uses optional repetition? Older adults should listen to the messages more times than younger adults do if they accurately monitor comprehension. Second, who benefits from this strategy? By listening more times, older adults may maximize recall and eliminate age differences in memory for the appointment information. If repetition reduces the effect of cognitive resource limits on comprehension, it may especially benefit lower ability listeners, whether they are older or younger (Morrow et al., 1999). On the other hand, if optional repetition increases rather than reduces demands on self-initiated processing, higher ability listeners may be more likely to benefit, because their cognitive resources enable them to accurately monitor comprehension and to engage in additional processing. Zabrucky and Moore (1994) found that readers who scored higher on a measure of memory-processing efficiency were more likely to selectively reread text and improve recall. Third, does repetition counter the effects of message length on recall? Our earlier studies found that recall tends to decline with length when messages are presented once (Morrow et al., 1998), and imposed repetition did not reduce this effect (Morrow et al., 1999). It is possible that people will listen to longer messages more times in order to remember longer messages as well as they remember shorter ones.

Experiment 1

Method

Participants.—Forty-five older and 45 younger adults participated. We recruited older adults from communities in the New Hampshire Seacoast region, and younger adults were college students. Table 1 shows that older adults were more educated and took more medication than younger participants but did not differ in self-reported health. They reported attending about the same
have been found to account for part of the age-related variance in recall of spoken text (Stine & Hindman, 1990) and written text (Stine & Wingfield, 1990). Age differences in sentence span scores from the two versions were correlated, \( r = .70, p < .001 \). We measured speed of mental processing by the mean of Letter and Pattern Comparison tasks (Salthouse & Babcock, 1991). Age differences in sentence span scores have been found to account for part of the age-related variance in recall of spoken text (Stine & Hindman, 1990) and written text (Hartley, 1993). For the participants in the present study, a mean span score was created from the listening and reading versions of the span task, because these scores were correlated, \( r = .65, p < .001 \). We measured speed of mental processing by the Letter Comparison and Pattern Comparison tasks (Salthouse & Babcock, 1991). In these paper-and-pencil tests, participants decide as rapidly as possible if pairs of letters or line patterns are the same or different. Age differences on the comparison tasks have been shown to account for age-related variance in performance on several verbal tasks (Salthouse, 1993; Salthouse & Babcock, 1991). A mean processing speed score was created from the Letter and Pattern Comparison tasks, because scores from the two versions were correlated, \( r = .70, p < .001 \). As in many aging and memory studies, older participants outscored younger participants on the vocabulary test, but they scored lower on both the sentence span and speed tests (see Table 1).

### Table 1. Mean Values for Demographic and Cognitive Ability Variables for Participants in Experiments 1 and 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Experiment 1</th>
<th></th>
<th></th>
<th>Experiment 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Older Adults</td>
<td>Younger Adults</td>
<td>( t \text{ test (df) = 88} )</td>
<td>Older Adults</td>
<td>Younger Adults</td>
<td>( t \text{ test (df) = 91} )</td>
</tr>
<tr>
<td>Age</td>
<td>71.5 (5.0)</td>
<td>20.7 (1.2)</td>
<td>—</td>
<td>68.6 (5.9)</td>
<td>18.6 (1.0)</td>
<td>—</td>
</tr>
<tr>
<td>Education (years)</td>
<td>15.5 (2.2)</td>
<td>14.7 (1.4)</td>
<td>2.2*</td>
<td>16.8 (2.8)</td>
<td>13.1 (1.8)</td>
<td>7.8**</td>
</tr>
<tr>
<td>Self-reported health</td>
<td>5.5 (1.5)</td>
<td>5.7 (1.0)</td>
<td>&lt; 1.0</td>
<td>5.6 (1.3)</td>
<td>5.8 (0.9)</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Number of medications</td>
<td>1.9 (1.6)</td>
<td>0.7 (0.8)</td>
<td>4.6**</td>
<td>2.1 (1.8)</td>
<td>0.5 (0.9)</td>
<td>5.5**</td>
</tr>
<tr>
<td>Vocabulary*</td>
<td>26.1 (7.7)</td>
<td>15.8 (4.2)</td>
<td>7.9**</td>
<td>26.6 (5.3)</td>
<td>11.9 (3.6)</td>
<td>15.6**</td>
</tr>
<tr>
<td>Sentence span*</td>
<td>3.2 (0.7)</td>
<td>4.5 (1.0)</td>
<td>7.5***</td>
<td>3.4 (0.9)</td>
<td>3.7 (1.1)</td>
<td>1.7**</td>
</tr>
<tr>
<td>Processing speed*</td>
<td>23.0 (5.0)</td>
<td>34.3 (5.6)</td>
<td>10.0**</td>
<td>25.2 (5.0)</td>
<td>32.2 (5.5)</td>
<td>6.4**</td>
</tr>
</tbody>
</table>

*Note: Numbers in parentheses are standard deviations of variables.

\*Advanced Vocabulary Test from the Kit of Factor-Referenced Cognitive tests (Ekstrom, French, & Harmon, 1976).

\*Mean of listening and reading versions of the sentence span test (Stine & Hindman, 1994).

\*Mean of Letter and Pattern Comparison tasks (Salthouse & Babcock, 1991).

