

Contextual Constraints in Situation Model Construction:

An Investigation of Age and Reading Span

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RUNNING HEAD: AGING AND CONTEXTUAL CONSTRAINTS

Abstract

This study examined the effects of age and reading span on the ability to use contextual constraints during language comprehension. Older and younger participants listened to sentences over headphones and named pictures that appeared subsequently. Older adults named pictures faster when the preceding sentence context matched rather than mismatched the shape of the depicted object, but younger adults showed less of a match advantage. This effect of contextual match was especially pronounced in older high-span participants, consistent with models of cognitive aging in which surface level processing declines in older adulthood whereas processing at the situation model level remains intact. Results suggest that the practiced ability to immediately construe word meanings and activate the appropriate stored representations is preserved, if not strengthened throughout the lifespan.

Introduction

Successful language comprehension requires the construction of a situation model, a mental model of the described state of affairs (Zwaan & Radvansky, 1998; Van Dijk & Kintsch, 1983). A growing body of recent research has suggested that this situation model employs perceptual-motor representations to simulate the situation described by a text (see Zwaan & Madden, 2005). These simulations are presumably constructed by reactivating the perceptual memory traces that were originally activated during previous experiences with the described situation. However, in order to perceptually simulate a word in a sentence, **the most appropriate of the word's experiential traces must be selected to become activated in the simulation.** For instance, most people have a multitude of stored experiences with viewing, petting, smelling, and hearing dogs. Upon hearing the sentence, “The dog chased after the tennis ball,” one must use context to choose the appropriate perceptual representation of “dog” from these stored experiences to activate within the specific simulation of the described event. Here, the appropriate perceptual representation should not be a dog curled up on the kitchen floor, but rather a dog in mid stride, presumably not far behind a tennis ball.

It is especially interesting that not only homographs, but also so-called “single meaning words” are postulated to have multiple representations. Even though unambiguous words have only one meaning, they nonetheless require meaning disambiguation because they can occur in varying contexts. These ideas are supported by studies showing that the comprehension of any word requires that the contextually

appropriate meaning be selected from a set of alternatives. Zwaan, Stanfield, & Yaxley (2002) showed that the shape of a target object in a situation model can be determined by the surrounding sentence context. For instance, the sentence “There was an eagle in the sky” suggests a different shape of eagle than does “There was an eagle in the nest.” (i.e. outstretched wings vs. wings folded in). Madden and Zwaan (2006) used this object shape paradigm to further demonstrate that high-span comprehenders were able to constrain their representations to the contextually appropriate meaning of a given word almost immediately upon hearing it in a sentence, whereas low-span comprehenders could only constrain their representations appropriately after a delay.

Because many cognitive faculties decline with age, it might be expected that older adults behave similarly to the less-skilled comprehenders described above. Specifically, declines in working memory could be responsible for age-related declines in text comprehension (van der Linden, Hupet, Feyereisen, Schelstraete, Bestgen, Bruyer et al., 1999). For example, older adults took longer to process ideas in a text and were more affected by increases in processing load than younger adults. This suggests that age differences in allocation time at clause boundaries when processing a text could be the result of more limited working memory ability with increasing age (Stine, 1990; Stine & Hindman, 1994). Moreover, older adults’ verbal working memory ability was correlated with their performance on a sentence comprehension task (Kemtes & Kemper, 1997), which is also indicative of a close relationship between working memory and text comprehension measures.

However, in certain domains of language comprehension, age does not always appear to have detrimental effects. A study on conceptual instantiation in sentence

processing showed no age differences in comprehension and memory for inferences (Light, Valencia-Laver, & Zavis, 1991). Age constancy in sentence comprehension was also demonstrated in activation of relevant aspects of word meanings, such as in “The oranges rolled off the uneven table” (Burke & Harrold, 1988). Both older and younger adults had faster verification times for relevant properties of oranges in relation to the sentence meaning “Oranges-Round?” than for irrelevant properties “Oranges-Juicy?” Results of another study showed that age was not associated with comprehension deficits when reading narrative texts as opposed to expository texts (De Beni, Borella, & Carretti, 2007).

In fact, some studies have found that age may bring greater skill in language comprehension. Similar to skilled comprehenders, older adults have been found to use sentence context to quickly constrain lexical access. Older adults demonstrated relatively greater attentional allocation to situation model features on the first reading than younger readers (Miles & Stine-Morrow, 2004). Furthermore, older adults showed less activation of contextually inappropriate subordinate meanings of ambiguous words than younger adults when deciding on the meaning of sentence-final ambiguous words (Winkler & Swaab, 2001), suggesting better use of contextual constraints by older compared to younger adults. Finally, older adults showed larger mismatch effects as indicated by longer response times when responding to pictures of objects that did not match the implied shape of the object in the preceding sentence compared to matching objects and younger adults (Dijkstra, Yaxley, Madden, & Zwaan, 2004).

