Aging Neuropsychology and Cognition
2003, Vol. 10, No. 2, pp. 158–166

1382-5585/03/1002-158$16.00

Aging and Situation Model Updating

Gabriel A. Radvansky[1], David E. Copeland[1], Diane E. Berish[2], and Katinka Dijkstra[3]
[1]University of Notre Dame, IN, USA, [2]University of Virginia, Charlottes-ville, VA, USA,
and [3]Florida State University, Tallahassee FL, USA

ABSTRACT

The aim of this study was to investigate age differences in narrative comprehension and memory, with a focus on the updating of situation models during comprehension. While there are large effects of aging on memory for propositional textbase information, there is very little evidence that older adults have difficulty at the situation model level. Because described events are often dynamic, a comprehender must consistently update their situation model to make it consistent with the new information. The current experiments investigated whether there are any age differences associated with the ability to update a situation model along the spatial and temporal dimensions. Although updating effects were observed, they were largely not influenced by age. The relation of these findings to an understanding of older adults' language comprehension and memory performance is discussed.

Research on the effects of aging on comprehension and memory has suggested that while cognitive aging is associated with a general decline at lower levels of processing, such as at verbatim or propositional textbase levels (e.g., Cohen, 1979; Kemper, 1987; Kemtes & Kemper, 1997; Light & Capps, 1986; Meyer & Rice, 1981; Stine & Wingfield, 1988, 1990), there may be aspects of higher level cognition that are preserved, particularly at the situation model level (Radvansky, 1999; Radvansky, Copeland, & Zwaan, in press; Radvansky, Zwaan, Curiel, & Copeland, 2001). A *situation model* is a mental representation or simulation of a described situation or event (Johnson-Laird, 1983; van Dijk, & Kintsch, 1983; Zwaan, & Radvansky, 1998). It conveys the described events, not the text itself (Glenberg, Meyer, & Lindem, 1987). The aim of the current study is to further investigate age-related influences in processing at this higher level of cognition. The particular focus is on older adults' ability to update their situation models in space or time when there is a change in the described event.

Research on aging and situation model use has often found little to no differences in younger and older adults' use of situation models (e.g., Gilinsky & Judd, 1994; Morrow, Leirer, & Altieri, 1992; Morrow, Stine-Morrow, Leirer, Andrassy, & Kahn, 1997; Radvansky et al., in press; Radvansky, Gerard, Zacks, & Hasher, 1990; Radvansky, Zacks, & Hasher, 1996; Radvansky et al., 2001; Stine-Morrow, Loveless, & Soederberg, 1996). For example, Radvansky et al. (2001) and Radvansky et al. (in press) found that while there were age-related deficits in verbatim and textbase memory, there was no age difference at the situation model level, with a nominal advantage for the older adults over the younger adults. One explanation for this is that younger adults increase effort toward maintaining the textbase, perhaps reflecting the demands of their current schooling. In contrast, the older adults seemed to use the textbase as a temporary scaffolding, used

Address correspondence to: G.A. Radvansky, 107 Haggar Hall, Department of Psychology, University of Notre Dame, Notre Dame, IN 46556, USA. Tel.: 219-631-6473. Fax: 219-631-8883. E-mail: Radvansky.1@nd.edu.
Accepted for publication: October 29, 2002.

to create their situation models and then discarded. The result was a poorer propositional memory representation.

A second idea is that older adults have well-preserved situation model abilities because they are most expert comprehenders (e.g., Ericsson & Kintsch, 1995) as a result of their longer reading development. This enables them to focus better on the described situation in the text as compared to younger adults. Thus, although older adults have fewer processing resources overall, those resources that are available can be better aimed at the end product of comprehension – the construction and retention of the situation model. This second idea is also in line with research in aging and social cognition showing that older adults are more likely to use diagnostic information to make trait decisions (Hess & Aumen, 2001). That is, when presented with a description of a person, rather than retaining a memory of the entire list of behaviors, older adults are more likely to pick out the subgroup of behaviors that are relevant to making a specific trait judgment. This parallels the idea that, in text comprehension, older adults are better able to use what resources they have to select out the relevant pieces of information for a higher-level task, which in this case is the construction of a situation model.