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

We measured cognitive ability by vocabulary, working memory, and perceptual-speed tests. We measured vocabulary by the Advanced Vocabulary Test from the Kit of Factor-Referenced Cognitive tests, an 8-min test with 36 multiple-choice items (Ekstrom, French, & Harmon, 1976). We measured working-memory capacity by a loaded sentence span test, containing a listening and reading component. This task measures the ability to simultaneously store and manipulate verbal information in memory. Participants respond true or false to progressively larger sets of spoken or printed sentences (2–8 sentences) and then recall the final word of each sentence in the span. The span score is the size of the largest set for which participants could recall all final words (for details on materials and scoring see Stine & Hindman, 1994). Age differences in sentence span scores have been found to account for part of the age-related variance in recall of spoken text (Stine & Hindman, 1990) and written text (Hartley, 1993). For the participants in the present study, a mean span score was created from the listening and reading versions of the span task, because these scores were correlated, \( r = .65, p < .001 \). We measured speed of mental processing by the Letter Comparison and Pattern Comparison tasks (Salthouse & Babcock, 1991). In these paper-and-pencil tests, participants decide as rapidly as possible if pairs of letters or line patterns are the same or different. Age differences on the comparison tasks have been shown to account for age-related variance in performance on several verbal tasks (Salthouse, 1993; Salthouse & Babcock, 1991). A mean processing speed score was created from the Letter and Pattern Comparison tasks, because scores from the two versions were correlated, \( r = .70, p < .001 \). As in many aging and memory studies, older participants outscored younger participants on the vocabulary test, but they scored lower on both the sentence span and speed tests (see Table 1).

**Apparatus: Automated telephone messaging system.**—The automated telephone messaging system (TeleMinder Model T-4; Decision Systems, Los Altos, California) had three components: (a) a standard microcomputer, (b) specialized hardware that interfaces with the public telephone system in order to number of health appointments in the past year as younger participants did (1.8 vs 1.7 mean number of appointments), \( F(1,88) < 1.0 \), and both groups reported rarely receiving telephone appointment reminders (1 = always receive reminders, 4 = never receive reminders: older \( [O] = 3.5 \), younger \( [Y] = 3.5 \) mean rating).

We measured cognitive ability by vocabulary, working memory, and perceptual-speed tests. We measured vocabulary by the Advanced Vocabulary Test from the Kit of Factor-Referenced Cognitive tests, an 8-min test with 36 multiple-choice items (Ekstrom, French, & Harmon, 1976). We measured working-memory capacity by a loaded sentence span test, containing a listening and reading component. This task measures the ability to simultaneously store and manipulate verbal information in memory. Participants respond true or false to progressively larger sets of spoken or printed sentences (2–8 sentences) and then recall the final word of each sentence in the span. The span score is the size of the largest set for which participants could recall all final words (for details on materials and scoring see Stine & Hindman, 1994). Age differences in sentence span scores have been found to account for part of the age-related variance in recall of spoken text (Stine & Hindman, 1990) and written text (Hartley, 1993). For the participants in the present study, a mean span score was created from the listening and reading versions of the span task, because these scores were correlated, \( r = .65, p < .001 \). We measured speed of mental processing by the Letter Comparison and Pattern Comparison tasks (Salthouse & Babcock, 1991). In these paper-and-pencil tests, participants decide as rapidly as possible if pairs of letters or line patterns are the same or different. Age differences on the comparison tasks have been shown to account for age-related variance in performance on several verbal tasks (Salthouse, 1993; Salthouse & Babcock, 1991). A mean processing speed score was created from the Letter and Pattern Comparison tasks, because scores from the two versions were correlated, \( r = .70, p < .001 \). As in many aging and memory studies, older participants outscored younger participants on the vocabulary test, but they scored lower on both the sentence span and speed tests (see Table 1).

### Messages and experimental design.**—**Appointment messages were created for hypertension, diabetes, and flu prevention services, three of the most common illnesses for older adults in the United States (U.S. Department of Health and Human Services, 1990). Short, medium-length, and long versions of each message were created based on the findings of a preliminary study. In this study, participants were presented nine types of information for each of the three services, and they judged whether each item was necessary or optional for a reminder message (see Morrow et al., 1998). Short messages contained the five items most frequently judged as necessary for a reminder (at least 75% of the participants thought these items were necessary)—clinic name, client name, appointment time, location, and preappointment procedure. Medium-length (seven-item) messages contained these items as well as purpose and whom to call (the next most frequently chosen items). Long messages contained all items (including possible side effects and a motivational item explaining why it was important to attend the service). All messages presented the information in the order that older and younger adults preferred in Morrow et al. (1998). Thus, all messages were compatible with older and younger adults’ appointment schemas (see Appendix A for an example of a long appointment message). The messages were digitally recorded by a male native speaker of English with normal conversational intonation. Speech rate did not differ for the three message lengths (long = 216.9, medium-length = 216.8, short = 220.8 syllables/min), \( F(2,10) < 1.0 \).

Participant age was a grouping variable and message length was a repeated measure. Each participant heard a short, medium-length, and long health service appointment message (each message was for a different service). Counterbalancing ensured that all three length versions of each health service message were equally likely to occur across participants in each age group. The order of the message-length conditions was also counterbalanced across participants.

**Procedure.**—The session lasted about 2 hr. Participants performed the following tasks: (a) demographic questionnaire, (b) appointment-message tasks, (c) cognitive-ability tests (vocabi-
lary, sentence span, letter and pattern comparison), and (d) appointment-keeping practices questionnaire. Participants completed the cognitive tests and the questionnaires in between the appointment-message recall trials.

In the appointment-message task, participants were asked to listen to three messages and then, after each message, to tell the experimenter in their own words everything they could remember about the appointment. The messages were delivered over a telephone with adjustable volume control for the handset receiver (volume was adjusted for each participant). Participants picked up the telephone, which prompted the automated system to deliver the message. After hearing the message once, they could listen to it again (by pressing 1 on the telephone keypad) or continue to the next part of the study (by pressing 3). After listening to the message as many times as they wanted, they performed a 1-min letter-cancellation task and then recalled the appointment information. Then they answered questions about explicitly stated (verbatim) information in the message as well as inference questions that required combining different types of information from the message (see Appendix A for examples). Free recall and question answers (cued recall) were taped as inference questions that required combining different types of information from the message (see Appendix A for examples). Free recall and question answers (cued recall) were taped and later scored using a gist criterion (i.e., credit was given for correct paraphrases). Participants practiced the procedure by listening to and recalling a job-interview reminder message.

