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Age and the Availability of Inferences

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Age differences in inference availability and memory were investigated using a speeded decision procedure and cued recall. Younger and older adults read passages that directly suggested either a target inference or an incorrect, competing inference before finally supporting the target inference. At critical points in a passage, subjects judged whether each of a series of words, including either the target or competing inference, was consistent with their current interpretation. Although both groups agreed on the final target inference, younger and older adults showed different patterns of inference availability and revision. Older adults showed broader and more sustained activation of alternative interpretations and also showed lower levels of inference recall. These findings are interpretable by a framework that proposes age-related breakdowns in inhibitory mechanisms that control the contents of working memory (Hasher & Zacks, 1988).

Comprehension of a passage requires the integration of content explicit in the text with relevant prior knowledge for the listener or reader to generate a coherent understanding of that text (e.g., Just & Carpenter, 1987). One measure of understanding is the availability of particular inferences or interpretations. Inferences, as markers of comprehension, have been the focus of considerable research in cognitive gerontology with a set of findings that suggest that under certain circumstances the interpretive processes of older adults may be the same as those of younger adults (e.g., Belmore, 1981; Burke & Yee, 1984), whereas under others, they may well be different (e.g., Cohen, 1979, 1981; Light, Zelinski, & Moore, 1982; see also Light, 1991).

One account for this mixed pattern of findings is based on the suggestion that working memory capacity declines with age (e.g., Hasher & Zacks, 1988; Light & Anderson, 1985). According to this view, age-related performance difficulties will be seen whenever tasks are arranged such that demands on working memory capacity are high. This is because high levels of demand on capacity will limit the ability to process incoming information while simultaneously maintaining, retrieving, and/or operating on other relevant information (Daneman & Carpenter, 1980, 1983).

A number of findings are broadly consistent with such a view. For example, large amounts of intervening text (Light & Capps, 1986), the use of spoken versus written presentation formats, and the use of rapid presentation rates (Cohen, 1979, 1981; Stine, Wingfield, & Poon, 1986; Zacks & Hasher, 1988; Zacks, Hasher, Doren, Hamm, & Attig, 1987) all differentially disrupt aspects of the language performance of elderly adults. All three manipulations may serve to overburden both the maintenance and processing functions of the reduced working memory capacity of elderly adults.

Recent work on inference recall by Zacks and her colleagues (Zacks & Hasher, 1988; Zacks et al., 1987) is also broadly consistent with the view that age differences in working memory capacity may limit comprehension. For example, in one study (Zacks et al., 1987), no age differences were found when the text supported an interpretation consistent with general knowledge (e.g., that a hunter on a photographic safari would be taking a shot with a camera). However, when the text initially misled readers (e.g., to believe that the safari hunter would be taking a shot with a gun), older adults were relatively impaired in their recall of the final, correct interpretation (a camera). Presumably, working memory limitations made it difficult for older adults to simultaneously retrieve the passage's relevant antecedent information, use their general knowledge, and also maintain current information in order to reconcile the discrepancies among facts in the misleading version and to arrive at the most appropriate interpretation (see also Light & Capps, 1986).

However, this conclusion is based on measures of inference accessibility (probed recall) taken only after the presentation of a series of passages. In the present work, a concurrent measure of interpretation is taken. Our goal was to learn what inferences subjects hold or accept closer to the time at which comprehension is thought to occur.

To measure concurrent interpretations, we studied subjects' speeded acceptance or rejection of inferences that were centrally important to a full comprehension of a passage. As well,

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these passages differed in their presumed ease (tied to limitations of capacity) of comprehension. Each core passage has two versions: In the expected version, a target interpretation is strongly supported by the text; in the unexpected version, readers are initially misled into forming an incorrect interpretation before they receive information that supports the final, target interpretation. Readers' interpretations were tested either near a midpoint or at the end of each passage using a variant of a speeded decision task (e.g., McKoon & Ratcliff, 1980), acceptance of inference terms. Subjects were to respond yes or no to each word on the basis of whether or not it was either consistent with their *current* understanding or interpretation of the passage or had actually appeared in the passage. The critical test word was first in the series and was either the "target" (e.g., camera) or the "competing" (e.g., gun) inference term. Responses to these inference words in the midst of the reading task, along with their subsequent recall, constitute the central measures of the study.[1]

Three empirical questions were addressed: (a) What are readers' inferences at critical passage points; (b) Are there any age differences in these inferences; and (c) How are different patterns of interpretation during reading related to subsequent inference recall?

As will be seen, interesting age differences were found that contradict the view that older adults have difficulty forming inferences when working memory demands are high. In particular, the present findings suggest that older adults actually form interpretations with ease. In doing so, they may consider more interpretations than younger adults. Indeed, older adults may have enriched working memories relative to younger adults, a view not particularly consistent with the idea of an age-related decline in working memory capacity. As well, older adults have greater difficulty in abandoning an interpretation even when it is no longer contextually appropriate. In the discussion, we integrate the present findings with an emerging theory of attention that may account for the obtained age differences in the contents of working memory and the attendant consequences of those age differences, including differential forgetting.