The processes of situation model updating occur to capture any changes in the described events. There are basically three kinds of updating: (a) adding new entities or properties to an existing model, such as reading that a new person has walked into the room (e.g., Zwaan, Langston, & Graesser, 1995), (b) altering the structural relations among entities in a model, such as reading that a person went under a bridge to get out of the rain (e.g., Radvansky & Copeland, 2000), and (c) maintaining or removing entities or properties when there is a shift in the event context (e.g., Glenberg, Meyer, & Lindem, 1987). It is the third type of updating that is the focus of the present study.

The effect of aging on the updating of situation models has been studied previously. A study by Radvansky and Curiel (1998) assessed updating by looking at character goal information. For example, a story might describe a boy wanting to get a new bicycle. When story characters complete their goals (e.g., the boy gets the bike), this goal related information becomes less available, whereas goal related information about unsatisfied goals (e.g., the boy still hasn't been able to get the bike) remains available. This was evaluated by looking at the ability of readers to answer probe questions pertaining to these goals. Although older adults were slower and more error prone overall, there was no age difference in the ability to maintain current goals and remove satisfied goals from the situation model.

The current study extends this effort to look at the updating of situation models along the spatial and temporal dimensions. For the spatial dimension we used a method originally developed by Glenberg et al. (1987) and adapted by Radvansky and Copeland (2001). This method looked at the availability of objects as a function of whether they were spatially associated or dissociated from a story protagonist. For the temporal dimension we used a method developed by Zwaan (1996) that looked at the availability of objects after a short or long shift in time.

The paradigms used in the current study differ from those used by Radvansky and Curiel (1998) in a number of ways. First, the spatial and temporal updating tasks involve the coordination of spatial and entity information (the critical object), whereas the Radvansky and Curiel study focused on goal-related information. Second, in the spatial and temporal updating tasks it is possible that the critical object will become important again in the passage when the protagonist moves from one situation framework to another. However, for character goals, once the goal is achieved and satisfied, it is much less likely that it will become relevant again. For example, if a boy wants a new bicycle and then gets one, he is unlikely to continue to want a new bicycle (at least for a little while). Third, as noted in the description of the Radvansky and Copeland (2001) study, the ability to update a situation model appears to be most related to how a person handles the associated condition, not the dissociated condition. Thus, while the Radvansky and Curiel study focused on updating that involves removal, the current study also looked at updating that involves information maintenance.

In general, by examining the spatial and temporal dimensions in text comprehension in younger and older adults, a better understanding

of memory for primary dimensions in text comprehension can be gained for people with and without age-related limitations on their cognitive resources.

EXPERIMENT 1: SPATIAL UPDATING

Experiment 1 used a paradigm employed by Radvansky and Copeland (2001), which in turn was a modification of a study by Glenberg et al. (1987). In this paradigm, people read a series of short passages, such as:

1. Warren spent the afternoon shopping at the store.
2. He *picked up/set down* his *bag* and went over to look at some scarves.
3. He had been shopping all day.
4. He thought it was getting too heavy to carry.

In each passage a critical object (e.g., the bag) is either spatially associated with (e.g., picked up) or is spatially dissociated from (e.g., set down) the story protagonist. As people read, when the protagonist moves from one place to another, they need to update their situation models with respect to the relative location of the critical object. After reading a story, people receive a probe question, such as ''Did the word ''it'' in the previous sentence refer to a bag?'' People make fewer errors when the object was associated than when it was dissociated. An associated object stays in the foreground of the situation model, and so is more available during memory retrieval. However, the dissociated object is moved to the background, and so is less available.