This finding is in line with previous text comprehension research demonstrating that older adults emphasized the end product of comprehension, the construction of the

situation model (Ferstl, 2006; Radvansky, Copeland, Berish, & Dijkstra, 2003; Radvansky & Dijkstra, 2007), whereas younger adults seemed to focus more on the surface representation of the text (Radvansky, Zwaan, Curiel, & Copeland, 2001). The differences in reading strategies would explain age by condition interactions with older adults displaying stronger updating effects of changes in the situation model than younger adults (Morrow, Stine-Morrow, Von Leirer, Andrassy, & Kahn, 1997; Radvansky et al., 2003), and age-related differences in allocation of time to process text components which may compensate for age-related declines in working memory capacity and speed of processing (Stine-Morrow, Soederberg-Miller, Gagne, & Hertzog, 2008). These findings suggest that older adults do in fact make use of their extensive reading and language experience. They have been shown to immediately activate lexically dominant meanings as a way to reduce demands on their cognitive resources (Syssau, Brouillet, & Groen, 2000). In a similar vein, the effective use of linguistic context may help older adults to construe an equally elaborate, or perhaps even a more elaborate representation of the sentence compared to younger adults (see Radvansky & Dijkstra, 2007; Stine-Morrow, Miller, & Hertzog, 2006).

The present study aims to replicate the larger effect of contextual match in sentence comprehension for older adults relative to younger adults (Dijkstra et al., 2004), and to extend the findings mentioned above by accounting for the effects of both reading span and age on **the ability to activate contextually appropriate word meanings** during sentence comprehension within a single experiment. In addition, the present study more directly assesses the simulation by employing a naming task **rather than a picture verification task, using auditory presentation**, and having no delay between sentence and

probe (see Madden & Zwaan, 2006) to make the task more challenging as listeners cannot control the pace with which the sentences are presented.

In the present study, both older and younger participants with high or low reading spans heard sentences describing the location of a target object. Participants were instructed to name, as quickly as they could, a subsequent picture of that object that either matched or mismatched the contextual constraints of the sentence. Given the prior research, we expected that high-span comprehenders would be able to constrain their representations to the contextually appropriate meaning of the target object at the time of naming, but that low-span comprehenders would be less able to do this. Thus, high-span comprehenders would name matching pictures faster than mismatching pictures, whereas low-span comprehenders would show a smaller difference if any. Specifically, because there is no delay between the presentation of the sentence and the subsequent picture, low-span comprehenders are less likely to have activated a situation model level representation, compared to high-span comprehenders. Moreover, given that older adults exhibit a stronger reliance on sentence context during construction of a situation model, and younger adults are more likely to engage in task-specific and text-based strategies than in situation model construction, the match effect for high-span comprehenders might be more pronounced in older adults than in younger adults. Thus, we hypothesize that the high-span older adults will be the group most likely to immediately activate a contextually appropriate situation model representation of the sentence.

Method

Participants

Forty undergraduate students enrolled at Florida State University, and forty-three high functioning older adults from the community participated in the experiment. Participation was part of a course requirement for the undergraduate students, whereas older participants were paid \$20 for their participation. All participants were native English speakers. The participant information by age and span group is displayed in Figure 1.

Materials and Procedure

Prior to the naming experiment, the older and younger participants completed a hearing test, which all participants passed. This was followed by a computer version of the reading span task (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002), which was comprised of trials in which the participant would read aloud a sentence and answer aloud “yes” or “no” as to whether it made sense. Then they would read aloud the capitalized letter that appeared next to the sentence, remembering the letter for a later test. For example, on a given trial, participants would see something like the following:

During the week of final spaghetti, I studied hard. ? J

Participants would read the sentence aloud, and when they saw the question mark they would report that the sentence did not make sense. Finally they would say the letter “J” aloud, remembering it for a later test. Participants would see 2, 3, 4, or 5 of these trials in a set before having to write the final letters they could recall in order for that set on a formatted sheet. Participants completed 3 practice sets and 12 experimental sets. The experimenter sat with the participants and controlled the progression from trial to trial to

assure that participants had no time to rehearse the letters before they had to write them down at the end of the set.