Results

We investigated age differences in repeating the appointment messages and whether repetition reduced the effect of age and message length on memory for the messages.

Message presentations.—Most participants listened to the appointment messages two or three times (see Table 2). We conducted an Age × Length mixed design analysis of variance (ANOVA) with length as a repeated measure on the mean number of presentations per participant. The number of message presentations did not significantly differ for older and younger participants (O = 2.5, Y = 2.3 mean presentations), F(1,88) = 2.0, p > .10, η² = .02, or for messages differing in length (short = 2.4, medium = 2.3, long = 2.4 mean presentations), F(2,176) < 1.0, η² = .01. To further examine who used optional repetition, we performed a hierarchical regression with the cognitive-ability measures (vocabulary, sentence span, speed) entered before age (a continuous variable) as predictors of the number of message presentations (also a continuous variable, see Table 3 for correlations among the variables). The regression model across all participants accounted for only 5% of the variance and was not significant, adjusted R², F(5,89) = 1.9, p = .10. Thus, both older and younger adults repeated messages, and there was no evidence that older adults repeated messages more times.

Message presentations, age, and recall.—In order to investigate whether repetition differentially benefitted older adults, we analyzed the joint effects of age and number of message presentations on memory for the messages in several ways. First, a presentation group variable was created from a median split of the mean number of message presentations per participant (O median = 2.3 presentations, Y median = 2.0 presentations). Participants in these high–low message presentation groups did not differ in education, health, or cognitive-ability scores. We analyzed the percentage of correctly recalled items by an Age × Presentation Group (above–below median) × Message Length mixed design ANOVA. Only the core set of items that occurred in all length conditions was analyzed. This “common item” analysis addressed the problem that new items were added to short messages in order to create longer messages. It allowed us to examine the effect of length independently of differences in content across messages (see Morrow et al., 1998). Younger adults recalled more information than older adults did (Y = 81%, O = 67% mean items correct), F(1,86) = 21.1, p < .001, η² = .20, and participants who repeated the messages more often recalled more information (77% vs 71%), F(1,86) = 4.3, p < .05, η² = .05. However, the Age × Presentation interaction was not significant, F(1,86) < 1.0. Message length was marginally significant (short = 77% correct items, medium = 72%, long = 72%), F(2,172) = 2.8, p < .07, η² = .03. The Age × Length interaction was not significant, F(2,172) = 1.2, p > .10.

Second, we examined whether the effect of age and message presentations on recall depended on individual differences in

<table>
<thead>
<tr>
<th>Age</th>
<th>One</th>
<th>Two</th>
<th>Three</th>
<th>&gt; Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older</td>
<td>7.3</td>
<td>48.0</td>
<td>34.7</td>
<td>9.7</td>
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<tr>
<td>Younger</td>
<td>11.0</td>
<td>60.0</td>
<td>21.3</td>
<td>7.7</td>
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</table>

Table 2. Percentage of One, Two, and Three or More Message Presentations, by Age (Experiment 1)

<table>
<thead>
<tr>
<th></th>
<th>Voc</th>
<th>Span</th>
<th>Speed</th>
<th>No. Pres</th>
<th>Rec</th>
<th>Rec Effic</th>
<th>Acc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.65***</td>
<td>-.62***</td>
<td>-.73***</td>
<td>.11</td>
<td>-.46***</td>
<td>-.42***</td>
<td>-.55***</td>
</tr>
<tr>
<td>Voc</td>
<td>-</td>
<td>-.28**</td>
<td>-.40***</td>
<td>.03</td>
<td>-.23*</td>
<td>-.18*</td>
<td>-.31***</td>
</tr>
<tr>
<td>Span</td>
<td>.61***</td>
<td>-</td>
<td></td>
<td>.13</td>
<td>.57***</td>
<td>.45***</td>
<td>.57***</td>
</tr>
<tr>
<td>Speed</td>
<td>-</td>
<td>.05</td>
<td>.51***</td>
<td>.26*</td>
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<td>.52***</td>
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<tr>
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<tr>
<td>Rec</td>
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<td>.46***</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>-</td>
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</tbody>
</table>

Table 3. Correlations Among Age, Vocabulary, Sentence Span, Processing-Speed Scores, Number of Message Presentations, Common Item Recall, Recall Efficiency, and Question Accuracy; Across all Participants (Experiment 1)

*Items recalled per message presentation.

*p < .05; **p < .01; ***p < .001.
cognitive ability by performing a hierarchical regression analysis with the cognitive measures (vocabulary, span, speed) entered first because they related to age (see Table 3), number of message presentations (a continuous variable) entered second, and age (a continuous variable) entered last. The cognitive measures accounted for 30% of the variability in free recall, adjusted $R^2$, $F(4,89) = 10.7$, $p < .001$. Higher span ($\beta = .33$, $p < .01$) and speed ($\beta = .30$, $p < .05$) scores predicted higher recall. Message presentations accounted for an additional 6% of the variability, $\beta = .24$, change $F(1,84) = 7.6$, $p < .01$. Age did not explain additional variability in recall, $\beta = -.13$, change $F(1,83) < 1.0$, which contrasts with the simple correlation between age and recall (see Table 3). The influence of age on recall appeared to be mediated by cognitive ability rather than message presentations: In a regression that included only number of message presentations and age as predictors of recall, the Beta for age was $-.44$ when age was entered first and $-.48$ when number of presentations was entered first. This finding converges with the ANOVA findings to suggest that age differences in message recall were not reduced by optional repetition.

Third, we investigated individual differences in recall while controlling for the number of message presentations by analyzing the percentage of items recalled per message presentation. The cognitive measures were entered before age in a hierarchical regression. These measures accounted for 17% of the variability in recall per presentation, adjusted $R^2$, $F(4,89) = 5.6$, $p < .01$, with higher span scores predicting higher recall ($\beta = .46$, $p < .01$). Age accounted for an additional 5% of the variability, $\beta = -.46$, change $F(1,84) = 6.8$, $p < .05$. Thus, greater working-memory capacity and younger age were associated with higher levels of recall per presentation.