What is particularly interesting about the Radvansky and Copeland (2001) study is that people differed in their ability to update the situation model. In that study, people were given measures of working memory span and general situation model processing ability. It was observed that the ability to update a model by removing a dissociated object during a spatial shift was unrelated to both measures. However, the ability to maintain the object when it was associated was related only to situation model processing, not span. In general, older adults may have preserved abilities at the situation model level even in the presence of working memory span declines. Thus, they may not be affected in their ability to update their situation models.

If older adults are able to process information effectively at the situation model level, then it is expected that they will show similar updating effects as the younger adults. That is, information should be more available in the associated condition relative to the dissociated condition. Moreover, this difference should be similar for the older and younger adults. This is in line with research showing that older adults tend not to show declines at the situation model level (e.g., Radvansky et al., 2001), and that this sort of spatial updating is unrelated to cognitive processes that are affected by aging, such as working memory capacity (Radvansky & Copeland, 2001).

Alternatively, it may be that older adults will do worse on the updating task than the younger adults. This is because the retention of information across a shift in a situation dimension is needed, which puts higher demands on their cognitive resources, such as working memory capacity. Age-related differences have been found to be larger when complexity of a task increases (Salthouse, Mitchell, Skovronok, & Babcock, 1989). In other words, preserved abilities at the situation model level may not be sufficient here to compensate for the high processing load. A successful monitoring of all of the information in the described situation may therefore not be possible to maintain and result in inadequate updating at the situation model level. This finding would be surprising, for until now it has not been observed with situation model processing.

METHOD

Unless mentioned otherwise, a criterion of $p < .05$ is assumed.

Participants

We tested 38 participants in each of two age groups. The younger adults ranged from 18 to 21 years of age ($M = 19.1$), were recruited from the University of Notre Dame and received partial course credit in exchange for their participation. The older adults ranged from 62 to 84 years of age ($M = 72.4$), were recruited from the South Bend community and received payment in

exchange for their participation. The younger adults had less education (Range = 12–15; $M = 13.1$ years) than did the older adults (Range = 12–20; $M = 14.9$ years), $t(74) = 3.78$, and the younger adults scored lower on the Shipley vocabulary test (Range 25–36; $M = 30.5$) than did the older adults (Range 26–39; $M = 33.8$), $t(74) = 3.36$. However, the younger adults scored higher on the Salthouse and Babcock (1991) figure comparison test, which serves as a processing speed measure (Range 8–30; $M = 19.3$), than did the older adults (Range 4–16; $M = 10.9$), $t(74) = 9.16$, and the younger adults scored higher on the Turner and Engle (1989) operation span test (Range 2–6; $M = 4.0$) than did the older adults (Range 1–5.5; $M = 2.8$), $t(74) = 4.90$. All participants were native English speakers.

Materials and Procedure

People in the study were first given the Shipley vocabulary test as a measure of general verbal ability followed by the Salthouse and Babcock (1991) pattern comparison test as a measure of processing speed, and then the Turner and Engle (1989) operation span test as a measure of working memory capacity.

People read five practice stories followed by a series of 24 experimental stories that were each four sentences long. An example of one such passage is provided in the introduction to this experiment. There were also 24 filler stories that were 3–5 sentences long. For the experimental stories, the second sentence described an object becoming either spatially associated with or dissociated from the story protagonist. There were two versions of each story, one associated and one dissociated, and these versions were counterbalanced across subjects. The final anaphoric sentence contained the word "it" which referred to the critical object. These stories were presented on a computer, one sentence at a time, and reading times were recorded. However, we only analyze reading times for the final, critical, anaphoric sentence. People pressed the space bar with their left hand to erase the current sentence and advance to the next one. After the last sentence there was a probe question, such as "Did the word 'it' in the previous sentence refer to the bag?" People were encouraged to respond as fast and as accurately as possible. Responses were made by pressing buttons on a computer mouse with the right hand. The left button was marked with a "Y" for "yes," and the right button was marked with an "N" for "no." The order of the experimental and filler stories was randomized for each person.