This test assesses a participant's ability to maintain linguistic information in working memory while simultaneously processing sentences, a crucial component of the language comprehension process. As such, this measure correlates well with other measures of reading comprehension, such as verbal SAT (Daneman & Carpenter, 1980; Daneman & Merikle, 1996). Based on a median split of scores for how many total letters were recalled on this test, participants were classified as high-span or low-span comprehenders. Every correct letter was scored as a point, even if it was recalled out of sequence within the trial. The cutoff score for the older participants was 31 letters recalled out of 42 total letters. Young participants, who typically have slightly higher span scores than older participants, were matched on these span scores. This required that several additional younger participants were tested on the reading span but were not included in the study.

After completing the reading span task, participants began the naming experiment. For this experiment, twenty-eight sentence pairs were adapted from Zwaan, Stanfield, and Yaxley (2002) each describing a target object in a location. These sentences were altered so that the target object was always the final word of the sentence, for example, "In the sky/nest there was an eagle," and they were recorded as sound files rather than visual stimuli. This auditory presentation was used in order to enable presentation of the picture immediately upon word offset (as in Madden & Zwaan, 2006). Each sentence pair was constructed such that the target object was described in two locations that implied two different object shapes (e.g., eagle with wings outstretched or

folded in). Two images, depicting the object in the two implied shapes, were also constructed to correspond to each experimental sentence pair. This yielded two sentences and two pictures for each target object (see Appendix for sample stimuli). Each experimental sentence could be paired with a picture that matched or mismatched the implied shape of the target object, yielding four possible sentence-picture combinations. Participants were to see only one of these four possible combinations for each target object, so four experimental lists were created and counterbalanced with respect to implied shape and match/mismatch condition of the 28 target objects. All images depicted high frequency objects with which older and younger participants would be familiar (e.g., lemon, egg, book, balloon, shirt). In addition to the experimental stimuli, 56 similar filler sentences and pictures were presented.

On all 28 experimental trials, the image depicted the final word of the sentence (the target object). However, on these experimental trials, the target object was pictured in a shape that either matched or did not match the contextual constraints of the sentence. For example, if the participant heard, “In the sky there was an eagle”, a matching picture would be an eagle with wings outstretched and a mismatching picture would be an eagle with wings folded in. The picture was also mentioned in the preceding sentence for 14 of the filler trials. On the remaining half of the trials (42 filler trials) the picture was unrelated and not mentioned in the preceding sentence. It should be noted that the pictures could be named without attending to the sentences. Thus, to ensure that participants actually comprehended the sentences, we inserted yes/no questions that required inferences about the sentences on 24 of the filler trials (evenly distributed between related and unrelated pictures). These questions appeared on the screen after the

naming response had been recorded, and occurred at random times throughout the experiment. Participants answered these questions using keys that were labeled with “y” and “n” stickers.

On a given trial, participants pressed the spacebar to hear a sentence over headphones. At the offset of the final word, a black and white picture (3 square inches) appeared in the center of the screen. The participants’ task was to name the pictured object. The latency of voice onset was recorded through a microphone attached to the headphone set. During the first trial, participants were instructed to adjust the volume on the speaker to their left to assure that the sentences were played at a comfortable listening volume, and special care was taken to ensure that older adults were able to hear the sentences clearly. The first four trials were practice trials. An experimenter sat with the participant during the experiment to record any misnamed trials, trials in which the participant coughed, spoke too quietly, or trials in which the microphone did not record the response correctly. Once the naming experiment was finished, participants were debriefed and assigned credit or paid for their participation and dismissed. Both the reading span task and the naming experiment were run on PCs with 19" flat-screen displays using the E-Prime stimulus presentation software (Schneider, Eschman, & Zuccolotto, 2002).

Results

Design

The experiment employed a 2 (match vs. mismatch) X 2 (span: high vs. low) X 2 (age: older vs. younger) mixed design, with match as a within subjects variable and span and age as between subjects variables. Although List was included as a factor in the analyses, effects for the list variable will not be reported given their lack of theoretical relevance (Pollatsek & Well, 1995; Raaijmakers, Schrijnemakers, & Gremmen, 1999). The dependent measure in this experiment was the response latency for the onset of naming the target object. Accuracy scores could not be calculated on the naming task, as trials were discarded for a number of reasons, including both inaccurate naming and equipment error. These trials were removed from the data set before any analyses were run (5% of the total data). Responses that were more than two standard deviations above or below a participant's condition mean were removed as outliers (5% of the total data analyzed). Percentage of bad trials and outliers removed did not differ by span group or by age group.¹