Method

Design

Younger and older adults read a series of passages in which the final inference was either expected or unexpected. For each passage, a speeded decision task occurred either approximately midway through the reading of a passage or immediately at its end. Crossed with these factors was the nature of the first item on the judgment test. This critical word was either the final target inference (e.g., camera), or it was the competing inference (e.g., gun; the interpretation that the unexpected version was designed to initially and misleadingly suggest). Thus the experiment was a 2 (ages: younger vs. older adults) × 2 (passage versions: expected vs. unexpected) × 2 (test positions: midway vs. end) × 2 (inference words: target vs. competing) mixed design. The last three factors were within subjects. This design was applied to the nature of the response to inference and other terms on the speeded decision task and to answers to the probe recall inference questions. Analyses of reading speed included an additional factor, Passage Part (first vs. second), which refers to the segments that precede and follow, respectively, the midpassage test position.

Subjects

Twenty-four young adults (mean age = 21.3, range = 18–31 years) and 24 older adults (mean age = 70.1, range = 62–75 years) participated in the main study. The young adults were undergraduate students enrolled in an introductory psychology course who received course credit for their participation. The older adults were active members of the community recruited from local senior citizen organizations. All subjects reported themselves to be in fair to good health. Four subjects in each age group were replaced because their scores on the Wechsler Adult Intelligence Scale—Revised (WAIS–R) Vocabulary subtest were below 30, a criterion adopted to keep the present sample approximately equivalent in verbal ability to the groups used by Zacks and Hasher (1988). The mean vocabulary scores for younger and older adults (43.25 and 42.25, respectively) did not differ and were in fact similar to those reported by Zacks and Hasher (1988).

Materials

Twenty-four short passages were used in this experiment (see Table 1 for an example). Twelve of the 24 were taken from Zacks et al. (1987), and 12 new passages were written. Each passage consisted of a title and a description of a concrete scene or event (e.g., a father and son on a camping trip, a dance marathon, a visit to the circus) and was prepared in both an expected and an unexpected version. Each passage implied a focal, target inference that was central to its understanding. In the expected version, the target interpretation is supported by the context of the passage. However, in the unexpected version there is little initial support in the text for the target inference and instead, readers may first be misled into drawing an incorrect interpretation (the competing inference). Later in the passage, conflicting information occurs that requires reinterpretation of the passage in favor of the final, target interpretation. This process is thought to require the retrieval and reevaluation of earlier parts of the passage (O'Brien & Myers, 1985).

Slight modifications were made to some of the original Zacks et al. (1987) passages. Several of the titles were changed to reduce the likelihood that the titles themselves would influence inference availability. As well, several of the passages were lengthened by one or two sentences to increase the number of nouns available for the speeded judgment task.

The 12 new passages were pretested to ensure that under optimal conditions they are comprehended equally by younger and older adults. This procedure was based on that used by Zacks et al. (1987) to validate their original materials. Twenty young adults (mean age = 19.3 years) and 17 older adults (mean age = 67.1 years) were selected from the same sources as those used in the experiment proper. Each participant read the 12 new passages (6 in the expected version and 6 in the unexpected version) at their own pace. Each passage was presented on two consecutive pages. The first page contained the part of the passage just prior to the disconfirming information in the unexpected version. After reading the first part, subjects answered the inference question for that passage (see Table 1 for an example). The second page contained the passage in its entirety. After reading the second page, subjects again answered the inference question. Subjects were always able to refer to the passage on a given page while answering the inference question. Using this procedure, the levels of understanding shown by

[1] Our goal in using a speeded decision task was to come close to a measure of comprehension during reading. The issue of when the interpretation is made (before the decision probe, coincident with it, or in response to it) is not crucial to our concerns; we are interested in determining how the passages are interpreted at critical points during self-paced reading.

Table 1
Sample Passage, Inference Words, and Inference Question

Carol's trip: Expected version

Carol was not feeling well and decided to find out what was wrong. Carol went into town and entered the large building hoping to find some books relevant to her problem. She walked through the doors and took an elevator to the third floor. (Midtest)

She found a book that seemed relevant to her problem. Carol then went to the main desk and checked out the book for two weeks so that she could read it carefully at home. When she left the building she saw that it had started snowing hard and she hailed a taxi to take her home. (Endtest)

Carol's trip: Unexpected version

Carol was not feeling well and decided to find out what was wrong. She called her friend who was a nurse to ask her for some advice. The friend told Carol what to do. Carol went into town and apprehensively entered the large building hoping to find an answer. She walked through the doors and took an elevator to the third floor. (Midtest)

She found a book that seemed relevant to her problem. Carol then went to the main desk and checked out the book for two weeks so that she could read it at home. When she left the building she saw that it had started snowing hard and she hailed a taxi to take her home. (Endtest)

Inference Question: In what kind of building did Carol use the elevator?
Target inference: Library
Competing inference: Hospital

younger and older adults were found to be equivalent to each other and comparable with those reported for the original set of 12 passages.