RESULTS AND DISCUSSION

Overall, the results showed evidence of an influence of spatial updating on cognition, although this was significant only in the recognition accuracy data. Furthermore, aging did not influence the ability to spatially update the situation models.

Reading Times

The reading time per syllable data for the anaphoric sentence are presented in Table 1. These data were not trimmed. These data were submitted to a 2 (Age) × 2 (Condition) mixed ANOVA. Although people read more slowly in the dissociated condition than associated condition, this difference was not significant, $F < 1$. A similar result was reported by Radvansky and Copeland (2001). The main effect of Age was significant, $F(1, 74) = 44.12$, $\mathrm{MSE} = 8725$, with older adults reading more slowly than younger adults. The interaction was not significant, $F < 1$.

Question Answer Accuracy

The recognition test data are presented in Table 1. These data were also submitted to a 2 (Age) × 2 (Condition) mixed ANOVA. People were less accurate to the memory probes that referred to a dissociated object than to an associated object, $F(1, 74) = 9.97$, $\mathrm{MSE} = 0.006$. This replicates the effect reported by Radvansky and Copeland (2001). Thus, when an object was associated with the protagonist, information about it was more available in the situation model compared to if the

Table 1. Recognition Test Accuracy Data (in Percentages) With Standard Deviations in Parentheses for Experiment 1.

	Reading times			Question accuracy			Question response times		
	Associated	Dissociated	Mean	Associated	Dissociated	Mean	Associated	Dissociated	Mean
Young	203 (42)	210 (44)	207	94.2 (5.4)	90.8 (6.8)	92.5	2878 (694)	2791 (757)	2835
Old	307 (92)	307 (79)	307	89.7 (9.2)	85.1 (12.1)	87.4	5481 (1899)	5711 (1733)	5596
Mean	255	259		92.0	88.0		4179	4251	

object was dissociated. The main effect of Age was also significant, $F(1,74) = 10.71$, MSE = 0.009, with older adults being less accurate than younger adults. Importantly, the interaction was not significant, $F < 1$. An analysis revealed that we had a power greater than .80 to detect this critical interaction. The updating effect was significant for both the younger, $F(1,37) = 7.75$, MSE = 0.003, and older adults, $F(1,37) = 4.33$, MSE = 0.009. Thus, older adults show a similar ability to update their situation models as the younger adults, even though they were less accurate overall.

Question Answering Time

Response times ≥ 5000 ms were discarded. The question answering time data are presented in Table 1. These data were also submitted to a 2 (Age) × 2 (Condition) mixed ANOVA. People were nominally slower responding to the memory probes that referred to a dissociated object than to an associated object, however, this difference was not significant, $F < 1$. The main effect of Age was significant, $F(1,74) = 87.64$, MSE = 3306691, with older adults being slower than younger adults, consistent with general age-related slowing. Finally, the interaction was not significant, $F(1,74) = 1.80$, MSE = 524827, $p = .18$.

EXPERIMENT 2: TEMPORAL UPDATING

Having established that spatial updating does not appear to be affected by aging we sought to extend this finding to another dimension. In this case, we looked at temporal updating when there has been a shift in time. The current experiment presented people with a series of brief stories used by Zwaan (1996) in his study of temporal updating. Each of these stories contained a critical sentence that described a shift in time. An example of one of these stories is provided in Table 2. There were two versions of each story. In one version, the shift in time was very short ("a moment later"), well within the confines of the current situation. As such, very little model updating would be required. However, for the other version the shift in time was rather long ("a day later"), well outside the confines of the current situation, although it was sensible in the context of the passage. As such, the situation model would need extensive updating. Following each critical sentence people were presented with a memory probe that referred to an object in the sentence just prior to the time shift. If people successfully make this time shift, this object should be less available after the long time shift compared to the short time shift.