**Question response accuracy.**—To investigate whether repetition reduced age differences in question accuracy, we analyzed percent correct answers by an Age X Presentation Group X Length X Question Type (verbatim or inference) ANOVA with the latter two factors repeated measures. Younger adults answered questions more accurately ($Y = 85\%$, $O = 65\%$ mean correct items), $F(1,84) = 29.1$, $p < .001$, $\eta^2 = .26$. Participants who repeated messages more times were also more accurate (80% vs 71%), $F(1,84) = 6.1$, $p < .05$, $\eta^2 = .07$. Accuracy did not decline with message length, $F(2,168) = 1.0$. Although the Age X Presentation interaction only approached significance, $F(1,84) = 2.9$, $p < .10$, $\eta^2 = .03$, we analyzed component effects (with unadjusted alpha levels) because of the theoretical importance of the interaction (Keppel, 1973). More message presentations tended to improve question accuracy for older participants (73% vs 57%), $t(43) = 2.7$, $p < .10$, but not for younger adults (87% vs 84%), $t(43) < 1.0$. The Question X Presentation interaction, $F(1,84) = 3.5$, $p < .10$, $\eta^2 = .04$, also approached significance. More presentations improved inference questions (83% vs 69%), $t(88) = 2.2$, $p < .05$, more than verbatim questions (77% vs 72%), $t(88) = 1.8$, $p < .10$.

**Discussion**

Older as well as younger adults took advantage of optional repetition, a routine feature of automated messaging systems. Both age groups repeated appointment messages, but older adults did not listen more times than younger adults did. Both groups also benefited from this strategy—number of message presentations predicted better memory for appointment information. There was also a trend for repetition to especially improve participants’ ability to answer inference questions about the messages (see Bromage & Mayer, 1986; Morrow et al., 1999, for similar findings).

There was, however, little evidence that repetition reduced age differences in memory for the appointment messages in the present study. The only evidence was a marginal Age X Presentation interaction for question accuracy, which may reflect a ceiling effect for younger adults. This interaction was also not replicated in Experiment 2. Optional repetition may not have reduced age differences in memory for appointment messages, because this type of repetition increases demands on self-initiated processing compared with imposed repetition, and self-initiated processing tends to decline with age (Craik & Jennings, 1992). We next examined whether age differences in memory for appointment messages would be reduced if older adults are provided additional forms of environmental support (cf. Bückman et al., 1990).

**Experiment 2**

We investigated the extent to which optional note-taking as well as repetition supports memory for appointment messages. Because older adults often report using external memory aids such as note-taking for everyday memory tasks (e.g., Burack & Lachman, 1996; Moscovitch, 1982), they may take notes to support comprehension of telephone messages. While participants in both experiments listened to messages as many times as they wanted, participants in Experiment 2 could also take notes while listening. Note-taking may improve memory for appointment information by providing an external storage aid. However, if this is the only benefit, taking notes would not improve recall in this experiment, because memory was tested without notes present. Taking notes may also improve memory for appointment information by focusing attention or helping listeners organize or elaborate information (Einstein, Morris, & Smith, 1985; Intons-Peterson & Fournier, 1986). Note-taking may also improve comprehension monitoring by providing feedback about what information in the message was missed during the first presentation. Note-taking reduces age differences in list recall whether or not participants are told to use notes to improve memory (Burack & Lachman, 1996). It also improves older adults’ memory for medication information (McGuire & Coddington, 1998). Note-taking and repetition strategies may cumulatively improve memory for appointment messages in our study, because both have been found to improve memory to the same extent for younger adults (Haenggi & Perfetti, 1992). Age differences in the present study should be reduced if older adults take greater advantage of both note-taking and repetition strategies to reduce demands of message comprehension on working memory. However, these strategies may increase rather than reduce overall processing demands, because listeners must decide whether to repeat the message and to take notes, and then coordinate the note-taking and listening activities (Einstein et al., 1985). In this case, higher ability listeners are more likely to benefit, because they more accurately monitor comprehension and listen to the message more times, take more elaborate notes, or both of these. Higher ability students have been found to take greater advantage of note-taking than lower ability students (Kiewra & Benton, 1988).
We varied message organization as well as length in Experiment 2 in order to examine the effect of message complexity on note-taking and repetition strategies as well as on message memory. The order of information in well-organized messages matched older and younger adults’ appointment schemas, while information order in poorly organized messages differed from the schematic order (Morrow et al., 1998). Well-organized and shorter messages may support note-taking or repetition strategies. If so, these message-presentation strategies may be more likely to reduce age differences in message memory for shorter, organized messages. Because note-taking reduces memory demands compared with the free-recall measure, we assumed that note-taking accuracy was more likely than recall to reflect comprehension. Thus, we investigated whether age and message complexity influenced comprehension as well as memory for appointment messages.

Method

Participants.—Forty-five older and 48 younger adults who did not take part in Experiment 1 participated in Experiment 2. We recruited older adults from communities in the New Hampshire Seacoast region, and younger adults were college students. Table 1 shows that older participants were more educated and had higher vocabulary scores but tended to score lower on measures of working memory and processing speed.

Messages and experimental design.—In addition to the messages for hypertension screen, diabetes screen, and flu vaccination that we used in Experiment 1, we used messages for a glaucoma screen, cholesterol check, and a dental checkup in Experiment 2 (all six messages were used in Morrow et al., 1998). Each participant listened to a message from each of six conditions created by orthogonally combining message organization (compatible or not compatible with listeners’ appointment schemas) and length (short, medium, or long). Each message was for a different health service. In the schema-compatible messages, items were presented in the preferred order identified in Morrow et al. (1998). In the noncompatible versions, each item was presented in a nonpreferred position. Items in the noncompatible messages were displaced by a mean of 2.4 positions from their position in the schema-compatible messages. We created compatible and noncompatible versions separately for short, medium, and long messages. Order of presentation of the messages was counterbalanced across participants.