For present purposes, each of the 24 passages was divided into midtest and end-test positions. For both the expected and unexpected versions of the passages, the midtest position corresponded to the point preceding the first piece of contradictory information that occurred in the unexpected version. The end-test position was the end of the passage (see Table 1). The combination of two passage versions (expected vs. unexpected), two test positions (middle vs. end of paragraph), and two inference words (target vs. competing) created eight conditions, each of which was represented by three passages for a given subject. Passages were counterbalanced across subjects such that each was presented in each condition approximately equally as often within the age groups.[2]

For each passage, 15 test words (2 critical and 13 control words) were selected to serve on the speeded judgment task. The critical word never actually appeared in the passages and was either the competing or target inference. Of the 13 control words, 6 were from the passage and 7 were new. The passage words were content items that were mostly concrete nouns. The new words were highly frequent, concrete nouns (Paivio, Yuille, & Madigan, 1968) and were unrelated to the contents of any of the passages. Control words were then randomly assigned to all but the first position in a test sequence. At the midparagraph test position, 10 test words were presented beginning with either the target or competing inference word, followed by 9 other words, 4 of which were from the passage and 5 of which were new. At the end-of-paragraph test position, 14 test words were presented, including the critical word, 6 old words (the 4 used for the middle test position plus 2 words from the second part of the passage), and 7 new words (the 5 used for the middle test position plus 2 others). The lengthy judgment list was included to obscure our central interest in the judgment made to the critical inference words. Finally, an inference question was written for each passage (see Table 1). It was designed to test inference recall under circumstances comparable with those used in earlier work (Zacks & Hasher, 1988; Zacks et al., 1987).

Procedure

Subjects were tested individually beginning with a series of demographic and health questions that were followed by the WAIS–R Vocabulary subtest. Four subsets of the experimental materials were presented on an Apple IIe microcomputer. Each subset consisted of the self-paced reading of a series of six paragraphs, each of which included a speeded judgment task on a series of 10 or 14 words (as appropriate for the middle vs. end-paragraph test position). This was followed by six inference questions, one per paragraph, asked in the order in which the original paragraphs had been read. Across subjects, there were two different random orders of paragraph presentation.

Participants read paragraphs by pacing themselves through each of two segments of a passage, using the space bar on the keyboard to advance from one passage segment to the next. The first segment of each paragraph included its title. Reading time for each portion of the paragraph was recorded. At either the midtest or end-test position, a space-bar press caused the text to disappear. It was replaced with a series of words that appeared one at a time on the screen, again at a self-determined pace. Subjects had to decide as quickly as possible whether or not each word was consistent with their current interpretation of the passage. Instructions informed them that some words had appeared in the passage. For these words, *yes* would be the appropriate response (indicated by pressing the *slash* (/) key that was marked with a large *Y*) because these words were consistent with the passage's meaning. Other words might also receive a *yes* response if they were judged to be consistent with the subject's interpretation of the passage. All other words should be responded to with a *no* (indicated by pressing the *?* key, which was marked with a large *N*). Response times were recorded although not analyzed because there were too few items (3) in each critical condition to provide stable reaction-time data. After the speeded judgment task, subjects were given prompts on the screen to press the space bar to move on to the second part of the passage, to begin a new passage, or to begin the inference test, as appropriate for their position in the sequence of events. Participants were prompted with a message on the screen when a new passage was to begin.

After every six passages, subjects were asked the inference question for each of the preceding passages. A single question with its appropriate passage title appeared on the screen and subjects answered aloud, with the experimenter recording the answer.

The experiment proper was preceded by a practice sequence that consisted of two paragraphs not used in the experiment itself. The practice included only reading and familiarization with the apparatus.

Results

Responses to Inference Terms

Yes responses indicate that subjects agree that a particular word was consistent with their current interpretation of the passage, that is, that the word is related to their current understanding of the passage or was from the passage itself. The

[2] Because of an error in the selection of the experimental conditions for older adults, one condition was assigned once too often, creating a situation in which a set of combinations of passages was used an extra time (i.e., given to 4 subjects rather than 3), and another was used one less time than intended (i.e., given to 2 subjects). No conclusions are changed by this error because the aging effects we report are representative of all sets of materials.

analysis of *yes* responses to target and competing inference terms is central to two critical questions: (a) What inferences do subjects hold at different points in the expected and unexpected passages; and (b) Are there any age differences in the inferences that are held?

To examine the effect experimental materials and manipulations had on subjects' *yes* responses to the critical inference terms, two separate Age × Passage Version × Test Position analyses were done on responses to the target and competing inference terms. This analysis plan was followed because the larger four-way interaction was close to significance and because of the striking pattern of data that is thus shown. As well, the items subjects are judging, target and competing inference terms, are actually unique sets of words that cannot be counterbalanced because of the construction of the passages. The data for the target inference term are straightforward and is discussed first (see Figure 1). As is apparent from Figure 1, younger and older subjects responded nearly identically to these words across the range of materials. There was no main effect of age here, nor did age interact with any other variable, largest $F(1, 46) < 1$. The remaining effects for the target inference are all consistent with the intended materials manipulations. Overall, more *yes* responses were made in the expected passage version (80%) than in the unexpected version (58%), $F(1, 46) = 50.94$, $p < .01$. Also, more *yes* responses were made at the end of the passage (90%) than at the middle of the passage (48%), $F(1, 46) = 210.99$, $p < .01$.