Table 2. Sample Story and Probe Word from Experiment 2.

James was an established novelist. However, lately, he had been experiencing a writer's block. He had not written a page in weeks. He decided to change his approach. From now on, he would systematically write one page a day. A day later, James got up very early. After drinking two cups of coffee, he entered his study. James turned on his PC and started typing. A moment/day later, the telephone rang. It was James' friend Warren. Warren invited James to a game of golf. James quickly agreed. He jumped at every opportunity to finally beat his friend.

Note. Probe word: Typing.

METHOD

Participants

We tested 72 people in each of the two age groups. The younger adults ranged from 18 to 22 years of age ($M = 18.9$). These people were recruited from the University of Notre Dame and Florida State University and received partial course credit in exchange for their participation. The older adults ranged from 62 to 90 years of age ($M = 74.1$), were recruited from the South Bend and Tallahassee communities and received payment in exchange for their participation. The younger adults had less education (Range = 12–15; $M = 12.6$ years) than did the older adults (Range = 11–20; $M = 15.4$ years), $t(142) = 8.34$, and the younger adults scored lower on the Shipley vocabulary test (Range 22.5–36.75; $M = 29.6$) than did the older adults (Range 25–40; $M = 34.2$), $t(142) = 7.69$. However, the younger adults scored higher on the Salthouse and Babcock (1991) figure comparison test (Range 6–30; $M = 17.7$), than did the older adults (Range −3–21; $M = 10.4$), $t(142) = 8.86$, and the younger adults scored higher on the Turner and Engle (1989) operation span test (Range 1.5–6; $M = 3.3$) than did the older adults (Range 1–4.5; $M = 2.6$), $t(142) = 4.38$. All participants were native English speakers.

Materials and Procedure

Participants in the study were treated the same as those in Experiment 1 with regard to the general ability measures (i.e., vocabulary, speed, and working memory capacity).

The primary task in this study was based on a procedure used by Zwaan (1996). Subjects read two practice stories followed by a series of 18 experimental stories that were each 10–13 sentences long (See Table 2). There were also 18 filler stories that were 13–14 sentences long. These stories were presented on a computer, one sentence at a time, and reading times were recorded. People pressed the space bar with their left hand to erase the current sentence and advance to the next one. For the experimental stories, one of the sentences described a shift in time that was either "a moment later" or "a day later". The first time shift should still be within the same situation, whereas the second time shift goes beyond that situation and is more likely to be interpreted as a marker that a new situation is now at hand. Following the time shift sentence, people were interrupted with a memory probe. Their task was to indicate whether the probe items were part of the story that they had already read. Responses were made by pressing buttons on a computer mouse with the right hand. The left button was marked with a "Y" for "yes," and the right button was marked with an "N" for "no." Response times and accuracy rates were recorded. After the last sentence there was a comprehension question, such as "Is the following statement correct? James drank two cups of coffee." This question was inserted to check whether subjects were taking the task seriously. The order of the experimental and filler stories was randomized for each person.

RESULTS AND DISCUSSION

Reading Times

The reading time data are presented in Table 3. These data were not trimmed. These data were submitted to a 2 (Age) $\times$ 2 (Condition) mixed ANOVA. People read the time shift sentence faster when the change in time was short rather than long, $F(1, 142) = 105.7$, MSE $= 80649$. Thus, people are sensitive to shifts in time in the described situation. This replicates Zwaan's (1996) primary finding. The main effect of Age was also significant, $F(1, 142) = 61.62$, MSE $= 717649$, with older adults reading more slowly than younger adults. This reflects general age-related slowing. Importantly, the interaction was significant, $F(1, 142) = 10.17$, MSE $= 80649$. Separate analyses revealed that the temporal shift effect was significant for both the younger, $F(1, 71) = 46.04$, MSE $= 43434$, and the older adults, $F(1, 71) = 61.62$, MSE $= 117863$, with the size of the effect being smaller for the younger adults (236 ms) than the older adults (449 ms). Thus, older adults show a similar effect of updating during their reading of the temporal shift sentence, and may in fact be more affected by this shift.