Procedure.—The session lasted about 2.5 hr, including rest breaks. As in Experiment 1, participants performed the following tasks: (a) demographic questionnaire, (b) appointment-message tasks, (c) cognitive-ability tests (vocabulary, sentence span, letter and pattern comparison), and (d) appointment-keeping practices questionnaire. Participants completed the cognitive tests and questionnaires in between the appointment-message recall trials.

In the appointment-message task, participants listened to and then recalled six messages. Participants picked up a telephone handset, prompting the automated system to present the message. They were provided lined paper and told that they could take notes while listening to the messages but did not have to do so. They were not instructed in any note-taking strategies. After the message, they had 30 s to finish their notes and decide whether to listen to the message again (by pressing 1 on the keypad) or to continue (by pressing 3). All participants responded within this 30-s time period. After finishing the message, they performed a 1-min letter-cancellation task, rated how well they thought they would recall the message, recalled the message in their own words, and then answered verbatim and inference questions about the messages. Participants could not refer to their notes during the memory tests.

Results

As in Experiment 1 we first examined age differences in message-presentation strategies (optional note-taking as well as repetition). We also examined whether the use of these strategies varied with message organization and length. Next, we investigated whether note-taking and repetition reduced differences in message memory associated with age and message length.

Note-taking.—Most participants took notes (Y = 96%; O = 99% of messages), and these notes were fairly complete for both age groups (Y = 93%, O = 90% of the items in the messages were also in the notes, whether correct or not). We analyzed note-taking accuracy (percentage of message items correctly noted) by an Age × Message Organization × Length mixed design ANOVA, with the latter two variables repeated measures. Age differences in note accuracy were marginally significant, but the size of this effect was very small (Y = 93%, O = 89%), F(1,86) = 3.3, p < .10, η² = .04. Notes were more accurate for shorter messages (shorter = 92%, medium = 93%, long = 88%), F(1,86) = 16.9, p < .01, η² = .16, and for more organized messages (compatible = 92%, noncompatible = 90%), F(1,86) = 6.7, p < .05, η² = .07.

To further investigate individual differences in note accuracy, we performed a hierarchical regression with the cognitive-ability measures (span, processing speed, vocabulary) entered first, followed by message presentations, and then age (Table 4 presents correlations among message presentations, cognitive-ability measures, age, note accuracy, and recall). Cognitive ability accounted for 5% of the variability in note-taking accuracy (adjusted R²), F(3,86) = 2.7, p = .05. Higher scores on the processing-speed measure predicted higher accuracy (β = .26, p < .05). Number of message presentations predicted an additional 18% of variability, F(1,85) = 21.3, p < .001, β = .43. Age accounted for an additional 4% of the variance, F(1,84) = 5.0, p < .05, β = -.43. Thus, participants with higher processing-speed scores and those who repeated messages more often took more accurate notes.

To investigate whether note-taking was supported by message organization, we analyzed accuracy for core items (e.g., appointment time) and for noncore items (e.g., side effects of the treatment) in the long messages, which contained all items. The core items were judged as necessary for reminder messages in an earlier study (Morrow et al., 1998) and thus were considered the more essential information. We predicted that listeners would more likely take notes about core items and that this strategy would be supported by schema-compatible message organization because core items are presented together and earlier in the message for the schema-compatible messages than for the noncompatible messages. We analyzed note accuracy by an Age × Message Organization × Information Type (core vs noncore items) ANOVA, with the latter two variables repeated measures (see Table 5). Older adults’ notes were as ac-
Table 4. Correlations Among Age, Vocabulary, Sentence Span, Processing-Speed Scores, Number of Message Presentations, Note-Taking Accuracy, Common Item Recall, Recall Efficiency, and Question Accuracy; Across All Participants (Experiment 2)

<table>
<thead>
<tr>
<th>Age</th>
<th>Span</th>
<th>Speed</th>
<th>No. Pres</th>
<th>Notes</th>
<th>Recall</th>
<th>Rec Effic</th>
<th>Acc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voc</td>
<td>.84***</td>
<td>.19**</td>
<td>-.57***</td>
<td>.01</td>
<td>-.22*</td>
<td>-.37***</td>
<td>-.34*</td>
</tr>
<tr>
<td>Vnc</td>
<td>—</td>
<td>.01</td>
<td>-.47***</td>
<td>.03</td>
<td>-.02</td>
<td>-.26***</td>
<td>-.09</td>
</tr>
<tr>
<td>Span</td>
<td>—</td>
<td>.18**</td>
<td>—</td>
<td>.08</td>
<td>.15</td>
<td>.35**</td>
<td>.21*</td>
</tr>
<tr>
<td>Speed</td>
<td>—</td>
<td>—</td>
<td>-.03</td>
<td>—</td>
<td>.27*</td>
<td>.24*</td>
<td>.19***</td>
</tr>
<tr>
<td>No. Pres</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>.46***</td>
<td>.36***</td>
<td>—</td>
<td>-.69***</td>
</tr>
<tr>
<td>Rec</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>.35**</td>
<td>—</td>
<td>.78***</td>
</tr>
</tbody>
</table>

Note. Voc = vocabulary; Span = sentence span; Pres = presentations; Rec = common item recall; Rec Effic = recall efficiency; Acc = question accuracy.