The only significant interaction was for Passage Version × Test Position, $F(1, 46) = 36.38$, $p < .01$. This interaction stemmed from the substantially greater increase in *yes* responses from the mid- to the end-of-passage test position for the unexpected than for the expected paragraphs. This finding is, of course, entirely consistent with the experimental manipulations. At the midtest position, subjects accepted the target inference of expected passages as consistent with their understanding of those passages about two thirds of the time. Their acceptance of this inference increased substantially by the end of the passage. By contrast, at the midpoint of the unexpected versions, subjects showed little tendency to accept the target inference, agreeing approximately one fourth of the time. By the end of both expected and unexpected passages, the target inference was judged to be fully consistent with subjects' interpretations.

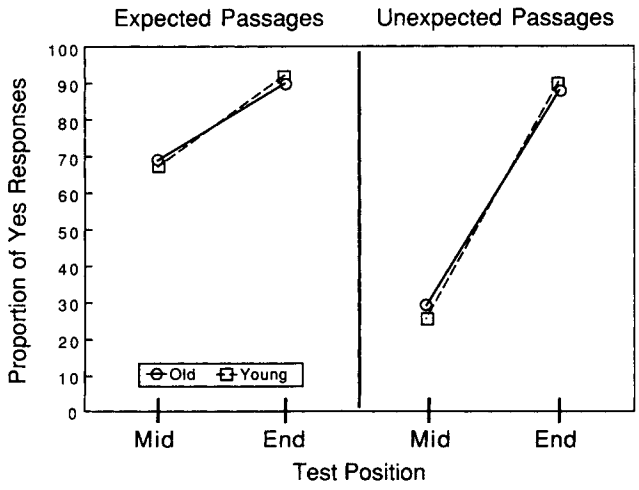

Figure 1. Mean proportion of *yes* responses made to the target inference as a function of passage version, test position, and age. Mid = middle.

The pattern of findings for the competing inference (see Figure 2) is quite different from that for the target term, including now the presence of age differences. We first consider those manipulations that are directly related to the intended impact of the materials manipulations. More *yes* responses were given in the context of unexpected passages (58%) than in that of expected passages (43%), $F(1, 46) = 14.65$, $p < .01$. As well, a higher proportion of *yes* responses was given at the midtest position (62%) than at the end-test position (39%), $F(1, 46) = 44.59$, $p < .01$. Also consistent with the materials manipulations is the Passage Version × Test Position interaction, $F(1, 46) = 15.08$, $p < .01$. In particular, subjects were more likely to accept the competing inference midway through the unexpected version than they were at any other combination of test position and passage type. Although the competing interpretation was compelling by the midposition test in unexpected passages, it was far less so by the end of those passages.

We consider next the presence of age effects. Overall, older subjects responded *yes* more often (56%) to the competing inference than did younger subjects (44%), $F(1, 46) = 4.52$, $p < .05$, $\omega^2 = .0057$. However, this tendency to agree with the competing inference cannot simply be the product of a lowered criterion for judging terms to be consistent with one's understanding of a passage. Recall that older adults did not differ from younger adults in their acceptance of the target inference term, although at the midtest positions and for both passage types, differences were possible. Older adults' higher overall rate of agreement with the competing inference is reflected as well in a three-way interaction with passage version and test position, $F(1, 46) = 4.27$, $p < .05$, $\omega^2 = .0030$. This interaction may be seen in Figure 2.

Consider first the left panel that shows performance on the expected passages. Older adults show a higher rate of acceptance of the competing inference than do younger adults, $F(1, 46) = 7.10$, $p < .05$, $\omega^2 = .0695$. Note that even young adults were agreeing with the competing inference approximately 33% of the time. Although this might seem like a high rate of agreement with the competing inference, similar findings have been reported before for young adults' reading of experimental materials that also included some that were garden-path messages that required reevaluations of original interpretations (Daneman & Carpenter, 1983). Thus, the rates of agreement to a competing interpretation that is not strongly supported by a passage may reflect subjects' consideration of a range of alternative interpretations.[3] Nevertheless, it is clear that older adults

[3] Indeed, to write garden-path stories like our unexpected passages, the initial misleading needs to be done along an expected or probable path so that a less likely path can be the ultimate focus of the passage. Thus, the expected versions deal with a less probable event in their larger context (e.g., bringing home a newborn kitten rather than baby). Hence it is possible and even reasonable for subjects to entertain a more highly probable inference (even in the context of expected passages), which, in the case of the present materials, is the competing inference.