Probe Accuracy

The probe accuracy data are presented in Table 3. These data were also submitted to a 2 (Age) $\times$ 2 (Condition) mixed ANOVA. Although the main effects of Age, $F(1, 42) = 2.24$, MSE $= 0.011$, $p = .14$, Condition, $F(1, 142) = 1.08$, MSE $= 0.010$, $p = .30$, and the interaction, $F < 1$, were not significant, the pattern of means were in the expected directions. An analysis revealed power greater than .80 to detect this interaction. Specifically, people were more accurate when the time shift was short rather than long, and the older adults showed a nominally larger effect of time shift than the younger adults.

Probe Response Time

Response times ≥ 5000 ms were discarded. This accounted for 4.3% of the data. The probe

Table 3. Reading Time (in ms), Probe Accuracy (in Percentages), and Probe Response Time Data (in ms) for Experiment 2.

	Reading times			Probe accuracy			Probe response times		
	Moment	Day	Mean	Moment	Day	Mean	Moment	Day	Mean
Young	1443 (382)	1679 (487)	1561	92.6 (9.3)	92.1 (9.2)	92.4	1433 (476)	1528 (406)	1481
Old	2120 (683)	2569 (865)	2345	91.5 (10.9)	89.5 (11.5)	90.5	2283 (525)	2365 (548)	2324
Mean	1782	2124		92.1	90.8		1858	1947	

response time data are presented in Table 3. These data were also submitted to a 2 (Age) × 2 (Condition) mixed ANOVA. There was a significant main effect of Condition, $F(1, 42) = 7.93$, $\mathrm{MSE} = 71615$, with people responding faster after a short time shift than a long time shift. Thus, the availability of entity information is affected by whether there has been a short or long shift in time. In addition, there was a significant main effect of Age, $F(1, 142) = 1241.08$, $\mathrm{MSE} = 412275$, with older adults taking longer to respond than younger adults. Importantly, the interaction was not significant, $F < 1$, although we had power greater than .80 to detect it. This suggests that younger and older adults were similarly able to update their situation models after a shift in time.

Comprehension Questions

Overall, people seemed to be making an effort to comprehend the stories, getting an average of 88% of the comprehension questions correct. Moreover, although the younger adults were more accurate (89%) than the older adults (87%), this difference did not reach significance, $F(1, 42) = 2.51$, $\mathrm{MSE} = 0.006$, $p = .12$.

GENERAL DISCUSSION

The current study looked at the effects of aging on the updating of situation models when there was a shift in space (Experiment 1) or time (Experiment 2). In both experiments, updating effects were observed for both the younger and older adults. In addition, there was no evidence of any age-related decline in the ability to detect and complete these shifts. Older adults showed updating effects as large as, if not larger than, the younger adults. This suggests that older adults may be as sensitive to changes in described situations as younger adults. This is consistent with the idea that there are few age-related changes in the ability to process information at the situation model level (e.g., Radvansky et al., 2001). This is also consistent with the results of Radvansky and Curiel (1998) who found that younger and older adults did not differ in updating situation models when that updating involved removing a newly completed character goal.

There are a few differences between the outcomes of the two experiments in the current study. In Experiment 1 the influence of spatial updating was present only for the recognition accuracy data, whereas in Experiment 2 the influence of temporal updating was present in the reading times and probe response times but not the probe accuracy data. While there were some methodological differences between the two experiments (e.g., the number of participants, the length of the stories, the presence of comprehension questions in Experiment 2), these differences in the pattern of results may also tell us something about the role of spatial and temporal dimensions in text comprehension. Spatial dissociation in a story is a common and plausible occurrence, thus it hardly affects reading times during processing. When it comes to retrieving that information from the situation model, however, the reader may have difficulty correctly deciding what the situation model consists of. This small impact of spatial shifts on performance is not unique. For example, in a study by Zwaan, Radvansky, Hilliard, & Curiel (1998) people read texts with several spatial shifts either after memorizing a map of the layout described in the texts, or without the benefit of such memorization. In this study, significant spatial shift effects were only observed after memorization.