Table 5. Percent of Correct Core and Noncore Items in Notes, by Message Organization and Age (Long Messages Only)

<table>
<thead>
<tr>
<th>Message Organization</th>
<th>Core</th>
<th>Noncore</th>
<th>Mean</th>
<th>Core</th>
<th>Noncore</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older</td>
<td>92</td>
<td>67</td>
<td>80</td>
<td>84</td>
<td>70</td>
<td>77</td>
</tr>
<tr>
<td>Younger</td>
<td>92</td>
<td>73</td>
<td>83</td>
<td>91</td>
<td>85</td>
<td>88</td>
</tr>
</tbody>
</table>

Message presentations.—Participants usually listened to the messages two times (see Table 6). We analyzed mean number of presentations per participant by an Age X Message Organization X Length mixed design ANOVA, with the latter two variables repeated measures. Participants listened fewer times to the shorter messages, F(2,180) = 7.3, p < .01, η² = .08, and to the more organized messages, F(1,90) = 12.1, p < .01, η² = .12 (see Figure 1). While there was no overall age difference, older adults, t(44) = 3.8, p < .01, but not younger adults, t(47) < 1.0, listened to the less organized messages more times, Age X Organization, F(1,90) = 6.0, p < .05, η² = .06. This suggests that older participants were sensitive to comprehension demands to some extent.

Table 6. Percentage of One, Two, and Three or More Message Presentations, by Age (Experiment 2)

<table>
<thead>
<tr>
<th>Age</th>
<th>One</th>
<th>Two</th>
<th>Three</th>
<th>&gt; Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older</td>
<td>28.1</td>
<td>60.0</td>
<td>11.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Younger</td>
<td>28.2</td>
<td>64.5</td>
<td>5.6</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Message presentations, note-taking accuracy, age, and recall.—The effect of the optional repetition and note-taking strategies on age differences in recall were examined in several ways, but we found no evidence that these strategies reduced age differences. First, as in Experiment 1, a presentation group variable was created from a median split of the mean number of message presentations per participant (median = 1.8 presentations for both age groups). Participants in the high–low presentation groups did not differ in education, health, or cognitive ability scores. We analyzed percent recall by an Age X Presentation Group X Message Organization X Message Length ANOVA, with the latter two factors as repeated measures. Recall was higher for younger participants (Y = 69%, O = 60% items correct), F(1,89) = 12.9, p < .001, η² = .13, and for participants who repeated messages more times (more presentations = 70%, fewer presentations = 60% items correct), F(1,89) = 13.7, p < .001, η² = .13. The Age X Presentation interaction was not significant (F < 1.0). Recall was also higher for organized messages (schema-compatible = 66%, noncompatible = 63%), F(1,89) = 5.4, p < .05, η² = .06, and for shorter messages (short = 67%, medium = 66%, long = 61%), linear trend, F(1,89) = 10.5, p < .01, η² = .11. Age differences in recall partly reflected the fact that younger adults recalled more information than older adults did from their notes (74% vs 65% of items in notes were recalled). In addition, message organiza-
tion and length effects on recall were not significant when note accuracy was controlled in an ANCOVA, suggesting that the influence of these message characteristics on recall was mediated by comprehension (as measured by note accuracy).

We also examined whether note-taking reduced age differences in recall by creating a note-accuracy group variable from a median split of mean note accuracy per participant (older median = 91%, younger median = 95%). Participants in the high-low note-accuracy groups did not differ in education, health, or cognitive ability scores. We analyzed percent recall by an Age × Note-Taking Accuracy × Message Organization × Length ANOVA, with the latter two factors as repeated measures. While participants who took more accurate notes also recalled the messages more accurately (68% vs 61% items correct), $F(1,89) = 8.5$, $p < .05$, $\eta^2 = .07$, the Age × Note Accuracy interaction was not significant ($F < 1.0$).

We examined whether number of message presentations reduced age differences in question accuracy as well as recall. Unlike Experiment 1, the Age × Presentation Group interaction did not approach significance ($F < 1.0$). The same was true in an analysis with age and high-low note-taking accuracy.

To examine recall while controlling for the number of message presentations, we analyzed the effect of age and message factors on the number of items recalled per presentation. Recall per presentation was higher for younger adults ($\bar{Y} = .42, \bar{O} = .36$ items per presentation), $F(1,90) = 5.5$, $p < .05$, $\eta^2 = .06$; more organized messages (compatible = .42, noncompatible = .37 items per presentation), $F(1,90) = 16.4$, $p < .001$, $\eta^2 = .15$; and shorter messages (short = .44; medium = .38, long = .35 items per presentation), linear trend $F(1,90) = 20.4$, $p < .001$, $\eta^2 = .18$.

Finally, a hierarchical regression analysis examined the effect of cognitive ability, number of message presentations, note accuracy, and age on recall, with presentations and note accuracy entered as a block after the cognitive-ability variables. Table 4 presents the correlations among these variables. Cognitive ability accounted for 16% of the variability in recall (adjusted $R^2$), $F(3,89) = 6.5$, $p < .01$. Higher scores on the sentence span measure predicted better recall ($\beta = .35$, $p < .01$). The message-presentation strategy variables explained an additional 13% of variability, $F(2,84) = 8.8$, $p < .001$. More message presentations ($\beta = .22, p < .05$) and more accurate notes ($\beta = .23, p < .05$) predicted better recall. Age accounted for an additional 2% of the variance, $F(1,83) = 4.2$, $p < .05$, $\beta = -.43$. Thus, participants who scored higher on the working-memory measure, who were younger, and who repeated messages and took more accurate notes tended to recall the messages more accurately.

**Metacognitive ability and recall.**—Because the use of repetition and note-taking may depend on metacognitive processes such as comprehension monitoring, we examined the accuracy of predicting message recall, a common measure of metacognitive ability. To do this, we correlated each participant’s predicted recall ratings with their actual recall for the six messages. Older and younger adults’ mean predicted accuracy did not significantly differ, older mean $r = .24$, $p < .05$, younger mean $r = .31$, $p < .05$, $r(91) < 1.0$. A hierarchical regression analysis that entered cognitive ability before age as predictors found that only sentence span scores explained a significant amount of variability in these recall prediction scores, $R^2 = .07$, $F(1,85) = 6.6$, $p < .05$. The fact that the age difference in accuracy of predicted recall was not significant suggests that the older participants monitored message comprehension and memory as accurately as younger participants did. We did not find that the accuracy of predicted recall was related to the number of times people listened to the messages or to recall per presentation.