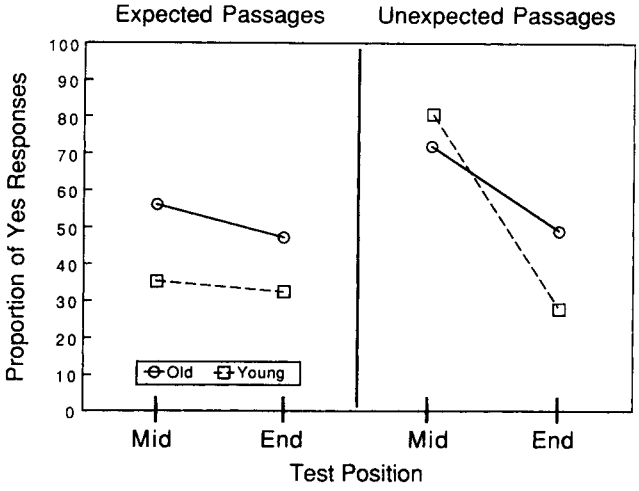

Figure 2. Mean proportion of *yes* responses made to the competing inference as a function of passage version, test position, and age. Mid = middle.

are more likely to accept a competing inference as consistent with their understanding of an expected passage than are younger adults.

Now consider performance on the right panel, which shows responses to competing inferences in the context of unexpected passages. The two-way interaction between age and test position depicted here is significant, $F(1, 46) = 6.23$, $p < .05$, $\omega^2 = .0113$. Although acceptance of the competing interpretation declines, as it should, from the middle to the end of the passage, the rate of decline is less steep for older than for younger adults. Indeed, older adults accept the competing interpretation fully 48% of the time at the end of the passage, despite the fact that *at that same time* they are also agreeing with the target interpretation 88% of the time.

Thus older adults have a tendency to judge a competing inference as consistent with their understanding of a story even when it means holding two not entirely compatible inferences simultaneously. Evidence supporting the view that older adults are responding uniquely to competing inference terms, rather than accepting items arbitrarily, comes from their responses to the remaining items on the speeded judgment task, as discussed next.

Responses to Noncritical Terms

All other items on the speeded judgment test were either actually presented in the passage or were new. During the test sequence, subjects pressed a yes or no response key to indicate whether a word on the screen had been in the passage, was consistent with their current understanding, or was new. Subjects should respond *no* only to the latter category of items. Thus, performance on these postinference term items could be treated as a standard recognition test. Responses to only those items that appeared in the first half of the passage were used in the analyses because only those four old words and those five new words appeared at both the midtest and end-test positions. The hit and false alarm measures are shown in Table 2. The data were analyzed in several ways, including with a modified signal detection analysis (Underwood, 1972). All analyses supported the same conclusions. We report Age × Passage Version × Test Position analyses on hits and false alarms, separately.

The hit rate was higher for items in unexpected passages (85%) than in expected passages (80%), $F(1, 46) = 24.64$, $p < .01$. Two other main effects, those involving test position and age, were also significant or nearly so, $F(1, 46) = 10.52$, $p < .01$, and $F(1, 46) = 3.57$, $p = .07$, $\omega^2 = .0092$, respectively, but interpretation of each is modified by their reliable interaction, $F(1, 46) = 5.47$, $p < .05$, $\omega^2 = .0042$. As can be seen from Table 2, young adults show a decline in hit rate from the midtest to end-test positions; older adults do not. This age difference in patterns of hit rates is probably related to the age differences in false alarm rates.

Indeed, for false alarms, only the Position × Age interaction, $F(1, 46) = 4.94$, $p < .05$, $\omega^2 = .0033$, was significant. This interaction is entirely attributable to the stability of false alarms shown by young adults and to the reliable increase in false alarms from midtest to end-test positions (9% and 12%, respectively) shown by older adults, $F(1, 23) = 5.80$, $p < .05$.

Although older adults had a greater tendency to say yes to new items at the end of the passage than younger adults, this cannot account for the pattern of findings for competing inference terms. Note particularly that the age differences in false alarm rates are very small, whereas those for acceptance of competing inference terms are very large. Thus, the tendency for older adults to accept competing inference words as consistent with their interpretation is not due simply to a broadly lower criterion for determining whether or not a term is consistent with their understanding of a passage.

Inference Recall

The means for recall of inferences are presented in Table 3. Young subjects recalled substantially more inferences (88%) than older subjects (58%), $F(1, 46) = 32.67$, $p < .01$, $\omega^2 = .1353$. Inference recall was disrupted by the presence of a competing word as the first item on the speeded judgment test, $F(1, 46) = 8.99$, $p < .01$, with recall at 76% overall when the target word was tested and 70% when the competing word was tested.