Upon inspection of the data by items, three items yielded a disproportionate amount of errors as well as extremely long naming times, suggesting that participants in general had difficulty recognizing these objects. These items were determined to be poor representations of the intended objects (fillet of fish, chewed gum, and crumpled wrapping paper) and were removed from the files before the analyses were conducted.² The data from one older adult were excluded from the analysis because the participant did not understand the task. The data from five older adults were excluded because the participants had at least four bad trials in a given condition. This helped to equate older and younger samples (none of whom had four bad trials on a given condition) on ability to complete the experimental task. **The removal of these six from the original sample of**

43 older adults yielded 37 older adults, who were divided into 17 high span and 20 low span participants based on the reading span cutoff score of 31 correct letters recalled. The sample of 40 younger adults was divided into 22 high span and 18 low span participants based on the same cutoff (see Figure 1 for demographic information).

Analyses of Match Effects³

The means and standard deviations for naming times by condition are displayed in Table 1. As predicted, the overall match by age by span mixed ANOVA showed a main effect of match, whereby participants were faster to name a pictured object when it matched rather than mismatched the contextual constraints of the preceding sentence [$F(1,61) = 11.82, MSE = 10663.98, p = .001, \eta_p^2 = .162$]. This match effect was qualified by an interaction between match and age [$F(1,61) = 8.95, p < .005, \eta_p^2 = .128$], indicating that the older participants displayed a larger difference across matching and mismatching trials than the younger participants. The match effect was also qualified by an interaction between match and span [$F(1,61) = 7.28, p < .01, \eta_p^2 = .107$], whereby high-span comprehenders showed a larger match difference than low-span comprehenders. Most importantly, the predicted three-way interaction among match, age, and span was observed [$F(1,61) = 4.02, p < .05, \eta_p^2 = .062$].

To better understand the nature of the three-way interaction, follow-up analyses were conducted, in which responses for high-span and low-span comprehenders were examined separately to determine how age differentially influenced the match effect for high-span and low-span groups. The ANOVA for high-span participants showed that they were faster to respond to matching rather than mismatching pictures, as evidenced by a main effect of match [$F(1,31) = 25.70, MSE = 7725.40, p < .001, \eta_p^2 = .453$]. Also

observed was a match by age interaction [$F(1,31) = 17.05, p < .001, \eta_p^2 = .355$], indicating that the older high-span adults showed a stronger effect of match than the younger high-span adults. Indeed, for high-span older adults, contrast tests showed that naming responses on matching trials were significantly faster than on mismatching trials [$F(1,13) = 18.95, MSE = 14372.23, p = .001, \eta_p^2 = .593$], but for high-span younger adults, there was no significant match effect [$F(1,18) = 1.46, MSE = 2924.91, p = .243, \eta_p^2 = .075$]. The ANOVA for low-span participants yielded neither a significant main effect of match nor a significant match by age interaction [both $F_s < 1$]. In summary, the three-way interaction of match, span, and age reflected a stronger match effect for high-span and older comprehenders than younger and low-span comprehenders.

Analyses of Non-Match Effects

The overall match by age by span mixed ANOVA yielded two main effects that were not associated with the match variable of interest. First, there was a main effect of age, whereby younger adults were faster to name the pictures than were older adults [$F(1,61) = 3.60, MSE = 129640.26, p = .06, \eta_p^2 = .056$]. Also, there was a main effect of span, whereby high-span comprehenders were faster to name the pictured objects than were low-span comprehenders [$F(1,61) = 4.23, p < .05, \eta_p^2 = .065$]. Because these main effects of age and span were highly expected, yet not associated with the manipulated variable of interest (Match) they will not be considered further. The interaction between age and span did not reach significance [$F(1,61) = 1.69, p = .20, \eta_p^2 = .027$].

Discussion

The current study was aimed at better understanding **contextual constraint in meaning activation** as it is affected by age and span. High and low span older and younger participants listened to sentences and named pictures that matched or mismatched the contextual constraints of the sentences. As expected, pictures that matched the contextual constraints of the preceding sentence were named more quickly than pictures that did not match the sentence context. This corroborates earlier findings demonstrating a match advantage (Zwaan et al., 2002). **This match advantage was shown to be strongest for older adults, which replicates findings previously demonstrated for this age group** (Dijkstra et al., 2004). Finally, the match advantage was stronger for high-span than low-span comprehenders replicating results of high and low span comprehenders in a young population (Madden & Zwaan, 2006).