In contrast, temporal shifts have different implications in a story. When a time shift is introduced, the reader takes this as a cue to set up a new time interval and situation associated with it which causes a momentary increase in on-line processing load (Zwaan, 1996), as was demonstrated in this study. This increase in on-line processing load would also explain the interaction between younger and older adults as older adults have more limited cognitive resources. These slower reading times could reflect their attempts to compensate for their limited capacity. The fact that they are not significantly different from younger adults in their probe accuracy indicates that their compensation mechanism pays off. Spatial and temporal shifts may reflect changes in the situation model that require a different amount of processing for reading versus retrieving

information. Specifically, there would be less processing involved but at the same time low accuracy for spatial updates, whereas more elaborate processing would be associated with high accuracy for temporal updates.

More generally, consistent with many studies of the effects of aging on language comprehension and memory, we observed slower reading and response times for the older adults, as well as lower accuracy levels on memory tests. This is consistent with the idea that there are some general declines in cognitive processes that accompany aging. However, these differences did not have a profound effect on older adults' ability to update their situation models within the confines of these cognitive constraints, except for the temporal updating difference noted in the previous paragraph. Furthermore, although there were age differences on a number of ability measures, when we did correlations of these with our various dependent measures, none of them were significant.

The results of both experiments in the current study demonstrate the finding that older adults eventually are able to update their situation models as completely as younger adults do, and this is consistent with previous work (Radvansky & Curiel, 1998). The present study extends these findings to spatial and temporal updating. Key differences between the current study and previous studies are that, (a) the updated information can still be relevant as the story progresses, (b) the updating task can involve the retention of information across a situation shift, and (c) the updated model possibly contains a new time period. Overall, these results are consistent with the view that while lower levels of comprehension and memory may be compromised by the effects of normal aging, processing at the higher situation model level may be much less affected (Radvansky, 1999; Radvansky et al., 2001).

ACKNOWLEDGEMENTS

We would also like to thank Seth Allen, Kate DiNardo, Melissa Ferrello, Priscilla Henson, and Kimberly Laime for their assistance in collecting the data. Experiment 1 was presented at the 2001 meeting of the Midwestern Psychological Association in Chicago, Illinois. This research was supported in part by a grant from the Army Research Institute, ARMY-DASW01-99-K-0001.

REFERENCES

Cohen, G. (1979). Language comprehension in old age. *Cognitive Psychology*, *11*, 412–429.

Ericsson, K.A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review*, *102*, 211–245.

Gilinsky, A.S., & Judd, B.B. (1994). Working memory and bias in reasoning across the life-span. *Psychology and Aging*, *9*, 356–371.

Glenberg, A.M., Meyer, M., & Lindem, K. (1987). Mental models contribute to foregrounding during text comprehension. *Journal of Memory and Language*, *26*, 69–83.

Hess, T.M., & Auman, C. (2001). Aging and social expertise: The impact of trait-diagnostic information on impressions of others. *Psychology and Aging*, *16*, 497–510.

Johnson-Laird, P.N. (1983). *Mental Models: Towards a cognitive science of language, inference and consciousness*. Cambridge, MA: Harvard University Press.

Kemper, S. (1987). Syntactic complexity and elderly adults' prose recall. *Experimental Aging Research*, *13*, 47–52.

Kemtes, K.A., & Kemper, S. (1997). Younger and older adults' on-line processing of syntactically ambiguous sentences. *Psychology and Aging*, *12*, 362–371.