**DISCUSSION**

Older and younger adults tended to take complete and accurate notes. Assuming that note accuracy reflects message comprehension under conditions of minimal memory load (compared with free recall), this finding suggests that age differences are minimal for comprehension of complex messages, at least when memory load is light (also see Light & Albertson, 1988). Note-taking accuracy was predicted by a measure of processing speed, conferring an advantage on younger adults, who tended to score higher on the speed measure. At the same time, accuracy was predicted by number of message presentations, which may explain the minimal age difference in accuracy, because older adults repeated the less organized messages more times. Older adults also tended to focus on more important information when taking notes, and this strategy was supported by message organization.

As in earlier studies (e.g., Burack & Lachman, 1996; Einstein et al., 1985), note-taking improved recall. Even though older adults took accurate notes and repeated the less organized messages more times, age differences in memory for the messages were not reduced. Older adults may not have taken greater advantage of repetition and note-taking because of age differences in self-initiated or metacognitive processes. We take up this issue in the General Discussion.

Schema-compatible and shorter messages were better recalled than less organized and longer messages (also see Morrow et al., 1995; Morrow et al., 1998), even though these messages were listened to fewer times than the more difficult messages in the present experiment. Thus, well-organized and shorter messages supported more efficient memory for appointment information. These benefits appeared to reflect comprehension (as measured by note-taking accuracy), because message differences in recall were eliminated when note-taking accuracy was statistically controlled. Comprehension of schema-compatible and shorter messages may impose fewer demands on working memory, because less information must be stored and processed during comprehension. Therefore, there is less need for message repetition.

**GENERAL DISCUSSION**

We examined three issues related to message-presentation strategies that older and younger adults use to understand and remember health appointment information: (a) Do older adults as well as younger adults repeat and take notes from appointment messages? (b) Do these strategies improve memory for appointment information, possibly reducing age differences? and (c) Do these strategies counter the effects of longer messages on memory? Investigating these issues also has implications for older adults’ use of communication technology and for explaining the influence of environmental support on age differences in memory for health information.

**Age Differences in Use of Presentation Strategies in Automated Messaging**

Older as well as younger adults in both experiments repeated messages when given the option, although older adults did not
appear to do so more than younger adults did. Both older and younger adults in Experiment 2 also took complete and accurate notes from messages. Thus, older adults are at least as likely as younger adults to repeat messages and to take notes when interacting with automated telephone messaging systems.

**Age Differences in Benefiting From Message Presentation Strategies**

Older and younger adults’ memory for appointment information was improved by both message repetition and note-taking. Clearly, older as well as younger adults took advantage of message-presentation strategies related to automated messaging systems in health care.

Optional repetition and note-taking did not, however, reduce age differences in remembering appointment information. Although the analysis of note accuracy in Experiment 2 suggested that older adults focused on the most important or core information from the messages, the common item analysis of recall showed that age differences occurred even for the core information, despite the support provided by repetition and note-taking. The finding that optional message-presentation strategies did not reduce age differences contrasts with Morrow et al. (1999), where imposed repetition reduced age differences in memory for appointment messages when retrieval support was provided. This suggests that older adults may not take full advantage of everyday message-comprehension strategies that are presented as optional. Thus, it may be important to identify factors that help older adults take advantage of message-comprehension strategies.

The use of optional presentation strategies may increase demands on self-initiated processing for older adults. For example, taking advantage of repetition requires monitoring and evaluating comprehension during the first message presentation, deciding whether to repeat the message, and then engaging in additional processing of the repeated message. Thus, optional repetition increases the difficulty of the decision component compared with imposed repetition. Listeners must also perform an action to repeat the message (e.g., press a key on the telephone keypad). Older adults may have particular difficulty with optional repetition because of age declines in self-initiated processing (Craik & Jennings, 1992). They may be more likely to benefit from repetition that imposes fewer demands on self-initiated processing. For example, repetition could be the default strategy in an automated messaging system, so that listeners act only not to repeat messages. Age differences may also be reduced if older adults are explicitly told to use presentation strategies, so that listeners do not need to decide whether to use them. Burack and Lachman (1996) found that note-taking reduced age differences in list recall, while Rabinowits (1989) found that age differences in list recall actually increased when participants had the option to self-pace, take notes, or use other strategies. Burack and Lachman (1996) suggested that older adults may particularly benefit when explicitly told to use notes. Similarly, Murphy, Schmitt, Caruso, and Sanders (1987) found that older adults were more likely to benefit from study time when required to study as long as younger adults did, compared with when study time was self-paced.

Older adults may also be less likely than younger adults to take full advantage of optional strategies because of age differences in metacognitive processes. Older adults may have difficulty monitoring comprehension, so that they are less likely to realize that they could improve comprehension by repetition. However, the fact that older adults were more likely than younger adults to repeat the less organized messages in Experiment 2 suggests that they were sensitive to comprehension demands at least to some extent. The absence of significant age differences in the accuracy of predicted recall (Experiment 2) also suggests that older adults monitored comprehension and memory as well as younger adults did (also see Zabrucky et al., 1987). It is possible that older adults monitored comprehension as well as younger adults did but were less able to coordinate this monitoring with the additional processing needed to improve memory during message review (Dunlosky & Connor, 1997).

**Message Presentation Strategies and Message Length**

Repetition and note-taking did not mitigate the effect of message length on recall (also see Morrow et al., 1999). This was the case even though participants tended to listen to the longer messages more times in Experiment 2. Both the present study and our earlier studies (Morrow et al., 1998; 1999) also show that memory for the most important information declines as more information is added to the message. Thus, there may be a cost to adding information to automated messages that is not mitigated by repetition.

**Implications for Automated Telephone Messaging**

Our findings suggest that message repetition and note-taking can enhance the potential of automated telephone systems to inform and remind older adults about their health services. Our findings also show the value of using brief, well-organized messages for automated systems. Such messages reduce the need for repetition and support older adults’ note-taking.