The fact that the older high-span comprehenders showed the largest match advantage supported our prediction. This effect is most likely the result of the benefit of a high working memory span, which allows for prolonged activation of relevant information, as well as expertise in language use that has been acquired across the lifespan. Older readers seem to have more unitized representations because their lifelong reading experience provides them with faster and more effective (in the sense of time allocation) access to words (Spieler & Balota, 2000). Older adults also show a stronger reliance on context in language comprehension, relative to their younger counterparts, which may reduce demands on cognitive resources. Their reliance on context and acquired expertise in language use and text comprehension may help older adults to construct situation models that are at least as strong, if not stronger than those of younger adults (Dijkstra et al., 2004; Morrow et al., 1997; Radvansky & Dijkstra, 2007).

Interestingly, the findings cannot be explained as the result of a reduction in working memory capacity in older adults. First of all, older high-span readers' RTs were shorter in the match condition than those of the younger low-span readers. Second, there was no span by age interaction, suggesting that reading span was independent of age. This finding is in contrast to research in which declines in more general measures of working memory capacity were considered to be responsible for age-related declines in text comprehension (van der Linden et al., 1999). However, a review of the literature on potential relationships on aging, working memory capacity and situation model comprehension (Radvansky & Dijkstra, 2007) revealed no direct relationships. It seems that working memory span better reflects the ability to remember words or the information explicitly described in the text than the mental representation, or situation model of the text (Radvansky & Copeland, 2004). Our findings support this lack of direct relationship.

The stronger match effect for older adults than for younger adults in the present study is consistent with studies suggesting an age-related advantage in constructing contextually appropriate representations (Dijkstra et al., 2004; Morrow et al., 1997; Radvansky & Dijkstra, 2007). The findings that older adults make better use of sentence context to constrain lexical access (Burke & Harrold, 1988; Winkler & Swaab, 2001) suggest that older adults utilize their available cognitive resources to focus on plausible meanings in the text. This allows them to maintain similar levels of performance as younger adults at the situation model level.

Older adults' expertise in these domains of language comprehension enables a text processing strategy to devote more attentional resources to situation model

construction than to surface or text levels representations. By allocating more effort to elaborate on text content, meaning of this content may be construed more effectively (Stine-Morrow et al., 2006). Naturally, these strategies can be best implemented by those older adults who have sufficient cognitive resources. Because a match effect is contingent on the activation of a situation model rather than the associations between the words and propositions in the sentence, the match advantage reported here is largely attributed to processing at the situation model level. The fact that younger participants did not show a match advantage implies that their representations at the situation model level were not as strong.

This lack of a match advantage in younger adults is also likely attributable to age differences in strategy for the naming task. Strictly speaking, the sentence reading and naming tasks in the current study can be optimally performed using merely surface level representations. It is possible that the younger adults adapted to these task demands rather than attending to situation level processing. Even though the high span younger adults should have the resources to process the stimuli at both the surface and situation model levels, they seem to have learned to perform the task rather economically, relying more on surface level representations than situation model representations, as the match effect is not significant even for high span younger participants. Response time data over the course of the experiment support this idea, as younger adults show an increase in response speed later in the experiment [from the middle to the last block of the experiment: $F(1,32) = 7.42$, $MSE = 2984.84$, $p = .01$, $\eta_p^2 = .188$], suggesting strategy implementation. On the other hand, older adults only show an initial increase in response speed, commonly observed towards the beginning of experiments as they familiarize

themselves with the task (Charness, Holley, Feddon, & Jastrzembski, 2004; Mykityshyn, Fisk, & Rogers, 2002), but no further speed up over the course of the rest of the experiment [from the first to the middle block of the experiment: $F(1,29) = 10.15$, $MSE = 9715.17$, $p < .01$, $\eta_p^2 = .259$; from the middle to the last block of the experiment: $F < 1$].

This economical strategy employed by the younger adults is not as available to older adults, as they exhibit an age-related decline in the ability to use surface level representations (Radvansky et al., 2003). Thus, older adults' attentional focus on the situation model level is most likely a consequence of the decline in processing at the surface level that has been well documented in older adults (Radvansky, 1999; Radvansky & Dijkstra, 2007). Moreover, older adults may rely more on their accumulated knowledge of text and contextual constraints during text or speech processing as a form of self-regulation that is reflected in an increased value for discourse level coherence rather than surface level representations (Stine-Morrow et al., 2006). **This idea is also consistent with a study by Price and Sanford (2008) in which older adults were more sensitive to focused information within a sentence, but less sensitive to non-focused information and changes in surface structure compared to their younger counterparts.** In most language situations, these strategies and age-related expertise enable older adults to maintain similar if not higher levels of performance as younger adults in meaningful comprehension.