Light, L.L., & Capps, J.L. (1986). Comprehension of pronouns in younger and older adults. *Developmental Psychology*, *22*, 580–585.

Meyer, B.J.F., & Rice, G.E. (1981). Information recalled from prose by young, middle, and old adult readers. *Experimental Aging Research*, *7*, 253–268.

Morrow, D.G., Leirer, V.O., & Altieri, P.A. (1992). Aging, expertise and narrative processing. *Psychology and Aging*, *7*, 376–388.

Morrow, D.G., Stine-Morrow, E.A.L., Leirer, V.O., Andrassy, J.M., & Kahn, J. (1997). The role of reader age and focus of attention in creating situation models from narratives. *Journal of Gerontology: Psychological Sciences*, *52B*, P73–P80.

Radvansky, G.A. (1999). Aging, memory and comprehension. *Current Directions in Psychological Science*, *8*, 49–53.

Radvansky, G.A., & Copeland, D.E. (2000). Functionality and spatial relations in situation models. *Memory and Cognition*, *28*, 987–992.

Radvansky, G.A., & Copeland, D.E. (2001). Working memory and situation model updating. *Memory and Cognition*, *29*, 1073–1080.

Radvansky, G.A., Copeland, D.E., & Zwaan, R.A. (in press). Aging and functional spatial relations in comprehension and memory. *Psychology and Aging*.

Radvansky, G.A., & Curiel, J.M. (1998). Narrative comprehension and aging: The fate of completed goal information. *Psychology and Aging*, *13*, 69–79.

Radvansky, G.A., Gerard, L.D., Zacks, R.T., & Hasher, L. (1990). Younger and older adults' use of mental models as representations for text materials. *Psychology and Aging*, *5*, 209–214.

Radvansky, G.A., Zacks, R.T., & Hasher, L. (1996). Fact retrieval in younger and older adults: The role of mental models. *Psychology and Aging*, *11*, 258–271.

Radvansky, G.A., Zwaan, R.A., Curiel, J.M., & Copeland, D.E. (2001). Situation Models and Aging. *Psychology and Aging*, *16*, 145–160.

Salthouse, T.A., & Babcock, R.L. (1991). Decomposing adult age differences in working memory. *Developmental Psychology*, *27*, 763–776.

Salthouse, T.A., Mitchell, D.R., Skovronok, E., & Babcock, R.L. (1989). Effects of adult age and working memory on reasoning and spatial abilities. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 507–516.

Stine, E.A.L., & Wingfield, A. (1988). Memorability functions as an indicator of qualitative age differences in text recall. *Psychology and Aging*, *3*, 179–183.

Stine, E.A.L., & Wingfield, A. (1990). The assessment of qualitative age differences in discourse processing. In T.M. Hess (Ed.), *Aging and cognition: Knowledge organization and utilization*. (pp. 33–92). New York: Elsevier.

Stine-Morrow, E.A.L., Loveless, M.K., & Soederberg, L.M. (1996). Resource allocation in on-line reading by younger and older adults. *Psychology and Aging*, *11*, 475–486.

Turner, M.L., & Engle, R.W. (1989). Is working memory task dependent? *Journal of Memory and Language*, *28*, 127–154.

van Dijk, T.A., & Kintsch, W. (1983). *Strategies in discourse comprehension*. New York: Academic Press.

Zwaan, R.A. (1996). Processing narrative time shifts. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 1196–1207.

Zwaan, R.A., Langston, M.C., & Graesser, A.C., (1995). The construction of situation models in narrative comprehension: An event-indexing model. *Psychological Science*, *6*, 292–297.

Zwaan, R.A., & Radvansky, G.A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin*, *123*, 162–185.

Zwaan, R.A., Radvansky, G.A., Hilliard, A.E., & Curiel, J.M. (1998). Constructing multidimensional situation models during reading. *Scientific Studies of Reading*, *2*, 199–220.