It is important to note that older adults in Experiment 2 did take complete and accurate notes about the appointments, especially for the core information. Because older adults often use external aids for prospective memory tasks such as attending appointments (e.g., Moscovitch, 1982), our findings suggest that they could use such notes as a reminder for actual appointments, thus bypassing age-related memory problems. To the extent that this is true, our procedure of testing memory without notes underestimated benefits of automated messaging for older adults in the real world. Nonetheless, it is probably also true that people do not always use their notes to remember to attend
appointments. Therefore, it is important to identify message and strategy factors that help improve comprehension and memory for appointment information. This will help older adults create a situation model of the appointment-keeping task that guides later adherence behavior.

A Collaborative Approach to Automated Communication
Successful communication, whether face to face or automated, requires collaboration between speakers and listeners. In both cases, speakers must deliver messages that will be understood by listeners based on shared knowledge, and speakers and listeners must monitor communication to ensure that the messages are mutually understood (Clark & Schaefer, 1989). For example, patients' memory for medical information improves when they are taught to ask questions during their consultations with physicians, perhaps because they are better able to monitor their level of comprehension and to clarify communication (Robinson & Whitfield, 1985; also see Morrow, 1997). The fact that older adults in our study took advantage of optional repetition as much as younger adults did suggests that they can participate as collaborative partners in automated as well as face-to-face communication. They provided feedback by appropriately responding to system prompts, so that message presentation could be tailored to their needs. This suggests that older listeners might benefit from more elaborate options in automated systems that could tailor message content and organization to their specific abilities and interests (see Piette, 1997). Automated health communication may sometimes be even more effective than face-to-face communication. For example, health professionals sometimes limit the amount of health information provided to older patients, because they assume the older patients have limited cognitive ability or interest (e.g., Greene, Adelman, Charon, & Hoffman, 1986). Automated communication provides the opportunity for older patients to determine the amount and type of information that they want to hear, at least if the automated system is easy to use. Facilitating older patients' use of optional features in automated communication systems may help them become more effective partners in their health care. More generally, our findings suggest that older adults can more fully participate in health communication (whether automated or face-to-face) when they are better able to evaluate and clarify their comprehension of health information.

Aging, Environmental Support, and Memory for Health Information
Both experiments provided evidence that age differences in memory for appointment messages reflected age differences in cognitive abilities, primarily working-memory capacity. This finding is consistent with other research on aging and memory for spoken text (Stine & Wingfield, 1990) and printed text (Hartley, 1993). However, even with cognitive ability and strategy use controlled, age still accounted for some variance in recall per message presentation (Experiment 1) and in overall recall (Experiment 2). Other age-related factors associated with recall may include different decisions about which information was most relevant and important to recall. For example, older adults were less likely to take notes about less important information in Experiment 2. Our findings also address the issue of whether environmental support is likely to compensate for age-related reductions in cognitive resources, so that differences between ability groups would be reduced (e.g., Bäckman et al., 1990; Craik & Jennings, 1992). Imposed repetition can reduce the effect of cognitive ability differences on memory, suggesting that lower ability people differentially benefit from external support in the form of repetition (Morrow et al., 1999). Such repetition also improves memory for older adults with Alzheimer's disease (Small et al., 1997). Optional repetition and note-taking, on the other hand, did not reduce the relationship between cognitive ability and memory in the present study. Indeed, older and younger participants with higher processing speed scores were more likely to take accurate notes in Experiment 2. Higher ability listeners may monitor comprehension more accurately so that they are more attuned to benefits of repetition. Similarly, Zabrucky and Moore (1994) found that older and younger participants who scored higher on a processing-efficiency measure were also more likely to reread passages (a measure of comprehension monitoring and regulation). More generally, forms of environmental support that require cognitive resources may be more likely to enhance high-ability groups (see Waddill & McDaniel, 1992, for a similar argument about illustrations in text). On the other hand, environmental support that eliminates the need for certain processes, for example by providing retrieval cues (Craik & Jennings, 1992) or by promoting knowledge-based processing (Bäckman et al., 1990), tends to differentially benefit lower ability groups. The challenge is to design communication systems that reduce demands on lower ability adults while affording opportunities for more capable adults.

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Appendix I

Sample questions about the messages:

Verbatim: Where was the appointment?

Inference: Do you need to record your diet on October 2-4 or October 4-6? (requires combining appointment date and preappointment procedure).

This is a prerecorded message for Terry Smith. You have an appointment with the Seacoast Clinic.

Your appointment is scheduled for October 4 at 3:00 p.m.

The purpose of the appointment is to have your blood cholesterol level checked.

The Seacoast Clinic is located at Lyndon Hospital, 391 Brookstone Ave., on the second floor of the hospital.

It is important to have your blood cholesterol level checked on a regular basis as untreated high blood cholesterol can lead to hardening of your arteries, heart disease, and eventually death.

Please remember to keep a record of your diet 2 days before the appointment and bring this record with you.

You may experience mild weakness immediately after the appointment.

Please call Sue at 555-6365 if you have any questions.

Appendix I

Example of Long Appointment Message and Verbatim and Inference Questions About the Message

[patient name] This is a prerecorded message for Terry Smith. You have an appointment with the Seacoast Clinic.

[clinic name]

[time] Your appointment is scheduled for October 4 at 3:00 p.m.

[purpose] The purpose of the appointment is to have your blood cholesterol level checked.

[location] The Seacoast Clinic is located at Lyndon Hospital, 391 Brookstone Ave., on the second floor of the hospital.

[motivator] It is important to have your blood cholesterol level checked on a regular basis as untreated high blood cholesterol can lead to hardening of your arteries, heart disease, and eventually death.

[preappointment procedure] Please remember to keep a record of your diet 2 days before the appointment and bring this record with you.

[sider effects] You may experience mild weakness immediately after the appointment.

[whom to call] Please call Sue at 555-6365 if you have any questions.