Although more inferences were recalled from expected (77%) than from unexpected passages (69%), $F(1, 46) = 19.34$, $p < .01$, the nature of this main effect is modified by a significant Age × Version interaction, $F(1, 46) = 11.36$, $p < .01$, $\omega^2 = .0062$. Young subjects recalled inferences equally well from the expected (89%) and unexpected versions (88%). By contrast, older subjects recalled considerably more inferences from expected (65%) than from unexpected passage versions (49%), $F(1, 46) =$ $p < .01$. There are two major differences in inference recall between the present study and the earlier work by Zacks and her collaborators: (a) Younger adults did not show their previously reported better inference recall for expected as compared with unexpected passages; (b) Older adults showed extremely low overall levels of inference recall.

Reading Time

Reading time was calculated by dividing the time taken to read each part of a passage by the number of words in that part.

Table 2
Mean Percentage of Hits and False Alarms and Standard Deviations as a Function of Passage Version, Test Position, and Test Word for Younger and Older Adults

	Younger adults						Older adults					
	Expected			Unexpected			Expected			Unexpected		
Inference word	Mid	End	*M*	Mid	End	*M*	Mid	End	*M*	Mid	End	*M*
Hits												
Target												
M	.82	.74	.78	.85	.80	.83	.78	.83	.81	.89	.87	.88
SD	.14	.12		.16	.18		.19	.12		.13	.09	
Competing												
M	.82	.70	.76	.86	.79	.83	.86	.83	.85	.88	.85	.87
SD	.14	.18		.10	.18		.13	.11		.11	.11	
False alarms												
Target												
M	.08	.08	.08	.09	.08	.08	.09	.11	.10	.10	.12	.11
SD	.07	.09		.10	.10		.07	.12		.11	.14	
Competing												
M	.07	.08	.08	.09	.08	.08	.08	.11	.10	.10	.14	.11
SD	.11	.12		.10	.12		.09	.13		.12	.12	

Note. Mid = middle.

The scores were then averaged across passages in a relevant condition (see Table 4). An analysis of the significant Age × Passage Part × Test Position interaction, $F(1, 46) = 21.02$, $p < .01$, $\omega^2 = .0017$, reveals the pattern of data for reading speed. This interaction was entirely attributable to differences found on the second part of passages: The pattern of performance across conditions was the same for younger and older adults for the first part of the passage; older adults, who read at 445 ms per word, were simply slower than younger adults, who read at 330 ms per word. Contrast performance on the second part of the passages. Here differences between younger and older adults were particularly pronounced when the speeded-judgment test intervened between the two portions. Indeed, younger adults were not particularly disrupted by the interposition of the judgment test. In fact, they tended to read the second part 12 ms faster when it followed a test (263 ms), compared with when it did not (275 ms), $F(1, 23) = 3.98$, $p < .06$. By contrast, older adults were substantially slowed (by 52 ms) when reading the second portion of a passage that followed a test (412 ms) as compared with a passage that did not (360 ms), $F(1, 23) = 24.82$, $p < .01$.

Table 3
Mean Percentage Recall and Standard Deviations of Inferences as a Function of Passage Version, Test Position, and Test Word for Younger and Older Adults

	Expected			Unexpected		
Group	Mid	End	*M*	Mid	End	*M*
Younger adults						
Target						
M	92	90	91	88	89	89
SD	20	18		19	21	
Competing						
M	89	85	87	83	88	86
SD	19	22		24	19	
Total mean	91	88	89	86	89	88
Older adults						
Target						
M	68	74	71	47	56	52
SD	36	31		37	29	
Competing						
M	60	58	59	40	54	47
SD	33	34		37	29	
Total mean	64	65	65	44	55	49

Note. Mid = middle.

The absence of a slowdown for younger adults following the interruption of an interpolated test was unexpected, on the basis of the findings of Glanzer and his colleagues (Fischer & Glanzer, 1986; Glanzer, Fischer, & Dorfman, 1984). However, in their work the interruption often consisted of unrelated text interleaved between segments of prose, to the detriment of reading speed on the continuation of the original text following the interruption. The Glanzer-type disruption effect might have been absent here, for younger adults at least, because the present interpolated task included text-related items. However, this potential relevance factor did not aid older adults. As well, our measure of reading speed was by passage part, whereas Glanzer and his collaborators used more fine-grained measures. The data may suggest then that older adults cannot quickly recover from an interruption, although younger adults can.

Verbal Ability

The contribution of verbal ability to passage interpretation effects was assessed by dividing younger and older adults into high and low verbal ability groups on the basis of a median split (at 42.5) on the Vocabulary subtest of the WAIS–R. The mean vocabulary scores for the high and low verbal ability young

Table 4
Mean Reading Speed Per Word in Milliseconds for Expected and Unexpected Passages as a Function of Age, Passage Part, Test Position, and Test Word

	Younger adults						Older adults					
	Part 1			Part 2			Part 1			Part 2		
Inference word	Mid	End	*M*	Mid	End	*M*	Mid	End	*M*	Mid	End	*M*
Expected passages												
Target												
M	337	335	336	259	276	268	451	487	469	393	349	371
SD	108	126		94	87		114	121		87	69	
Competing												
M	331	329	330	249	258	253	438	438	438	428	347	338
SD	128	103		79	82		100	106		138	72	
Total mean	334	332	333	254	267	260	444	462	453	410	348	380
Unexpected passages												
Target												
M	328	321	324	276	292	284	445	425	435	428	365	397
SD	107	88		96	97		105	91		116	81	
Competing												
M	321	340	330	268	274	271	433	439	436	398	378	388
SD	88	144		66	86		120	112		94	105	
Total mean	324	331	328	272	283	278	439	432	436	413	372	392