While it is true that the naturally observed span score would have been higher for the younger high span group if we had not matched them to the older sample, the average span score for this sample of younger adults is comparable to that in earlier studies. Furthermore, a higher span would not necessarily increase the match effect for younger

adults, because this lack of effect is at least partially attributable to the ability of high span younger adults to adapt to the task demands and name the pictured object at a more surface level without much focus on a deeper level of integration. Of course, the naming task allows for the use of this strategy more so than a decision task, as the pictures do not have to be explicitly compared to the preceding sentences when they are named, as they do in a decision task (“Was the pictured object mentioned in the preceding sentence?”). In previous research on younger adults, the naming task has been shown to yield weaker effects of match than the decision task. Had we used the decision task, we probably would have observed a stronger match effect for the younger adults. However, we opted to use the naming task here because it is a more direct measure of lexical access and thus is more likely to yield differences between our age groups.

One avenue for further research is to better outline the conditions under which age-related benefits on comprehension occur as opposed to age constancy. The present study reports greater contextual constraint on representations for older adults than for younger adults, but similar investigations have reported age constancy (Light et al., 1991; Burke & Harrold, 1988). Without further research, we can only speculate about the reasons for this differential finding. One factor contributing to the age-related benefits observed here may be the fact that our task taps online comprehension processes. Burke (1997) argues that offline tasks and tasks that require greater memory retention are more likely to show age deficits. **Our task employed a more direct measure, requiring** fewer memory processes relative to tasks such as property verification or relatedness judgment that have shown age constancy. Thus, our task may be more likely to show age-related benefits in constructing contextually appropriate representations. However, this idea

requires further investigation in order to uncover the conditions under which older adults' comprehension may be optimized.

The present results contribute to a growing body of literature uncovering a variety of comprehension skills that are preserved or strengthened over the lifespan (Burke & Harrold, 1988; Dijkstra et al., 2004; Light et al., 1991; Morrow et al., 1997; Radvansky et al., 2003; Winkler & Swaab, 2001). The observed pattern of data supports the idea that even single-meaning words have a variety of possible representations and therefore must be disambiguated when constructing a situation model. In addition, this study shows that not only high-span comprehenders, but also older comprehenders, and particularly high-span older comprehenders are better able to constrain the set of activated experiential traces to only those that are contextually appropriate. Thus, whereas many other cognitive faculties decline with age, a lifetime of experience in constructing situation models appears to sharpen the skill of rapid contextual constraint in our representations of textual information.

References

- Burke, D. M. (1997). Language, aging, and inhibitory deficits: Evaluation of a theory. *Journals of Gerontology, 52B*, 254-264.
- Burke, D. M., & Harrold, R. M. (1988). Automatic and effortful semantic processes in old age: Experimental and naturalistic approaches. In L. L. Light & D. M. Burke (Eds.), *Language, Memory, and Aging* (pp. 100-116). New York: Cambridge University Press.
- Charness, N., Holley, P., Feddon, J., & Jastrzembski, T. (2004). Light pen use and practice minimize age and hand performance differences in pointing tasks. *Human Factors, 46*, 373-384.
- Conway, A.R.A., Cowan, N., Bunting, M.F., Theriault, D.J., & Minkoff, S.R.B. (2002). A latent variable analysis of working memory capacity, short-term memory capacity, processing speed, and general fluid intelligence. *Intelligence, 30*, 163-184.
- Daneman, M., & Carpenter, P.A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning & Verbal Behavior, 19*, 450-466.
- Daneman, M., & Merikle, P.M. (1996). Working memory and language comprehension: A meta-analysis. *Psychonomic Bulletin & Review, 3*, 422-433.
- De Beni, R., Borella, E., & Carretti, B. (2007). Reading comprehension in aging: The role of working memory and metacomprehension. *Aging, Neuropsychology, and Cognition, 14*, 189-212.