Note. Mid = middle.

subjects were 47.7 (n = 14) and 37.0 (n = 10), respectively. For high and low verbal ability older subjects, the means were 49.4 (n = 10) and 37.1 (n = 14), respectively. Analyses of these scores showed only a significant difference between high and low vocabulary groups, $F(1, 44) = 102.45$, $p < .01$. Verbal ability was then included as a variable in analyses on all dependent measures. We report here data for inference judgments and recall, for which clear patterns were found.

For judgments on inference words, the sole significant effect involving vocabulary differences was the interaction between test word (target vs. competing) and test position, $F(1, 44) = 4.76$, $p < .05$. This interaction is shown in Figure 3. As can be seen, target inference terms were responded to equivalently by subjects of different verbal ability. The key difference between the two ability groups lies in their responses to competing inference terms, a difference that is reliable at the end of the passage, $F(1, 46) = 9.10$, $p < .01$. Whereas high vocabulary subjects accept the competing inference as consistent with their final interpretation of the passage only 29% of the time, low vocabulary subjects accept this term 49% of the time. These figures are surprisingly similar to the pattern of age differences found for competing inferences. No interactions that included age were significant. Thus, the differential likelihood of older adults' accepting the competing inference as consistent with their understanding cannot be attributed to poorer vocabulary and associated ability differences.

We note that the performance of low vocabulary participants here is consistent with other data showing that poor readers, whether children (Merrill, Sperber, & McCauley, 1981) or young adults (Gernsbacher, Varner, & Faust, 1988), have greater difficulty with ambiguity than do better readers. Older adults appear to have greater difficulty as well, although verbal ability appears not to be the source.

Verbal ability also influenced the probed recall of inferences, $F(1, 44) = 19.39$, $p < .01$. High verbal ability subjects recalled more inferences (85%) than did low verbal ability subjects (60%). No interaction with age was found.

Verbal ability thus affected the two main measures of comprehension, inference judgments and recall.

Discussion

The goals of this experiment were to determine the existence, if any, of age differences in a central interpretation accorded a text and the relation between those interpretations and recall. Interpretations were indexed by speeded responses made to inference terms presented either near the middle or at the end of a paragraph. Expected paragraphs consistently supported a

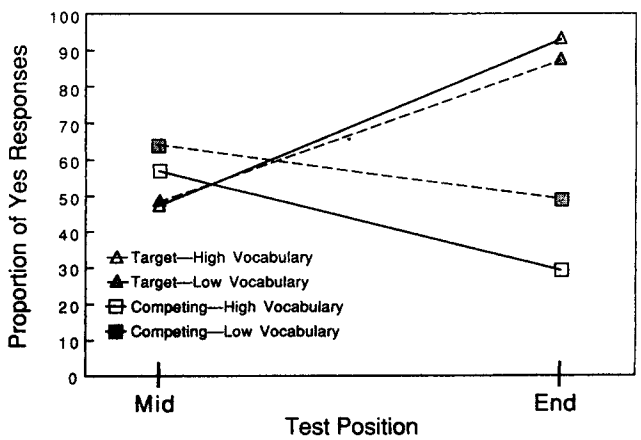

Figure 3. Mean proportion of *yes* responses made to the inference terms as a function of verbal ability and test position. Mid = middle.

focal, target interpretation and unexpected paragraphs were garden-path versions that initially misled participants to a competing inference before providing information leading to the correct target inference. The data are clear in showing no age differences in the patterns of acceptance of the final target interpretation. Younger and older subjects perform comparably, across both types of passages, whether tested in the middle of a passage or at the end. By contrast, there are substantial age differences in responses made to the competing interpretation term. Older adults are far more likely to accept a competing inference as consistent with their understanding of a passage than are younger adults. As well, older adults show a very strong tendency to continue to agree with the competing interpretation even when, by the end of a passage, they also show a far stronger tendency (one that is the equivalent of younger adults') to agree (appropriately) with the target interpretation.

The apparent agreeableness on the part of older adults cannot be attributed to a nonspecific tendency to say yes to all items on the speeded judgment test. Several findings argue against such a possibility. First, older adults are no more likely to agree to target inference terms than are younger adults, even at midpassage test points for expected passages—when agreement rates are well below 100%—and so permit the detection of elevated agreement tendencies. Second, age differences in recognition of control items, especially in the false-alarm rates, were small in comparison with age differences in the tendency to accept the competing inference. Older adults are not simply saying yes to all potential words. The evidence points clearly to the existence of large age differences in the tendency to agree to the competing interpretation.