- Dijkstra, K., Yaxley, R.H., Madden, C.J., & Zwaan, R.A. (2004). The role of age and perceptual symbols in language comprehension. *Psychology and Aging, 19*, 352-356.
- Ferstl, E. C. (2006). Text comprehension in middle aged adults: Is there anything wrong? *Aging, Neuropsychology, and Cognition, 13*, 62-85.
- 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., Valencia-Laver, D., & Zavis, D. (1991). Instantiation of general terms in young and older adults. *Psychology and Aging, 6*, 337-351.
- Madden, C.J., & Zwaan, R.A. (2006). Perceptual Representation as a Mechanism of Lexical Ambiguity Resolution: An Investigation of Span and Processing Time. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*, 1291-1303.
- Miles, J. R., & Stine-Morrow, E. A. L. (2004). Adult age differences in self-regulated learning in reading sentences. *Psychology and Aging, 19*, 626-636.
- Morrow, D. G., Stine-Morrow, E. A. L., Von Leirer, O., Andrassy, J. M., & Kahn, J. (1997). The role of reader age and focus of attention in creating situation models from narratives. *Journals of Gerontology, 52B*, 73-80.
- Mykityshyn, A. L., Fisk, A. D., & Rogers, W. A. (2002). Learning to use a home medical device: Mediating age-related differences with training. *Human Factors, 44*, 343-354.

- Pollatsek, A., & Well, A.D. (1995). On the use of counterbalanced designs in cognitive research: A suggestion for a better and more powerful analysis. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *21*, 785-794.
- Price, J.M. & Sanford, A.J. (2008). Focus effects in healthy aging: Ease of reference and shallow processing. Poster presented at the *CUNY Conference on Human Sentence Processing*, March 13-15, Chapel Hill, North Carolina.
- Radvansky, G. A. (1999). Aging, memory and comprehension. *Current Directions in Psychological Science*, *8*, 49-53.
- Radvansky, G. A., & Copeland, D. E. (2004). Working memory and situation model processing: Language comprehension and memory. *American Journal of Psychology*, *117*, 191-213.
- Radvansky, G. A., Copeland, D., Berish, D., & Dijkstra, K. (2003). Aging and situation model updating. *Aging, Neuropsychology, and Cognition*, *10*, 158-166.
- Radvansky, G. A., & Dijkstra, K. (2007). Aging and situation model processing. *Psychonomic Bulletin & Review*, *14*, 1027-1042.
- Radvansky, G. A., Zwaan, R. A., Curiel, J. M., & Copeland, D. E. (2001). Situation models and aging. *Psychology and Aging*, *16*, 145-160.
- Raaijmakers, J.G.W. (2003). A further look at the "language-as-fixed-effect fallacy". *Canadian Journal of Experimental Psychology*, *57*, 141-151.
- Raaijmakers, J.G.W., Schrijnemakers, J.M.C., & Gremmen, F. (1999). How to deal with "The language-as-fixed-effect fallacy": Common misconceptions and alternative solutions. *Journal of Memory & Language*, *41*, 416-426.

- Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime 1.0*. Pittsburgh, PA: Psychological Software Tools.
- Spieler, D. H., & Balota, D. A. (2000). Factors influencing word naming in younger and older adults. *Psychology and Aging, 15*, 225-231.
- Stine, E. A. L. (1990). On-line processing of written text by younger and older adults. *Psychology and Aging, 5*, 68-78.
- Stine, E. A. L., & Hindman, J. (1994). Age differences in reading time allocation for proportionally dense sentences. *Aging and Cognition, 1*, 2-16.
- Stine-Morrow, E.A.L., Soederberg-Miller, L.M., Gagne, D.D., & Hertzog, C. (2008). Self-regulated reading in adulthood. *Psychology and Aging, 23*, 131-153.
- Stine-Morrow, E.A.L., Miller, L.M.S., & Hertzog, C. (2006). Aging and self-regulated language processing. *Psychological Bulletin, 132*, 582-606.
- Syssau, A., Brouillet, D., & Groen, S. (2000). The study of inhibitory processes in aging with the Faust et al. paradigm (1997). *Brain and Language, 72*, 150-157.
- van der Linden, M., Hupet, M., Feyereisen, P., Schelstraete, M., Bestgen, Y., Bruer, R., et al. (1999). Cognitive mediators of age-related differences in language comprehension and verbal memory performance. *Aging, Neuropsychology, and Cognition, 6*, 32-55.
- van Dijk, T.A., & Kintsch, W. (1983). *Strategies of Discourse Comprehension*. New York: Academic Press.
- Winkler, T., & Swaab, T. Y. (2001). Category ambiguity resolution in aging: an ERP study. *Journal of Cognitive Neuroscience, (Suppl.)*, 165.

- Zwaan, R.A., & Madden, C.J. (2005). Embodied sentence comprehension. In: D. Pecher & R.A. Zwaan (Eds.), *The Grounding of Cognition: The Role of Perception and Action in Memory, Language, and Thinking*. Cambridge, UK: Cambridge University Press.
- Zwaan, R.A., & Radvansky, G.A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin*, 123, 162-185.
- Zwaan, R.A., Stanfield, R.A., & Yaxley, R.H. (2002). Do language comprehenders routinely represent the shapes of objects? *Psychological Science*, 13, 168-171.

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Endnotes

¹ Bad trials removed by group and condition. High span/young: match = 4.1%, mismatch = 4.8%; High span/old: match = 4.4%, mismatch = 5.8%; Low span/young: match = 4.6%, mismatch = 3.8%; Low span/old: match = 5.3%, mismatch = 6.8%

Outliers removed by group and condition. High span/young: match = 5.2%, mismatch = 4.1%; High span/old: match = 6.6%, mismatch = 5.8%; Low span/young: match = 5.9%, mismatch = 3.8%; Low span/old: match = 6.8%, mismatch = 5.7%

² Only the poorly recognized pictures (chewed gum) were removed in both their match and mismatch conditions, but not their corresponding well-recognized pictures (stick of gum). This was done to preserve as many items as possible in the analysis. The three removed items fell evenly across the 4 lists, resulting in the removal of one item per match condition and 1 item per mismatch condition on each list, except that no items were removed in the match condition of list A or the mismatch condition of list D. Thus, the counterbalancing of the lists was relatively preserved, and the resulting lists after removal of the poorly recognized picture items were as follows.

List A: 14 match items, 13 mismatch items

List B: 13 match items, 13 mismatch items

List C: 13 match items, 13 mismatch items

List D: 13 match items, 14 mismatch items

Percentages for outliers and bad naming trials do not including these 3 bad items.

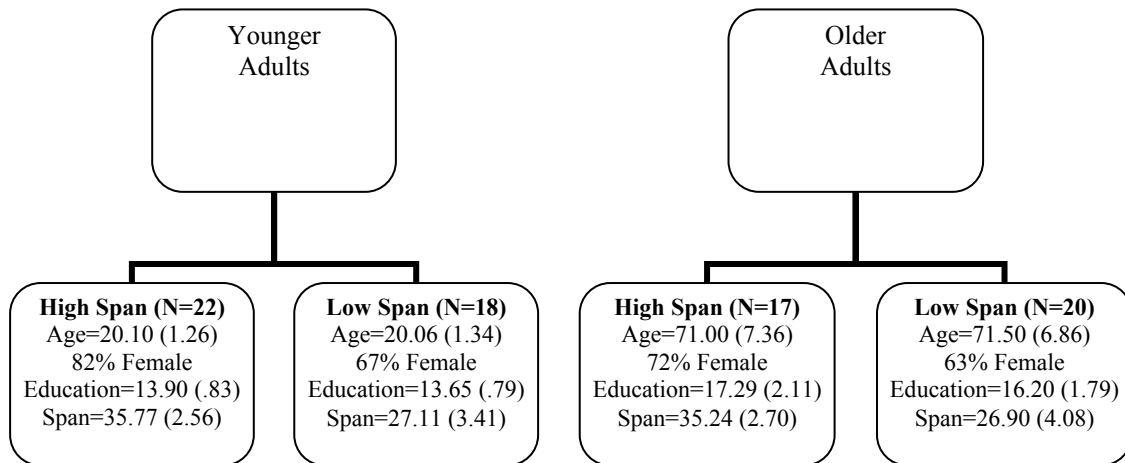
³ For counterbalanced designs only subject analyses should be performed (Raaijmakers, 2003; Raaijmakers, Schrijnemakers, & Gremmen, 1999). Raaijmakers, Schrijnemakers, & Gremmen (1999) explain that there is no need to include both subject and item analyses in cases where item variability is experimentally controlled by matching or counterbalancing. Specifically, they state that “it is not required to do separate analyses over subjects and items in order to test the effect of the treatment factor. The expected means-squares, under the assumption that List is a random effect, show that the treatment effect can always be tested directly using the mean-squares obtained from the standard subject analysis (averaging over items).” (p. 425).

Table 1.

Response Times and Standard Deviations (in ms) for Naming Task in Younger and Older Participants

	Younger Participants		Older Participants	
	match	mismatch	match	mismatch
High-span	670 (137)	686 (122)	754 (181)	946 (302)
Low-span	862 (307)	869 (168)	902 (346)	936 (367)

Figure 1.



Appendix A

Samples of Sentence-Picture Pairs

In the skillet/refrigerator there was an egg.



In the nest/sky there was an eagle.



On the ice/bench there was a hockey player.



On the floor/rack there was a towel.