The data suggest then that older adults entertain a broader range of possible interpretations in the course of reading a passage (witness age differences on the competing inference at the midpassage test of expected passages) and fail to quickly narrow that range (witness age differences on the no-longer-appropriate competing inferences tested at the end of unexpected passages). The broad and sustained activation of interpretations shown by older adults is not easily accommodated by views that propose that age differences in comprehension are attributable to age-related declines in working memory capacity. Such declines should *reduce* the amount of information older adults maintain in active memory in the face of the competing and sustained processing demands that are made by ongoing discourse. Indeed, from a capacity-based perspective, one might have assumed that one source of inference failure for older adults was their inability to maintain enough information in working memory to do the computations necessary to arrive at inferences. Instead, older adults rather surprisingly appear to have enriched, not impoverished, content in mind.

We now turn to an explanation for the enhanced breadth of activation shown by older adults and suggest how that activation may account for the extremely poor inference recall shown here by older adults. This explanation draws heavily on an attention-based theory proposed by Hasher and Zacks (1988), which argues that the efficacy of inhibitory mechanisms is central to the control of action tendencies and the contents of attention (e.g., Neumann, 1987). Their theory specifies the importance of inhibitory mechanisms in regulating the contents of working memory. It also proposes that inhibitory control of attention diminishes with age. Indeed, several recent studies offer evidence that this diminution does not occur (e.g., Hasher, Stoltzfus, Zacks, & Rypma, 1991). As applied to discourse comprehension, the Hasher-Zacks theory argues that efficient inhibition functions to limit entrance into working memory to information central to understanding a message. Because any message can activate well-learned connections that are not directly relevant to that particular message (or that are only marginally relevant), inhibition also functions to suppress such information, should it enter working memory.

The present finding of older adults' differential acceptance of the competing inference terms midway through the critical passages is consistent with the suggestion that they have inefficient inhibitory mechanisms that permit a broader range of ideas to be activated. The finding of continued differential rates of accepting the competing inference at the end of the passage is consistent with the suggestion that once activated, an inefficient inhibitory system will be slow to suppress irrelevant ideas. Also consistent with this sustained activation view is recent evidence using sentence frame completions as an indirect measure of word accessibility. Older adults sustained both target and disconfirmed sentence endings that occurred earlier in the experiment, whereas younger adults sustained access only for the targets (Hartman & Hasher, 1991). Older adults also considered more alternative endings, even for sentences whose last word was highly normatively predictable (Stoltzfus, 1991). In the present experiment, the greater disruptive effect of a midpassage text on reading speed for older adults may well be the product of a diminished ability to inhibit attention to irrelevant information.

A number of consequences can be expected as a result of the broader range of activation permitted by diminished inhibition (see Hasher & Zacks, 1988). One major consequence, increased forgetting, is directly relevant to the present findings. One mechanism of forgetting is that of competition among interrelated ideas (Postman & Underwood, 1973). Competition increases with the number of ideas connected to the same cue, diminishing both speed and accuracy of retrieval (e.g., the fan effect, Anderson, 1983). Recent findings show clearly that older adults are more susceptible to forgetting due to competition, as indexed by the fan effect (Gerard, Zacks, Hasher, & Radvansky, 1991), a finding consistent with Winocur's (1988) view of an age-related increase in susceptibility to associative interference. In the present case, older adults show activation of both central (the target) and peripheral (the competing) inferences. This may well set the stage for increased competition. It is not surprising then that the inference recall of older adults is substantially impaired relative to younger adults who appear more likely to hold one interpretation at a time.

The major findings regarding the text interpretation performance of older adults may also be described in a somewhat different way. Older adults may actively try to reconcile discrepancies in ambiguous situations. For example, with respect to the unexpected version of a passage about a safari, several people (mostly older) have pointed out the potential value of having a gun along with one's camera on a photographic safari. This apparent style or strategy difference in comprehension may well be the product of the inefficient inhibitory mechanisms described here. But the product of such a style will be a less coherent or less well-structured representation.

A final comment is warranted regarding the value of working memory as an explanation of a variety of language-related

phenomena in cognitive gerontology. There are a number of reasons to be concerned about any mechanism tied to the notion of capacity (see, e.g., Hasher & Zacks, 1988; Navon, 1984). As Light (1991) pointed out, there are nonetheless compelling findings consistent with the general notion of group and individual differences in working memory capacity that affect cognitive functioning (see also Just & Carpenter, 1992; Salthouse, 1991). It may be the case that the inhibition mechanism discussed here interfaces with working memory rather directly by determining its capacity (by the admission and sustenance of irrelevant information) to process target information.

In sum, inefficient inhibitory mechanisms associated with aging may permit a broader range of activation of ideas as well as an extended duration for that activation for older adults. In turn, a broad range of activation may also set the stage for substantial forgetting, as the responses to inference questions suggest. It is of course possible that the efficacy of inhibition develops across the childhood years (Tipper, Borque, Anderson, & Brehaut, 1989), and there may be reliable individual differences present among young adults in this process. If so, the present research suggests that these differences may have consequences for understanding and remembering discourse (see also Gernsbacher, 1990).

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